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ENERGY AND THE ENVIRONMENT: A REVIEW OF ALTERNATIVE ENERGY SOURCES

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Abstract: One of the greatest challenges facing humanity today has been identified as climate change. The world's ever increasing energy requirements are endangering the global environment. The overall dependence on fossil fuels to generate power throughout the nations is threatening the climate across the planet. The negative effects created by the use of fossil fuel generated power have made it apparently clear that the nations of the world need to develop and promote clean and renewable energy sources. The future of the Earth is dependent on the reduction of carbon dioxide and alternative energy that focuses on clean power and sustainability. Together these issues have encouraged the development and the use of alternative energy that is environmentally safe and economically effective. This study presents and reviews data covering various alternative energy sources and the progress of their perspective applications.

Keywords: Alternative Energy, Renewable Energy, Climate Change, Sustainability, Environmental Issues.

ENERJİ VE ÇEVRE: ALTERNATİF ENERJİ KAYNAKLARININ İNCELENMESİ

Özet: İklim değişikleri insanoğlunun günümüzde karşılaştığı en büyük sorunlardan biri olarak sayılmaktadır. Dünya'nın giderek artan enerji gereksinimleri küresel çevreyi tehlikeye atmaktadır. Ülkeler tarafından enerji üretmek için kullanılan fosilli yakıtlara olan bağımlılık, dünyanın iklimini tehdit etmektedir. Fosilli yakıtlar tarafından üretilen enerjinin kullanımının yarattığı olumsuz etkiler, dünya ülkelerinin temiz ve yenilenebilir enerji kaynaklarını geliştirmesi ve teşvik etmesinin gerekliliğini açıkça ortaya koymuştur. Dünyanın geleceği, karbondioksitin azaltılması ve temiz güç ile sürdürülebilirlik üzerinde yoğunlaşan alternatif enerjiye bağlıdır. Bu konular, çevresel olarak güvenli ve ekonomik olarak verimli olan alternatif enerji kaynaklarının geliştirilmesini ve kullanımını teşvik etmiştir. Bu çalışma çeşitli alternatif enerji kaynaklarını kapsayan verileri ve bu kaynakların uygulanması ile ilgili gelişmeleri gözden geçirecektir.

Anahtar Kelimeler: Alternatif Enerji, Yenilenebilir Enerji, İklim Değişikliği, Sürdürülebilirlik, Çevresel Sorunlar.

I. INTRODUCTION

Alternative energy is a term used by the Intergovernmental Panel on Climate Change to describe energy derived from many sources without the negative effects caused from the burning of fossil fuels, specifically carbon dioxide emissions which are the major contributing factor of global warming [1]. The Oxford University Dictionary and Princeton University WorldNet expand on this description by adding that alternative energy is derived from sources that do not use up natural resources or harm the environment [2,3]. While there are many reasons to seek alternative energy sources, reducing the carbon dioxide released into the atmosphere is a key concern among today's generation. In an effort to promote the reduction of greenhouse gases and reduce the pollutants introduced into the environment many nations have signed the Kyoto Protocol. This protocol signifies each entity's general commitment to reduce four targeted greenhouse gases (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) and two groups of gases (hydrofluorocarbons and perfluorocarbons) produced by them 5.2% from their 1990 levels [4].

The alternative energy solutions vary, however they all support the reduction of greenhouse gases as well as preserve natural resources that are diminished or damaged by the use of fossil fuel energy. It is necessary to review the alternative energy sources available to ensure sustainable energy solutions that improve and protect the global environment. Gale Encyclopedia of Science states the progress toward a sustainable economy is through a wider use of renewable sources of energy [5]. According to the US Department of Energy these sources include wind and solar power, bio fuel and geothermal energy. While fossil fuel remains the primary source of the world's energy, alternative energy sources represent the anticipated future leading energy sources of tomorrow [6].

II. ALTERNATIVE ENERGY SOURCES

Wind Power

Wind power is an energy derived from wind. This form of energy has been in use for many years dating back to ancient times with the use of sails to propel ships

through the water. Later, wind mills were created and used for mechanical power [7]. Today, wind power has been expanded with the introduction of wind turbines to produce electricity for commercial use. The power output from wind turbines is relative to wind speed; therefore some regional areas are preferred due to their increased and/or sustained wind speeds such as offshore and high altitude sites. The use of wind turbines for commercial use is affected by environmental concerns such as the amount of land use required for wind farms [8]. Some believe wind power has the long term potential to be five times the total global energy currently produced. To meet this expectation, large areas of land mass would be required to support wind farms. For this reason, wind farms are not globally welcomed.

A positive effect from wind power for governments is that the generation of wind power is shifting to the private sector. According to the Economist Intelligence Unit, Morocco is planning to construct a wind farm costing 160 Million Euro in the Tangiers area. This endeavor is to be majority financed by private banks [9]. In other regions, such as the United States, utility companies are buying the surplus energy from large scale wind farms that are connected to the electric power transmission network. An added benefit is the reduction in energy required from the burning of fossil fuels which in turns reduces carbon dioxide emissions. California facilitates the use of wind power and now leads the United States in wind power production. However Denmark leads to world in wind energy utilization. While wind power may not be suitable to all regions it produces energy without creating harmful greenhouse gases, has a renewable energy source, can be widely and cleanly produced making it an attractive alternative to fossil fuel energy [5].

Hydropower

Hydropower is power obtained from water. As with wind power, hydropower has been in use for many years in different capacities. Earlier uses for hydropower were irrigation and operation of grist mills. This water power expanded to textile machines, sawmills, dock cranes and today's commercial electric power. There are various methods of extracting energy from water to enable it to be put to effective use [10]. The most familiar form or hydropower for commercial energy use is the hydroelectric dam. This form of commercial power production is seen across the globe with the Akosombo Dam in Ghana and the Grand Coulee Dam in Washington State in the United States [11,12].

On a smaller scale is the micro hydro system used in remote areas rich in water. These micro systems usually produce up to 100kW of power. This type of system is in use around the world with the Solomon Islands having several that produce in the area of 50 kW of power [13]. While hydroelectric dams do not produce harmful greenhouse gases, there are other environmental concerns associated with them. Dam failures are not common however have devastating effects when they occur as with the Banqiao Dam, which killed more than 150,000 [14]. Ecological threats also exist as it pertains to plant and animal life due to water flow and quality. Reduced water flow created from the dam lowers the oxygen levels in the water endangering the ecosystem. These negative effects can be addressed with the installation of fish ladders providing safe passage around the area and aerating the water on a regular basis [15].

Several other forms of hydro power are in use and or being tested. There are hydro systems that operate without dams by using kinetic energy from rivers and oceans. The technologies used to harness energy from the ocean and sea is referred to as Ocean energy. Some of the energy harnessed from these vast bodies of water range from tidal power, wave power, marine current power and vortex power. The source of energy for these forms of hydro power is derived from their names. For example, tidal power captures the energy from the incoming and outgoing tide and wave power uses the energy from waves. Vortex power is generated by creating vortices in a river through the use of obstacles placed in the river's flow which can then be harnessed and used for energy. Other forms of hydro power are still in the testing phase [16].

Solar Energy

Solar energy is an energy that is derived from sunlight [17]. This form of energy has been used in many ways throughout the years [18].The earlier use of solar energy was in the primitive form of direct heat as seen in greenhouses and solariums. The heat from the sun's rays pass through the glass surfaces warming the internal space and the glass slows the escape of heat. Flatplate roof top solar collectors were later developed that enabled the production of up to one-third the energy required for heating internal spaces. These forms of solar energy are referred to as passive systems. Once a pump, fan or other machinery is added to the system it is then referred to as an active system [5].

In addition to the direct transfer passive systems, solar energy can be converted to electoral power using photovoltaic cells. A direct electrical current is produced by the absorption and conversion of a part of the incoming solar radiation collected by the photovoltaic cells. The efficiency rate is about 14%. Technology in this area is being further developed to improve cost and efficiency. This form of energy is presently being used economically in smaller applications and in remote areas where wide spread power may not be available such as isolated homes, lighthouses and rural villages [5].

Solar power systems used for larger applications have also been developed. These systems incorporate mirrored reflectors that concentrate the solar energy collected and use parabolic trackers enabling them to follow the sun. This maximizes the time available to collect and convert the sun's rays into energy. According to Gale Encyclopedia of Science, these systems can develop intense heat that can be used to generate steam. This steam is used to drive turbine generators that then produce electricity [5]. As with wind farms, this system can require large areas of land to produce enough energy to support wide spread commercial use. Many argue that unusable desert land could be used to support solar energy with minimal effect on the environment [19].

Biofuel

Biofuel is a fuel that is derived from various agriculturally produced plants that is used to generate energy such as biodiesel, ethanol and bagasse. These fuels are typically burned in internal combustion engines or boilers. However research is underway to develop more efficient methods of producing electricity through the use of fuel cells [20]. The UNEP indicates that Biofuels have gained the support of many governments due to the research indicating biofuels could provide substantial energy while reducing negative effects on climate change. Private industry has also invested heavily into biofuel research. Many farmers support the use of biofuels as it provides them with additional income opportunities [21].

While biofuel research indicates that the use of biofuels will assist in the reduction of greenhouse gases, specifically carbon dioxide, opponents are weary of the negative implications of their increased use. The UNEP reports growing concerns regarding the use of food crops as fuel sources. The concerns sited were negative effects on the price of food, competition for livestock feed and possible competition between food and fuel. Land use was also a growing concern with the reference to ecosystems that are currently diverse and crucial to local economies being compromised [21]. Opposing views and counter points are mentioned by Worldwatch Institute's report "Biofuels for Transportation: Selected Trends and Facts" stating 25 of the world's poorest countries import all of their oil, however many of these same countries are capable of producing highly productive energy crops thus reducing their dependency on fossil fuel. This reduction in fossil fuel use will greatly reduce the greenhouse gases and help stop the deterioration of the ozone and the climate. An added benefit referenced by World Bank stated the ethanol industry is credited with providing more than 200,000 jobs in the US and half of a million in Brazil [22].

Geothermal Energy

Geothermal energy is derived from heat created by the earth's core [23]. Capturing and using geothermal energy dates back to ancient times with geothermal heat being used for space heating by the ancient Romans [24]. Geothermal energy has progressed with the development of geothermal plants to create electricity. As with wind farms, geothermal power plants have been limited to regions that will support this form of energy capture, such as areas near tectonic plate boundaries and geologically unstable parts of the world [25]. The most familiar in the US is Yellowstone National Forest [26]. The areas for geothermal exploration for widespread use have been increased due to recent technological advances.

There are three types of geothermal power plants, dry steam, flash and binary. All three use steam to turn turbines to create electricity. The dry steam plant uses steam derived from the earth and the flash plant brings hot water to the earth's surface allowing it to boil and create steam. The binary plant runs the hot water through heat exchangers and is used to boil fluid creating the steam to spin the turbine. The condensed steam and remaining fluid from each of these plants are injected back into the earth for reheating. Australian companies are exploring a technology to generate geothermal energy from hot dry rocks [27]. Deep holes, approximately 3km or more, are drilled into rocks and water is pumped into some holes and hot water pumped out of others. The underground radiogenic granite is heated when sediment builds between the deep rock and the earth's surface [28].

Building a geothermal plant is an expensive endeavor, however once completed the operating expense is low resulting in low energy costs [29]. The use of geothermal energy may have an increased negative effect on the environment when compared to wind and solar power. According to Gale Encyclopedia of Science, geothermal plants could emit toxic elements such as mercury and arsenic and dissolved salts contributing to air pollution. Some argue that these emissions are much lower than that of fossil fuels and if operated correctly, geothermal plants produce no harmful bi-products. Furthermore, these power plants are usually small in size and have little effect on the natural landscape. The use of geothermal energy has the potential to reduce global warming if it replaced the use of fossil fuels [5].

III. ALTERNATIVE ENERGY IN POLITICS

Alternative energy is an important topic in politics across with globe as witnessed by many political campaigns as well as the Kyoto Protocol [4]. While this protocol has not been signed by every country, policy targets were in place in 73 countries as of 2009 [30]. Also, in countries that have not signed the protocol, such as the United States, many cities and local governments

around the world are seeking or implementing alternative energy policies linked to the reduction of greenhouse gases, specifically carbon dioxide [4,31].

In an attempt to support their efforts and encourage research and development and cooperation from their general populations, these governments offered economic stimulus and job creation packages. To name a few examples, the United States released their goal of $150 billion in alternative and renewable energy over 10 years with $1.6 billion in tax credit bonds to finance renewable investments, Japan announced a $1 trillion yen investment, equivalent to $12.2 billion, over five years and Australia was to accelerate an existing $370 million renewable energy fund from six years to 18 months. Further evidence of political involvement is the European Union's formal target to reach a 20 percent share of alternative and renewable energy by the year 2020. They further adopted country specific goals for all member states. These statics support the global political commitment to alternative energy [30].

IV. PROGRESS METRICS FOR ALTERNATIVE ENERGY

Alternative energy sources have become popular in recent years as indicated by the continual growth and investment in the industry. When we review the statistics for alternative energy in the chart below, an increase in the capacity can be seen in recent years. This increase can be attributed to rising concerns regarding climate change. Reviewing these results, excluding large hydropower, global power capacity derived from new renewable energy sources reached 280,000 megawatts (MW) in 2008. This represents a 16 percent increase from the 240,000 MW in 2007. In recent years the European Union and the United States have added more renewable energy power capacity than conventional power capacity. The top countries in the world with renewable power capabilities are China with 76 GW, the United States with 40GW, Germany with 34 GW, Spain with 22 GW, India with 13 GW and Japan with 8 GW respectively [30].

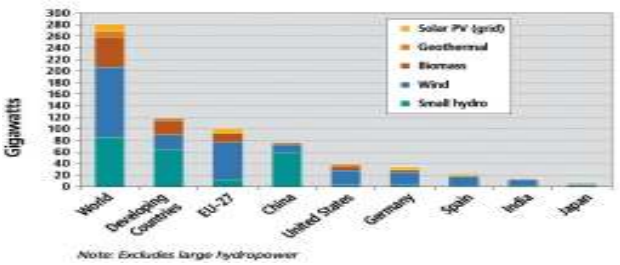

Figure.1. Renewable Power Capacities, Developing World, EU, and Top Six Countries, 2008

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 12 [30].

Wind power produced from the conversion of wind into a useful form of energy has been the largest addition in renewable energy capacity in recent years. This sector of alternative energy has tripled in the last five years. The following graph depicts the impressive growth in the global capacity of wind power. As of 2008 global capacity of wind power reflects an increase of 29 percent reaching 121 GW when compared to the capacity about 40GW in 2003 [30].

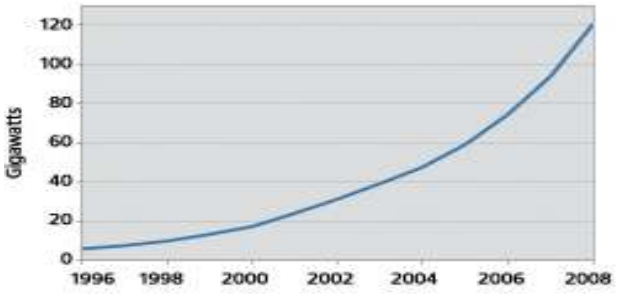

Figure.2. Wind Power, Existing World Capacity, 1996–2008

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 11 [30].

When the details of the 2008 increase as referenced in the chart below are reviewed closer, the rise in wind power capacity is most notably attributed to the United States with 8.4 GW follow by China with 6.3 GW , India with 1.8 GW and Germany with 1.7 GW. An added note of interest is China's progress in wind power capacity since 2003. China's successfully doubled their capacity each consecutive year from 2003 to 2008 reaching 12 GW in 2008. This achievement has exceeded China's 2010 target of 10 GW [30].

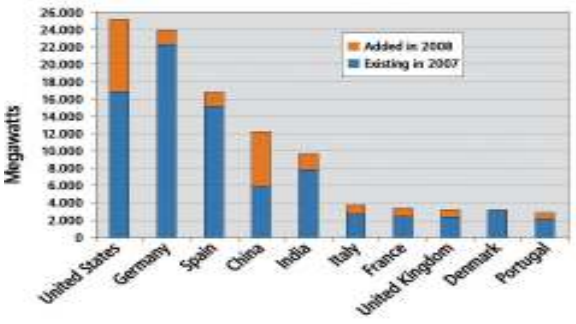

Figure.3. Wind Power Capacity, Top Ten Countries, 2008

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 11 [30].

Hydropower plants have been constructed across the globe and account for approximately 24% of the world's electricity [32]. According to the National Renewable Energy Laboratory, the world's hydropower plants produce energy equivalent to 3.6 billion barrels of oil [33]. The REN21 2009 update indicates $120 billion

was invested in renewable energy with an additional $40-$45 billion invested in large hydro systems. This report also indicated that small hydropower worldwide increased to approximately 85GW with the majority of the small plants in being in China. In the years between 2004 and 2008, China added 4-6 GW annually. On the other hand, the development of small and micro-hydro systems was ongoing in several Asian and African countries. China also led the increase in power developed by large hydro systems by in 2008. The global overall increase was estimated 25-30 gigawatts in 2008, notably higher than previous years [30].

Moving on to the Solar Photovoltaic (PV) power graph that follows, it can be determined that grid-connected PV power capacity is notably higher than off grid capacity. Since 2004, solar PV technology has grown more than 6 times reaching 13 GW in the year 2008. With 2.6 GW of new grid-tied installations, Spain became the PV market leader followed by Germany with 1.5 GW, United States with 310 MW, South Korea with 200–270 MW, Japan with 240 MW, and Italy with 200–300 MW.

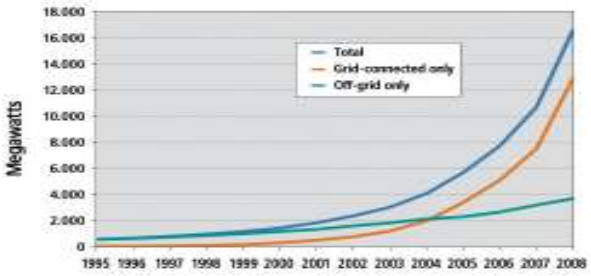

Figure.4. Solar PV, Existing World Capacity, 1995–2008

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 12 [30].

Alternative energy renewable heating markets have made good progress as well and continue to grow. The capacity in the solar heating sector has increased by 15 percent reaching 145 gigawatts-thermal (GWth) doubling the capacity since 2004. The following charts reflect China's leadership in the hot water heating sector and their continued progress represented by their impressive 80 percent share in 2007's added capacity. The share contributed by others countries was notably lower with the European Union holding 9.5 percent, Turkey 3.5 percent, Brazil 1.5 percent and India holding 1.0 percent [30].

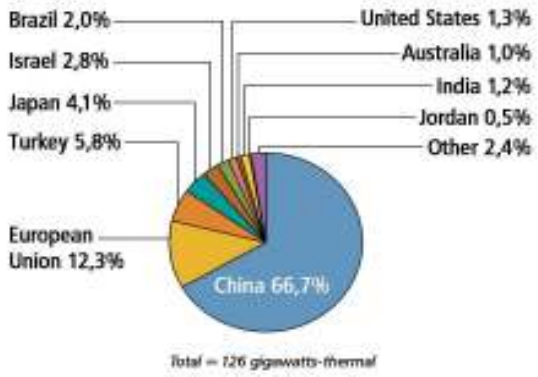

Figure.5. Share of Solar Hot Water/Heating Capacity Existing, Top 10 Countries, 2007

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 13 [30].

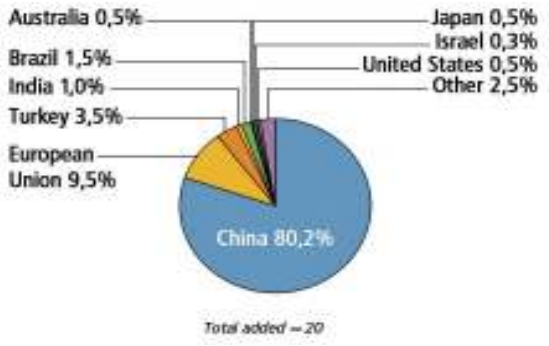

Figure 6. Share of Solar Hot Water/Heating Capacity Added, Top 10 Countries, 2007

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 13 [30].

According the REN21 2009 update, the United States was the leader in geothermal power. Other countries such as Australia, El Salvador, Guatemala, Iceland, Indonesia, Kenya, Mexico, Nicaragua, Papua New Guinea and Turkey all made progress in geothermal power developments in recent years [30].Geothermal energy is now in use by more than 20 countries some of which are Chile, Iceland, New Zealand, the Philippines and Italy [5]. Iceland was able to produce enough geothermal energy to heat most of the homes and buildings [34].

The graph below depicts the anticipated growth in geothermal capacity over the next seven years. This information suggests the capacity will continue to grow and actually increase by almost double the 2008 capacity of 11,007 to 20,841 by 2015. This represents a growth of 89 percent [35].

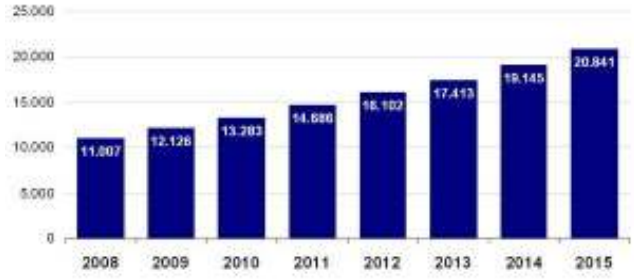

Figure.7. Cumulative Installed Geothermal Power Capacity by Year 2008-2015 in MWe

Source: (2010). Geothermal Power Generation Capacity To Grow 89% 2008 to 2015. (http://thinkgeoenergy.com/ archives/1158). [08.01.2010] [35].

Biofuels for Transportation Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century reports that in 2005 the European Union represented almost 89% of the world's biodiesel production (derived from rapeseed or sunflower seed). In the same year 32.7 billion liters of ethanol was produced by Brazil (45.2%) and the US (44.5%). Sugar cane was the most important crop required for producing biofuels with corn ranking second. They further report in 2009 that the use of biofuels represented a respective reduction in greenhouse gases of 57% when compared to the emissions if fossil fuels were produced and used alone [22].

In the eight year period between 2000 and 2008 the production of biodiesel and ethanol biofuels increased by 34 percent as indicated in the chart below. This increase represents 67 billion liters of ethanol in 2008 which is more than double the production in 2004 of 30 billion liters. While the overall production of biodiesel in 2008 of 12 billion liters is far less than that of ethanol, the growth rate is much higher at six times the 2004 production of 2 billion liters [30].

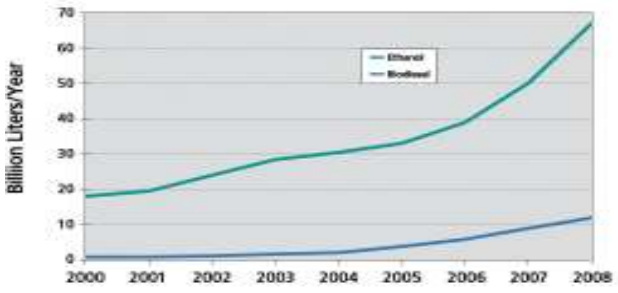

Figure.8. Ethanol and Biodiesel Production, 2000–2008

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 13 [30].

As it can be seen from the figure below, the investment in renewable energy doubled from 2006 to 2008 with an estimated $120 billion reported. While this is up from $63 billion in 2006, it is up $100 billion from 2004. These results suggest the global commitment to alternative energy such as wind, solar PV, biofuels and geothermal energy is clearly supported in the financial sector [30].

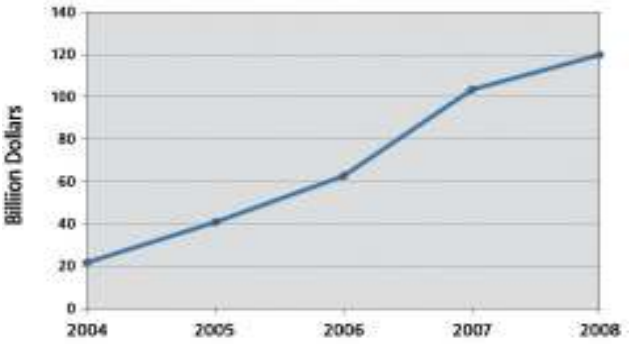

Figure.9. Global Investment in Renewable Energy, 2004–2008

Source: (2009). Renewables Global Status Report: 2009 Update. Renewable Energy Policy Network for the 21st Century. Paris, 14 [30].

V. CONCLUSION

This study suggests alternative and renewable energy sources are the pathway to the future and will replace the environmentally damaging fossil fuel produced energy of today. The alternative energy options under development and currently available have the capability to reduce greenhouse gas emissions and pollutants with a specific target reduction in carbon dioxide. These renewable energy sources such as wind, hydro and solar power, biofuels and geothermal energy also focus on sustainability. While each of these options have their own potential drawbacks, such as land use with wind, hydro, solar power and biofuels or possible environmental concerns if not properly executed as with geothermal energy, they all reduce carbon dioxide limiting and reducing the negative effects on the environment and climate change.

The statistics reviewed in this study indicate a global commitment and improvement in the use and capacity of alternative energy. The multinational agreement known as the Kyoto Protocol formally documents the continued efforts by global governments to support a reduction in greenhouse gases and affect a positive trend in climate change. While some governments have not signed the protocol, evidence exists that these governments, such as the United States, encourage and support alternative energy use and development through renewable energy targets as well as stimulus and job creation packages. The private sector is

also supporting this endeavor through investments in research and production of alternative energy sources. If the progress indicated in this study continues, the negative effects on the environment and climate caused by carbon dioxide will be notably reduced in the coming years and calm the concerns of today's generation.

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