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.QUANTUM JUMPS IN THE RENEWABLE ENERGY TECHNOLOGIES.

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Fossil Fuels Resources Are Finite, Renewable Energy Resources Last Indefinitely

Introduction:

As we enter the new millennium, population explosion, increasing worldwide energy demands and rapid climate change are now threatening our fragile environment as at no other time in known history. There is an urgent need for research and education to focus on the complex and direct link between energy and the environment and for the continuing promotion of transference of renewable energy technology and its infrastructure development from developed to developing countries. Within the framework of this global view, energy and environmental policy issues can no longer be viewed in isolation. National security, climate change and energy economics are convergent rationales that provide a global platform for scientists and politicians alike; scientific measured data on atmospheric changes reflects facts, but still open to interpretation from special interest groups.

For millions of years, prior to the industrial revolution, the carbon dioxide concentration in our atmosphere was about 100-250 parts per million (ppm), but in the last 200 hundred years the concentration has significantly increased to 380 ppm. According to United States Energy Information Administration (EIA); "World energy-related annual carbon dioxide emissions rise from 30.2 billion metric tons in 2008 to 35.2 billion metric tons in 2020 and 43.2 billion metric tons in 2035, an increase of 43 percent over the projection period." (U.S. EIA. (2010a). *2009 EIA-860*.).

In the last hundred years, world population increased from 1.6 billion to 7.1 billion, and the consumption of commercial energy increased by more than 100 times the levels in the early 1900's. If the world economy expands to meet the aspirations of countries around the globe, the demand for energy in this century is likely to increase substantially even if strenuous efforts are made to increase the efficiency of fossil fuel utilization. According to global energy demand scenario, EIA. (2010a) adopted for this century, "the world marketed energy consumption [is expected to grow] by 53 percent from 2008 to 2035 and global electricity production would double by the year 2025 and more than triple by 2050." If existing energy trends continue as predicted "reserves could supply only petroleum needs for 50-60 years, natural gas for 60-80 years, and coal for 200 years and uranium for 40 years." By contrast, renewable energy resources, including biomass, hydro, geothermal, solar,

wind, ocean thermal, wave and tidal action, are naturally replenishing. They are virtually inexhaustible in duration, and not susceptible to geo-political conflicts.

Based on current financial, technological, and political constraints, energy resource distribution and diversification must be based on exploiting and implementing existing energy sources with focus on renewable energy and supporting infrastructure. Knowledge of how energy is used is essential in understanding the importance of improving energy efficiency and alleviating the wide range of energy related environmental problems. Industrialized nations have an important role to play in providing commercially viable alternative technologies, implanting new, sustainable, more efficient energy policies and generating innovative financial mechanism to overcome inadequate, inefficient energy supplies and widespread lack of efficient and modern energy infrastructure.

Energy is lost at every stage of production, distribution and use. In general, two thirds of potential energy in fossil fuels is lost to incomplete and inefficient energy extraction, and largely wasted in thermal heat generation. New technologies, such as fuel cells and other renewables aim to boost energy conversion to approximately 2/3 of total available energy. However, adapting newer technologies in general does not mean improving energy efficiency, proper energy management practices can minimize energy waste. Until recently, investment in energy efficiency was not a priority. Developing nations focused on increasing supply quickly not managing supplies to maximize service. The use of more efficient appliances and processes could result in energy savings of as much as 50% over the life time of equipment, according the US Office of Technology Assessment; on the supply side, a 50% increase in power plant efficiency and decrease in transmission loss of about 6% is possible and obtainable with current technologies and know-how. With 20% increase in end use efficiency, these efforts could cut electricity generation needs by more than 40%, leading to tremendous capital investments savings and dramatically reducing the need to utilize dirty carbon heavy sources of energy, such as coal and risky nuclear energy.

Although, some of renewable energy resources,especially wind, solar, are subject to limited amount of energy per unit time, they are for the most part immune to geopolitical uncertainties, it is difficult to block the sun from a resource competitor or plug geothermal resources and stop/redirect the wind and running rivers. Of all the renewable energy resources, solar is by far the most abundant. At any given time, 162,000 terawatts of solar energy reaches the earth; 1 hour of sunlight could theoretically provide all of the world population energy needs for 1 year. Wind power and solar radiation has no national boundaries and cannot be manipulated by radical regimes and corporations, at least not for the foreseeable future. During the development of wind power technology, between 1981 and 2001

the capital cost of wind power dropped by a factor of about four, and solar photovoltaic energy cost decreased by a factor of more than ten. The installed global renewable energy capacity has more than quadrupled between 2000 and 2010.

Every year an assessment or updated projections for international energy trends for the first half of 21 st century is published by the U.S. Energy Information Administration (EIA). Although these projections do not incorporate geopolitical fluctuations and regional armed conflicts that might affect energy markets, it provides most valuable data for the past energy production-consumption as well as future projections to energy policy makers and analysts, both in government and in the private sector. The Objective of this paper is to convey the latest projections appearing in the *International Energy Outlook, DOE/EIA- IEO-2011* Reference case which are not predictions of what will happen, but what may happen given the specific assumptions and methodologies used for any particular scenario. The IEO 2011 Reference case projections and other data presented in this article is based on business-as-usual trend scenarios, as well as known technological and demographic world population trends.

In order to place renewable energy in the future spectrum of existing energy resources, it is imperative to point out the latest IEO (2011) findings for global energy trends over the first half of this century."The world marketed energy consumption [is expected to grow] by 53 percent from 2008 to 2035. Total world energy use [is expected to rise] from 505 quadrillion British thermal units (Btu) in 2008 to 619 quadrillion Btu in 2020 and 770 quadrillion Btu in 2035". Much of the growth in energy consumption occurs in countries outside the Organization for Economic Cooperation and Development (non-OECD nations), where demand is driven by strong long-term economic growth. In the reference case, energy use in non-OECD nations increases by 85 percent, as compared with an increase of 18 percent for the OECD economies

Due to rapid increase in energy consumption among the developing world, it is clear that an effective, encouraging and innovative financing tools need to be developed for renewable energy industry to invest in developing world.
Renewable energy sources are proven to be more sustainable against to future energy volatility, which serve as an inspiration for the investors. In fact, in the last two decades, private investment in renewable energy grew rapidly in part to impressive new advances in renewable energy technologies, and steady decrease in levelized cost (LCOE), shown in figure 1 below.

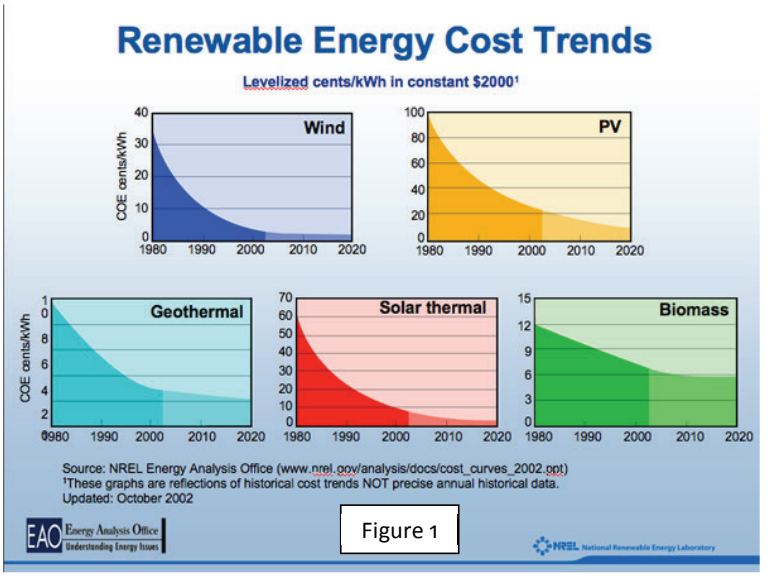

Figure 1

For instant, from 2004 to 2008, global private-sector investment in solar energy increased by more than a factor of 25. These investments set the foundation for the rapid expansion of the industry in 2004. According to US-DOE SunShot initiative reports "Compound Global Annual Growth rate (CAGR) for renewable energy source between 2000 and 2010 for renewable energy is given in the following table 1. (REN21 – Renewables 2011 Global Status Report).

Table 1:

Renewable Energy	**CAGR**
Wind	27.1%
Solar Photovoltaic	39.8%
Concentrated Solar Power	10.3%
Geothermal	3.2%
Biomass	5.3%
Hydro	17.6

Renewable energy-generation is also inherently safer than fossil fuel, which minimize the environmental risks and liability for investors and local communities. Previously projected LCOE and global grow show that 16%–34% of the PV and wind market by 2012 is already accomplished. Total global renewable energy investment in 2005 of $2.5 billion marked a 256% increase over the $702 million of investment in 2004. In 2008, global private-sector investment in solar energy

technology reached to $16 billion. In the same time period, **g**lobal average Photo-voltaic (PV) module prices dropped 23% from $4.75/W in 1998 to $3.65/W in 2008. (NREL http://www.nrel.gov/csp/solarpaces/by_country.cfm). (LCOE, is the ratio of an electricity-generation systems amortized lifetime costs including installed cost plus lifetime Operation and maintenance cost to the system's lifetime electricity generation)

Development: Overview of global renewable energy resources and electric energy

An important characteristic of renewable energy is that there is no point price of cost of fuel. A single price for renewable energy does not exist but rather a price of interval or range, depending on the type of renewable resources. In the past few decades, wind and solar were considered intermittent electricity generating technologies useful only when resources

are available. However, new-innovative energy storage methods such as pumped hydro,

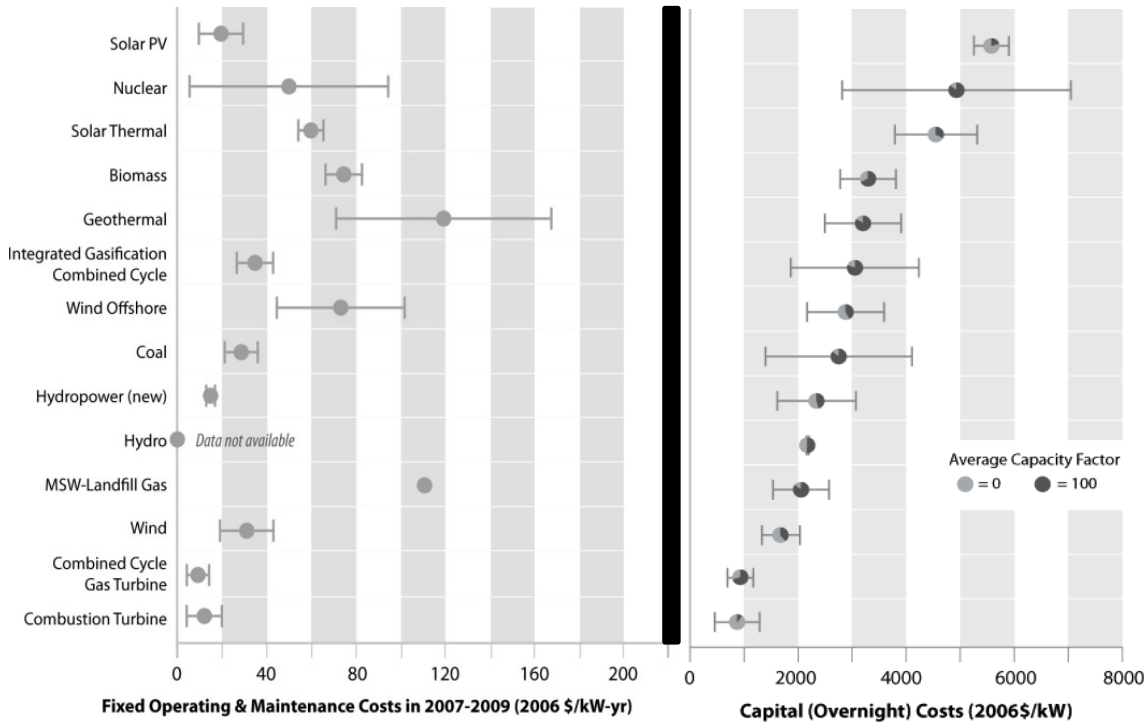

Figure 2

compressed air, advance batteries, thermal storage are being developed to store excess power and reuse it. During the down times in Europe more than 5 percent and in Japan more than 10 percent of excess renewable energy is stored. In the US about 20 gigawatts of energy is stored annually using pumped hydro technique. Although capital costs of solar power are higher than the other energy resources, wind has the lowest capital investment requirements. Government policies or

incentives often provide the primary economic motivation for construction of renewable generation facilities.

Over the last 25 years the cost of generating electricity from utility-scale wind systems has dropped by more than 80 percent. Figure 2 (DOE/EIA-0484- 2011) shows that, once wind or solar power plants are built their operating costs generally are much lower than the operating costs for fossil fuel-fired power plants, and most importantly they are almost free of market manipulations. In addition, many developed countries, particularly those in Europe and USA, have government policies that include, feed-in tariffs (FITs), tax incentives, and market share quotas, design to encourage the construction of such renewable electricity facilities.

Renewable energy is the fastest-growing source of electricity generation, including hydropower, renewable energy accounts for 21% of all annual global electricity generation.
Wind power capacity has developed very rapidly in recent years, on average approximately by 30% per year during the last 10 years. Thus, at present, total wind power capacity is doubled every three years According to the *IEO 2011* Reference case, (table 2). "Total generation from renewable resources increases by 3.1 percent annually, and the renewable share of world electricity generation is expected to grow from 19 percent in 2008 to 23 percent in 2035, and if this trend continues into the future, 4.6 trillion kilowatt hours of new renewable generation added over the projection period".

It is important to point out that the *IEO 2011* projections for renewable energy sources include only marketed renewables. Non-marketed (noncommercial) biomass from plant and animal resources is not included in the projections, and off-grid renewables produced and consumed at the site, such as off-grid (PV) panels are not included.

Table 2: Worldwide Renewable Electricity Generation as a Percent of Total Generation

Year	**Hydro**	**Solar PV**	**Bio mass**	**Wind**	**Geo thermal**	**All Renewables**	**Renewable (excl. Hydro)**	**Renewable Generation (excl. Hydro)**

								(MM kWh)
2000	16.8%	0.0%	1.2%	0.3%	0.3%	18.7%	1.9%	274,019
2001	17.3%	0.0%	1.3%	0.4%	0.3%	19.3%	2.1%	304,469
2002	17.1%	0.0%	1.2%	0.5%	0.3%	19.2%	2.1%	324,827
2003	18.0%	0.0%	1.2%	0.7%	0.3%	20.2%	2.2%	348,777
2004	17.3%	0.0%	1.1%	0.8%	0.3%	19.5%	2.2%	371,028
2005	16.9%	0.0%	1.2%	0.9%	0.3%	19.4%	2.5%	427,880
2006	16.7%	0.1%	1.2%	1.1%	0.3%	19.4%	2.7%	485,477
2007	17.4%	0.1%	1.3%	1.3%	0.3%	20.3%	2.9%	552,703
2008	17.8%	0.1%	1.3%	1.7%	0.3%	21.1%	3.4%	642,327
2009	17.8%	0.1%	1.3%	2.1%	0.3%	21.7%	3.9%	766,333
2010	17.7%	0.3%	1.4%	2.5%	0.3%	22.3%	4.6%	932,590

The production of power is the single most important factor for calculating the cost per generated unit of power. The cost of conventional electricity production is determined by three components, fuel cost, operating & maintenance costs and Capital cost. However, due to steady decline of capital cost of global renewable electricity installations (excluding hydropower) renewable resources have more than quadrupled from 2000–2010 (table.3). Including hydropower, renewable energy accounts for 21% of all global electricity generation; without hydropower, renewable energy accounts for 3.8% of global generation.

In general, energy market projections are subject to much uncertainty. Many of the events that shape fossil fuel energy markets are control by energy corporations and cannot be anticipated. Although, renewable portfolio standards including official definition of feed in tariff applicable to renewable energy source may be different in the different countries, wind and solar energy are not subject to much uncertainty and they are the fastest growing renewable energy technologies worldwide. Wind produced electrical energy grew by a factor of 11 and solar PV electrical generation grew by a factor of more than 28 between 2000 and 2010. In 1980's cost of wind power was 30 cents/Kwh, currently in certain locations cost of wind electricity is about 5 cents/Kwh.

Table 3: World Renewable Cumulative Electricity Capacity Percent Increase from the Previous Year :(U.S Global Renewable Energy Development | September 2011)

Year	Hydro	Solar PV	CSP	Wind	Geothermal	Biomass	Renewable (excl. Hydro)	All Renewables
2000	0%	22%	0%	31%	0%	6%	11%	1%
2001	5%	29%	0%	33%	0%	8%	15%	6%
2002	2%	33%	0%	29%	2%	0%	11%	3%
2003	9%	25%	0%	29%	9%	-3%	11%	9%
2004	1%	33%	0%	20%	0%	0%	10%	1%
2005	2%	38%	0%	23%	4%	13%	18%	4%
2006	2%	32%	0%	25%	3%	7%	17%	4%
2007	9%	5%	5%	27%	0%	6%	17%	10%
2008	4%	71%	14%	29%	4%	4%	22%	6%
2009	4%	62%	22%	31%	7%	4%	25%	7%
2010	3%	90%	83%	25%	3%	15%	27%	8%

Most renewable energy growth in OECD countries comes from non-hydroelectric sources, especially wind, solar and biomass. Global interest in advanced water power such as tidal, river and ocean current, and ocean wave energy is beginning to grow; with many prototype projects particularly proof-of-mechanism studies are in testing stages. Given historical and current social-economic and geopolitical realized scenarios, global fossil fuel prices will continue to increase over time. Generating electricity from fossil fuels has proven to be highly vulnerable to not only price changes but also political changes. For the developing countries, we need to translate these global concerns into action, and effective and innovative financing needs to be developed for encouraging renewable energy industry to invest in developing countries.

Hydroelectric: Strong growth in hydroelectric generation, primarily from mid- to large-scale power plants, is expected in China, India, Brazil, Turkey and a number of nations in Southeast Asia, including Malaysia and Vietnam. In non-OECD countries, hydroelectric power is expected to be the predominant source of renewable electricity growth, and if trend that continues in this century, an

estimate of 4.6 trillion kilowatt hours of new renewable generation will be added over the projection period, 2.5 trillion kilowatt hours (55 percent) of which will be produced by hydroelectric power

Wind: Worldwide, wind energy is one of the fastest growing renewable energy technologies, between 2000 and 2010, wind energy generation worldwide increased by a factor of 11. According to IEO 2011 figures, the contribution of wind energy has grown constantly over the past decade, from 18 giga watts of net installed capacity at the end of 2000 to 121 giga watts at the end of 2008, and 1.3 trillion kilowatt hours electrical energy produce by wind power plants. As of 2010, the countries with major wind energy installed capacity are indicated in table 4.

USA	40.267 MW
Canada	4.009 MW
Denmark	3.752 MW
U.K	5.204 MW
France	5.660 MW
Spain	20.676 MW
Germany	27.214 MW
Italy	5.797 MW
India	13.065 MW
China	42.287 MW

Table 4: (Sources: GWEC – Global Wind 2010 Report, REN21, GWEC, LBNL 59).

Growth rates for wind-powered generation also are high in non-OECD countries. The most substantial additions to electricity supply generated from wind power are expected for China. In 2010, China surpassed the United States as the world leader in cumulative installed wind capacity, with more than 42 GW installed.

Solar: Solar power technologies were not historically cost-effective; they were considered a "niche" source of renewable energy. However, with advances in technology, solar power can be economical where electricity prices are especially high, where peak load pricing occurs, or where government incentives are available. In Europe, generous feed-in tariffs, which obligate the retail utilities to purchase electricity from renewable producers, have been responsible for "Solar Bubble" driving down the price of solar panels in Europe.

Following table 5. Shows solar energy installed capacity of major industrial countries (2010).

USA	2.660 MW
Czech Rep.	1.953 MW
Italy	3.494 MW
Japan	3.622 MW
China	893 MW
Germany	17.193 MW
France	1.025 MW
Spain	4.317 MW

Table 5: (Source: SEIA/GTM, GTM, EPIA).

The global PV market has accelerated over the past decade, with PV shipments averaging 53% annual growth and reaching 17 gigawatts (GW) in 2010, bringing cumulative shipments to about 40 GW in 2010. The market share for crystalline-silicon PV was 95%, compared with 5% for thin-film PV. By the end of 2010, thin-film technology accounted for 13% of global PV shipments (3% a-Si, 8% CdTe, and 2% CIGS). Figure 3 below shows that annual PV Cell/Module shipment (GW/Year), that China and Taiwan are the market leaders with nearly 60% of the global PV cell production combined. Source; (*DOE-SunShot Vision Study – February 2012)*

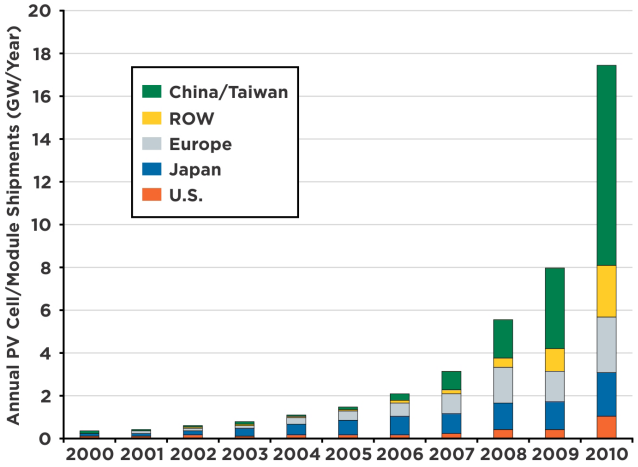

Figure 3: Annual PV Cell/Module Shipments (GW/Year)

Concentrating Solar Power (CSP): Globally, the most suitable sites for CSP plants are arid lands within 35° north and south of the equator. By December 2010, global CSP capacity increased to about 1,300 MW. Most of the capacity additions during 2009–2010 were in Spain, and at the end of 2010, Spain accounted for about 57% of all global CSP capacity. Parabolic trough technology accounted for about 96% of global CSP capacity at the end of 2010; tower technology accounted for 3%. (NREL. (2011a). *Concentrating Solar Power Plants by Country)*

Geothermal: As a base-load source of energy, geothermal is distinct from other renewables such as wind and solar, because it can provide consistent electricity. Global Geothermal Electricity Capacity is steadily increasing, as of 2009 following table 6 shows major geothermal power plants that are in operation in all continentals. (IEO 2011)

Table 6:

Iceland	575 MW
U.S	3.102 MW
Japan	536 MW
Italy	843 MW
Mexico	958 MW
Philippines	1.904 MW
Indonesia	1.197 MW

Other Renewable Fuels: Ethanol, corn ethanol production continues to expand rapidly in the United States. Between 2000 and 2010, production increased nearly 8 times. Ethanol production grew nearly 19% in 2010 to reach 13,000 million gallons per year. Ethanol has steadily increased its percentage of the overall gasoline pool, and was 9.4% in 2010. In 2010, the United States produced 56.5% of the world's ethanol, followed by Brazil at 30.1%, the European Union at 5.1%, China at 2.4%,

Global Ethanol Production; Top three Countries (2010) Ethanol Production (millions of gallons/year) is Canada: 357; EU: 1,177; United States: 13,000; China: 54. Biodiesel production globally grew more than 14% in 2010; Germany leads the world in biodiesel production, followed by Brazil, Argentina and France. Biodiesel has expanded from a relatively small production base in 2000, to a total U.S. production of 315 million gallons in 2010. However, biodiesel is still a small percentage of the alternative fuel pool in the U.S., as over 40 times more ethanol was produced in 2010. Biodiesel production in the U.S. in 2010 is 63 times what it was in 2001. There are over 1,000 stationary fuel cell (hydrogen) installations worldwide, 22 of which are greater than 1 MW in capacity. (Renewable Fuels Association (RFA), 2011 Ethanol Industry Outlook).

Geo-political renewable energy trends

World net electricity generation increases by 84 percent in the *IEO2011* Reference case, from 19.1 trillion kilowatt hours in 2008 to 25.5 trillion kilowatt hours in 2020 and 35.2 trillion kilowatt hours in 2035. It is clear that electricity is the world's fastest-growing form of end-use energy consumption, as it has been for the past several decades. In the Reference case, net electricity generation worldwide rises by 2.3 percent per year on average from 2008 to 2035, while total world energy demand grows by 1.6 percent per year. The strongest growth in electricity generation is projected for non- OECD countries. Non-OECD electricity generation increases by an average annual rate of 3.3 percent in the Reference case which is almost twice the increase rate for OECD countries. However most of these predictions are based on business as usual and did not include the externalities such as; water supply, land use, wildlife, resource availability, reliability, thermal pollution, water pollution, nuclear proliferation, and geo-politic fluctuations .

North America; Canada has plentiful of renewable energy resources, and generates significant part of its electricity from hydropower dams, and also has the fastest growing

renewable energy companies. In United Sates, investment in renewable energy has grown dramatically in the past decade, and in 2010 annual investment reached more than $28 billion. In 2010 in the United States, wind and solar photovoltaic (PV) were two of the fastest growing generation technologies. In 2010, cumulative wind capacity increased by 15% and cumulative solar PV capacity grew 71% from the previous year. U.S. venture capital and private equity investment in solar technology companies has increased from $40 million in 2001 to more than $1.7 billion in 2010.

Europe: Renewable energy is OECD Europe's fastest-growing source of electricity generation. As indicated in the Reference case, renewable energy growth is expected to be 2.5 percent per year through 2035; where the majority of this growth is almost entirely from wind and solar. OECD Europe's leading position worldwide in wind power capacity is maintained through 2035, with growth in wind generation averaging 6.4 percent per year, for example, a small nation Denmark has one of the world largest wind farms. Strong growth in offshore wind capacity is underway, with 883 megawatts added to the grid in 2010, representing a 51-percent increase over the **a**mount of capacity added in 2009. Germany is the leader of Solar photovoltaic accounting % 47 (1.328 MW) of the world market installation in 2007. Spain and Italy have the largest installed PV capacity in Europe. (European Photovoltaic Industry Association (EPIA) – Global Market Outlook for Photovoltaic until 2015,)

Other Non-OECD Europe and Eurasia: Although hydroelectric projects dominate the renewable energy mix in non-OECD Asia, generation from no hydroelectric renewable energy sources, especially wind, is expected to grow significantly. In the *IEO2011* Reference case," electricity generation from wind plants in China is expected to grow by 14.2 percent per year, from 12 billion kilowatt-hours in 2008 to 447 billion kilowatt-hours in 2035". In addition, government policies in China and India are encouraging the growth of solar generation. Under its "Golden Sun" program, the Chinese Ministry of Finance plans to subsidize 50 percent of the construction costs for grid-connected solar plants.

India's National Solar Mission, launched in November 2009, aims to have 20 gig watts of installed solar capacity (both PV and solar thermal) by 2020, 100 gig watts by 2030, and 200 gig watts by 2050. Australia and New Zealand, as a region, rely on coal for about 66 percent of electricity generation, based largely on Australia's rich Renewable generation in non-OECD Europe and Eurasia, almost entirely from hydropower facilities, increases by an average of 1.9 percent per year.

After Fukushima nuclear accident, 52 of 54 nuclear reactors in Japan are still shut down. Soon after accident, Prime Minister Naoto Kan stated that the plan to increase the nuclear power share of the country's electricity supply, from about 26 percent at present to 50 percent by 2030, "will have to be set aside". Instead, the Japanese government plans to pursue anaggressive expansion of renewable energy capacity, especially solar power from which electricity generation increases by 11.5 percent per year from 2008 to 2035, making solar power Japan's fastest-growing source of renewable energy.

Central and South America: Electricity generation in Central and South America is shown to increase by 2.4 percent per year in the *IEO2011* Reference case, from 1.0 trillion Kilowatt-hours in 2008 to 1.9 trillion kilowatt-hours in 2035. The electricity generation in Central and South America is dominated by hydroelectric power, which accounted for nearly two-thirds of the region's total net electricity generation in 2008. However, the first steps of wind development are now taking place in Brazil. In fact, hydropower ProviIn, as of December 2009, held its first supply tender exclusively for wind farms. At the event, 1.8 gig watts of capacity were purchased, for development by mid-2012. In the *IEO2011* Reference case, wind power generation in Brazil is expected to grow by 10.8 percent per year, from 530 million kilowatt-hours in 2008 to 8,508 million kilowatt-hours in 2035.

Africa: Demand for electricity in Africa grows at an average annual rate of 3.0 percent in the *IEO2011* Reference case. Fossil-fuel-fired generation supplied 81 percent of the region's total electricity in 2008, and reliance on fossil fuels is expected to continue through 2035. Generation from hydropower and other marketed renewable energy sources is expected to grow relatively slowly in Africa. The region's consumption of marketed renewable energy is expected to grow by 2.9 percent per year from 2008 to 2035.

Discussion and recommendations

The last 100 years of international energy markets experience show that fossil fuel energy markets are complex, and influenced by uneven distribution of global energy production and consumption. In addition, national and international regulations, and limitations on producer and consumer market behavior during the times of global and regional conflicts show that difficulties are political not necessarily technological. In the light of latest geopolitical developments in the Middle East and North Africa, existing energy market projections are

subject to much more uncertainties than ever before. As a result, energy prices swings will not be in response to small changes in demand anymore, but many of the future unforeseen geo-political events that may shape fossil fuel energy markets that are random and cannot be anticipated

Global logic dictates that energy diversification has to be based on expanding existing energy sources with a special focus on exploiting renewable energy sources. Although countries haves different and often conflicting goals and interests in every step of energy policies and production, they all converged on the unquestionable fact that, in this century, difficulties involved with energy policies are driven by geo- political uncertainties.

Therefore, generating electricity from fossil fuels and nuclear energy is highly vulnerable to fuel cost which has been subject to political/external manipulations. To establish a fair comparison of the different electricity production activities in this century, all internal and external costs to society need to be taken into account as well. Hence, it is important to identify external effects of different energy systems and to minimize their social costs. Uncertainties relating to future fossil fuel prices imply a considerable risk for future generation costs of conventional power plants. The non-reversible environmental and social costs of fossil fuel power and nuclear energy systems make these technologies less competitive in comparison with renewable energy as the externalities are included.

In fact that, Prof. Mark Z. Jacobson at the Department of Civil and Environmental Engineering, Stanford University, California USA, conducted a most comprehensive research project in which 11 different externalities-categories considered in evaluating existing energy resources which are; “The electric power sources considered here include solar photovoltaics (PV),Concentrated solar power (CSP), wind turbines, geothermal power plants, hydroelectric power plants, wave devices, tidal turbines, nuclear power plants, and coal power plants fitted with carbon capture and storage (CCS) technology. The two liquid fuel options considered are corn-E85 (85% ethanol; 15% gasoline) and cellulosic-E85”.

The major purpose of this research was to provide quantitative information to policy makers and investors about the most effective solutions to the problems associated with climate change and externalities so that better decisions about clean energy policies can be provided. “This review evaluates and ranks 12 combinations of electric power and fuel sources from

among 9 electric power sources, 2 liquid fuel sources, and 3 vehicle technologies, with respect to their ability to address climate, air pollution, and energy problems simultaneously. The review also evaluates the impacts of each on water supply, land use, wildlife, resource availability, thermal pollution, water chemical pollution, nuclear proliferation, and under nutrition"." **Wind-BEVs performed best in seven out of 11 categories, including mortality, climate-relevant emissions, footprint, water consumption, effects on wildlife, thermal pollution, and water chemical pollution**".

"Costs are not examined since policy decisions should be based on the ability of a technology to address a problem rather than costs (e.g., the U.S. Clean Air Act Amendments of 1970 prohibit the use of cost as a basis for determining regulations required to meet air pollution standards) and because costs of new technologies will change over time, particularly as they are used on a large scale. Similarly, costs of existing fossil fuels are generally increasing, making it difficult to estimate the competitiveness of new technologies in the short or long term".

The findings of this important research, ranked the wind and solar power as the best energy sources in 21st century, and ranking is summarized as follows; **" In sum, the use of wind, CSP, geothermal, tidal, solar, wave, and hydroelectric to provide electricity for BEVs and HFCVs result in the most benefit and least impact among the options considered. Coal-CCS and nuclear provide less benefit with greater negative impacts**.

"The biofuel options provide no certain benefit and result in significant negative impacts. Because sufficient clean natural resources (e.g., wind, sunlight, hot water, ocean energy, gravitational energy) exists to power all energy for the world, the results here suggest that the diversion of attention to the less efficient or non-efficient options represents an opportunity cost that delays solutions to climate and air pollution health problems". Mark Z. Jacobson," Review of Solutions to Global 1 Warming, Air Pollution, and Energy Security". *Energy Environ. Sci.,* 2009, doi: 10.1039/b809990C

Nuclear energy and climate change: Based on a review of 103 new and old lifecycle studies of nuclear energy, Dr. Jacobson estimates that mean lifecycle emissions of nuclear reactors as 40 g CO2 per kWh, the range appears to be low but within reason. “Nuclear power plant emissions include those due to uranium mining, enrichment, and transport and waste disposal as well as those due to construction, operation, and decommissioning of the reactors. We estimate the lifecycle emissions of new nuclear power plants as 9–70 g CO2e kWh_1, with the lower number from an industry estimate 49 and the upper number slightly above the average of 66 g CO2e kWh”

Nuclear energy and nuclear weapons: The Treaty of Non-Proliferation of Nuclear Weapons has been signed by 190 countries. “Here, we detail the link between nuclear energy and nuclear weapons and estimate the emissions of nuclear explosions attributable to nuclear energy. The primary limitation to building a nuclear weapon is the availability of purified fissionable fuel (highly-enriched uranium or plutonium). Worldwide, nine countries have known nuclear weapons stockpiles (US, Russia, UK, France, China, India, Pakistan, Israel, North Korea). In addition, Iran is pursuing uranium enrichment, and 32 other countries have sufficient fissionable material to produce weapons. “However Among the 42 countries with fissionable material, 22 have facilities as part of their civilian nuclear energy program, either to produce highly-enriched uranium or to separate plutonium, and facilities in 13 countries are active. Thus, the ability of states to produce nuclear weapons today follows directly from their ability to produce nuclear power. In fact, producing material for a weapon requires merely operating a civilian nuclear power plant together with a sophisticated plutonium separation facility.

Finally, in the last 100 years, production, distribution, and use of fossil fuels and nuclear energy not only caused irreversible global climate changes, depletion of ozone layer, and polluted land and oceans, but also replaced the national borders, created regional wars, and forced migrations of many indigenes people. By contrast, renewable energy resources, including biomass, hydro, geothermal, solar, wind, is naturally replenishing. They are virtually inexhaustible in duration; internal costs such as fuel are practically unchanged during their life time, and not susceptible to geo-political conflicts.