A Study on Renewable Energy: A Sustainable Solution for Future Energy Security

Dewan Mowdudur Rahman[#1], Mahmudur Rahman[*2], Riasad Amin[#3], Navid Bin Sakhawat[**4]

[#]Department of EECE, Military Institute of Science and Technology, Dhaka, Bangladesh

[*]Department of CSE, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

[**]Department of EEE, BRAC University, Dhaka, Bangladesh

[1]mowdudur@gmail.com; [2]tonmoymahmud@gmail.com; [3]riasad_929@yahoo.com; [4]photobynavid@gmail.com

Abstract- **Our changing climate is placing our planet in peril. CO_2 is the main green house gas emitted from various sources and power sector is solely responsible for 30% emission of CO_2 throughout the world and this emission from power generation are projected to increase 46% by 2030. Fossil fuels had for so long been the most convenient and cheapest means of powering the world economy. But now they have been proved worthless to ensure energy security as 1.4 billion people have no access to electricity and world electricity demand is projected to grow by 2.2% per year between 2008 and 2035, from 16,819 TWh to about 30,300 TWh. It's for sure that we cannot sustain a future, powered by a fuel which is rapidly disappearing. Nuclear energy would also not be a sustainable solution as it associates with some fatal risk. Therefore, renewable energy is the only viable option to ensure energy security in a sustainable way. It has no environmental degradation problem like fossil fuel and not associates with any radiation problem like nuclear energy. Most importantly renewable energy is abundant in nature, all we need is to just tap energy and transform. In this paper authors discussed about the risk from running out conventional energy and imposing threat to the human race and found out its solution by unearthing the real fact of renewable energy which will surely ensure sustainable development of civilization.**

Keywords- Renewable Energy; Climate Change; Sustainable Solution; Energy Security; Conventional Energy

I. INTRODUCTION

World is now passing an energy constraint time. As an easily accessible source, we have been dependent on fossil fuel so far. However, fossil fuel production and usage damage our environment and our health inflicting even greater damage on world economy and our living standard. Our over-reliance on carbon-based fuels from very beginning of civilization is now at the core of all three of these challenges - the economic, environmental and worldwide security crises. Electricity is the most common form of energy and world electricity demand is projected to grow by 2.2% per year between 2008 and 2035, from 16,819 TWh to about 30,300 TWh [1]. Today, more than 1.4 billion people worldwide lack access to electricity: 585 million people in sub-Saharan Africa (including over 76 million in Nigeria and some 69 million in Ethiopia) and most of the rest in developing Asia (including 400 million in India and 96 million in Bangladesh) [1]. Therefore, it's the toughest challenge to ensure electricity for all and surely not possible to meet the ever increasing demand by fossil fuel or nuclear energy. Environmental degradation by fossil fuel and proliferation and waste management risk from nuclear energy make that repellent choice for future energy generation. Moreover, fossil fuel and nuclear energy are not abundant at all. Therefore, renewable energy is the most elegant choice to make for meeting our energy demand and help human race to continue, at least not make an end from energy crisis. Though renewable energy industry is now capital intensive, its increasing use will surely decrease its cost. Per dollar investment in renewable energy will ensure sustainable development for future, whereas per dollar investment in traditional energy will push human race at the verge of extinction.

II. GLOBAL CLIMATE CHANGE EFFECTS

In recent years, dramatic environmental changes have caused extraordinary climate changes around the globe. This has made countries all over the world to focus on greenhouse effect issue and consider it seriously [2]. Developing countries are the most vulnerable to these risks [3] because of their generally low adaptive capacities [4]. Emission of carbon dioxide (CO_2) is one of the main causes of global warming, melting of polar ice, rise in sea level, and consequent flooding of coastal areas. CO_2 is the main green house gas (GHG) emitted from various sources and power sector is solely responsible for 30% emission of CO_2 throughout the world [5]. Furthermore, the CO_2 emissions from power generation are projected to increase 46% by 2030 [6]. Man made CO_2 emission is closely linked to the combustion of coal, oil and gas. Moreover during past thirty years only coal consumption has increased by 48% [7]. Global average atmospheric CO_2 rose from 280 ppm at the start of the industrial revolution to 381 ppm in 2006. The present concentration is the highest during the last 650,000 years [8, 9] and probably during the last 20 million years [10]. In the past century, research and literature have concluded that CO_2 concentration increased by 28% following the industrial revolution [11]. The global average temperature has increased by 0.3˚C to 0.6˚C, and the sea level rose 10 to 15 cm in the past 100 years. Scientists predict that if greenhouse gas emissions continue and no effective protection policies for the environment are put into place, the global temperature will increase by 1˚C to 3.5˚C, and the sea level will increase by 15 to 95 cm. Rise in temperature of 4˚C would decrease the food grain production some 28% and 68% for rice and wheat, respectively [12]. This will make many countries uninhabitable by 2100 [13]. Therefore, it is very clear that, the adverse effects of CO_2 emission will be more intense for any low laying country like Bangladesh, Maldives etc. This includes mass migration, famine and extreme poverty. Sulfur emission, resulting primarily from burning of fuel in conventional power plant to produce electricity, is the main source of acid rain which damages crop, forest and can make lakes and rivers too acidic to support life. Usage of significant amount of water for steam generating or cooling in conventional electricity production creates imbalance in underground water. Flood, tropical cyclones, droughts, storm surges are most likely to become frequent and severe in coming years and will make it more difficult to ensure sustainable development.

III. ENERGY SOURCES

The energy sources can be split into three categories: fossil fuels, renewable sources, and nuclear sources. The fossil fuels are coal, petroleum, and natural gas. The renewable energy sources are solar, wind, hydroelectric, biomass, and geothermal power. The nuclear-powered sources are fission and fusion.

A. Fossil Fuels

These constitute the main forms of energy used worldwide. These are formed over a period of millions of years by the decomposition of animals and plants. These are not renewable sources as it would take too long to form these again in a natural process. These generally consist of carbon, sulphur and hydrogen, and therefore, upon combustion form carbon dioxide, sulphur dioxide and water vapor (H_2O). Whilst the latter is relatively harmless, the previous two are responsible for global warming and acid rain. Oil, coal and gas are the main forms of fossil fuel.

B. Nuclear Energy

Nuclear energy originates from the splitting of uranium atoms in a process called fission. Fission releases energy that can be used to make steam, which is used in a turbine to generate electricity. Uranium is a non-renewable resource that cannot be replenished on a human time-scale. Uranium is extracted from open-pit and underground mines. On average, uranium ore contains only 0.1% uranium. Most nuclear reactors require one specific form of uranium, uranium-235 (U-235). This form represents only 0.7% of natural uranium. To increase the concentration of U-235, the uranium extracted from ore goes through an enrichment process, resulting in a small quantity of usable 'enriched' uranium and huge volumes of waste. Today, the 439 commercial nuclear reactors in operation generate around 15% of the world's electricity [14].

TABLE I GLOBAL CRUDE OIL RESERVES BY REGION [15]

Country	bbl Mn	Percentage
Middle East	754,000	59.9
Africa	125,200	10
South and Central America	123,200	9.8
Euracia (excluding Central Asia)	101,000	7.6
North America	70,900	5.6
Asia-Pacific	42,000	3.4
Central Asia	40,000	3.2

TABLE II GLOBAL NATURAL GAS RESERVE BY COUNTRY [16]

Country	Proved Natural Gas reserve (million cubic meters)
Russia	47,570,000
Iran	29,610,000
Qatar	25,370,000
Saudi Arabia	7,807,000
United States	7,716,000
Turkmenistan	7,504,000
United Arab Emirates	6,453,000
Nizeria	5,292,000
Venezuela	5,065,000
Aljeria	4,502,000
Iraq	3,170,000
Australia	3,115,000
China	3,030,000
Rest of the World	35,216,543

TABLE III PROVED URANIUM RESERVE BY COUNTRY, 2008 [17]

Country	Amount (tonnes per year)	Global percentage (%)
Australia	1,243,000	23
Kazakhstan	817,000	15
Russia	546,000	10
South Africa	435,000	8
Canada	423,000	8
US	342,000	6
Brazil	278,000	5
Namibia	275,000	5
Niger	274,000	5
Ukraine	200,000	4
Jordan	112,000	2
Uzbekistan	111,000	2
India	73,000	1
China	68,000	1
Mongolia	62,000	1

C. Renewable Energy

Renewable energy is sustainable as it is obtained from sources that are inexhaustible (unlike fossil fuels). Renewable energy comes from enticing sources: wind, which also produces waves; water, which includes hydroelectric, tidal and geothermal energy (water heated by hot underground rock); and sun, which includes photovoltaic and solar power plants that focus sunlight to heat a fluid that drives a turbine to generate electricity. Renewable energy, generally speaking, is clean energy and non-polluting. It is a sustainable energy source which can be relied on for the long-term. Renewable energy is cost-effective and efficient. On a global scale, 19% of electricity comes from renewable in 2008 [1].

IV. IMPACTS FROM FOSSIL FUEL

Fossil fuels have been a widely used source of energy since the industrial revolution, just before the dawn of the 20th century. Fossil fuel consumption is the leading contributor to global warming and the burning of fossil fuel is by far the highest contributor of green house gases linked to climate change, and any progress on climate change must address the use of fossil fuels [18]. Global warming will affect both the demand for and the supply of energy: Hotter temperatures will mean more air-conditioning and less heating for consumers, and more difficult and expensive operating conditions for electric power plants. Global warming has the potential to impose vast and unpredictable impacts on our environment and our lives. A warmer planet means changing weather, melting ice and shifting ocean currents. These changes go on to cause tertiary impacts, such as altered water resources, agricultural production and fish stocks. A global temperature increase of 5 to 6 degrees Celsius—which, the review finds, is a "real possibility" within the next 100 years—could result in the permanent loss of 5 to 11 percent of global GDP, and possibly up to 7 to 14 percent of GDP [19]. If losses of 14 percent had occurred in 2007, for example, they would amount to a worldwide economic cost of more than $7 trillion [20]. These costs arise from several impacts of

global warming. According to [21], if the world's nations do not take action to reduce global warming pollution, sea level will have risen nearly 23 inches by 2050 and by close to 45 inches by 2100. Damage on the order of a few percentage points of GDP each year would be a serious impact for any country, even a relatively rich one like the United States. The sad irony is that while richer countries like the United States are responsible for much greater per person greenhouse gas emissions, many of the poorest countries around the world will experience damages that are much larger as a percentage of their national output.

V. PROBLEMS WITH NUCLEAR ENERGY

Nuclear power is often described as "the most expensive way to boil water". Despite its proponents now claiming it to be cost-effective, cost estimates for proposed projects have consistently proved inaccurate. Nuclear reactors present too large a liability for insurance companies to accept. One major accident, costing hundreds of billions of Euros (the total Chernobyl cost is estimated at €358 billion) would bankrupt them. Governments, and ultimately their taxpayers, are forced to shoulder this financial liability. The cost of clean-up after a nuclear power plant closes and the safe management of nuclear waste for many generations is also largely carried by the states instead of the companies themselves. In addition to substantial capital costs for construction of power plants, nuclear energy includes significant external costs like applying safeguards to sensitive activities, such as fuel making, securing nuclear facilities against terrorist attacks, decommissioning reactors, storing highly radioactive waste, and paying for insurance to cover the costs of an accident. The declining nuclear industry is attempting to latch on to the climate crisis and concerns about energy security, by promoting itself as a "low carbon" solution. The Energy Scenario produced by the International Energy Agency (IEA) shows that, even if existing world nuclear power capacity could be quadrupled by 2050, its share of world energy consumption would still be below 10%. This would reduce carbon dioxide emissions by less than 4% [22]. Other radioactive products formed in nuclear reactors can be used to produce dirty bombs. A nuclear power plant produces 10-15 tons of Spent Fuel a year on average. One ton of spent nuclear fuel typically contains about 10 kilograms of plutonium – enough for a crude nuclear bomb. Therefore we can say that, a typical nuclear power plant produces sufficient plutonium every year for 10-15 crude nuclear bombs.

VI. CONVENTIONAL ENERGY VS RENEWABLE ENERGY

The energy which is being used for many years and on which dependency is tremendous is called conventional energy. Though nuclear energy is not that much old and it has the capability to produce huge energy from relatively very small amount of Uranium, however, Uranium stock is not infinite. Therefore we can't say that nuclear energy is renewable. On that sense fossil fuel and nuclear energy both are conventional sources of energy. Whereas, renewable energy can be regarded as an elegant source of energy for its endless nature. The major drawback to popularize renewable energy is the difference of pricing. However, the main driving factor to lower the conventional energy is subsidies. Subsidy artificially lowers energy prices, which encourages wasteful energy consumption, exacerbate energy price volatility by blurring market signals, incentivize fuel adulteration and smuggling, and undermine the competitiveness of renewable sources. In 2009, $ 312 billion dollar has been wasted as subsidies for fossil fuel throughout the world whereas; only $ 57 billion has been invested for renewable energy [1]. There are expectations by consumers that the cost difference will be made up by government subsidies or that innovation will eventually drive down the cost of renewables compared to fossil fuels [23]. However, an important reason of fossil fuels are less expensive is that the damage caused by carbon emissions is treated as an externality to the price. An externality is an economic term that describes a cost associated with a market transaction that is not part of the selling price. It is instead a cost is borne by society as a whole. In a price driven market, there is great incentive to externalize as many factors as possible from transaction costs, because lower prices result in more sales. As long as the cost of carbon emissions remains an externality, renewable energy sources will be more expensive [24].

VII. SUSTAINABILITY VS CONVENTIONAL ENERGY

Sustainability is characterized by the environmental friendly process best fitted for eco-systems and the capacity to maintain a process smoothly indefinitely. Human beings are said to be at the centre of concerns for sustainable development. We are entitled to a healthy and productive life in harmony with nature. Environmental sustainability is a prominent public concern. A large factor in the strain on the global environment is the world's dependence on fossil fuels. This dependence places stress on the environment in two distinct ways. One is that the supply of fossil fuels is finite, and there are diminishing expectations that the current energy infrastructure will be able to match supply with future demand [18, 24]. Secondly, the use of fossil fuels for energy causes carbon emissions linked to climate change [26]. The shortcomings of nuclear energy include: the storage and management of dangerous high level radioactive waste, the possibility of proliferation of nuclear materials and potential terrorist applications, the high cost of building nuclear facilities and the possibility of accidents. It is difficult to put a price tag on many of the costs of climate change, loss of human lives and earth, species extinction, loss of unique ecosystems, increased social conflict, and other impacts created by usage of fossil fuel and nuclear energy extend far beyond any monetary measure. Therefore, sustainability has no match with conventional energy.

VIII. RENEWABLE ENERGY AND ECONOMIC GROWTH

The economic and environmental burden of fossil fuel dependence will only worsen in the years to come. Investing in clean energy that never runs out can reap economic savings. The costs of our dependence on fossil fuels—both for the environment and our economy—and the increasing obstacles to continuing along our current path, now require us to make a change, and to embrace a new energy future which is clean and renewable in nature. The quickest, cheapest and best way to start using all this renewable energy is in the production of electricity. It is capital intensive of course but investment in renewable energy will not just waste away and turned into smoke and ash like fossil fuel. Rather, this investment will ensure energy security, bring technological advancement, create new businesses and millions of new jobs, jobs that pay well, jobs that can't be outsourced. According to [27], solar industry creates 5.65 jobs and the wind energy creates 5.7 jobs per million U.S. Dollar investment. By contrast, coal industry creates only 3.96 jobs per million dollar investment. Countries that are lower in per capita energy consumption

usually have low adult literacy rates, lower life expectancies and a low education index [28]. Renewable energy investment will surely ensure electricity for all and there will be no disparity in per capita energy usage which is now acute in between nations and that's why we find Bangladesh with only 0.52 (on a scale of 0 to 1) in Human Development Index with its 144 kWh annual per capita energy usage, where Malaysia and Singapore are over 0.8 on that index with their 2300 kWh 8200 kWh per capita energy usage respectively [29]. Investment in renewable energy is as such, the more we invest, the more technological advancement will happen and the more rapidly it will force to decrease the cost of energy usage. According to International Energy Agency (IEA) Levelised Cost of Energy (LCOE) of solar photo voltaic was $260 per MWh in 2008 which is now $220 per MWh and predicted to be only $45 per MWh by 2030. And for wind power it is now $50 per MWh and by 2030 it is predicted to be decreased down to $30 per MWh [30]. Therefore it is a clear indication that investment in renewable energy reduces installation cost, increase lifetime of renewable energy based electricity production equipment, create more job opportunity, develop life standard and take part in GDP growth.

IX. DEVELOPMENT OF RENEWABLE ENERGY

Renewable energies use local resources which fluctuate along local conditions. They rely on sites with prolific energies such as rivers, solar light, wind at certain speeds, geothermal heat or biomass and waste. Renewables have a regional face. Transportation and trade are possible, but more on a regional than a world market level. While use of non-renewable energies is relying on extraction of stored chemical energy, storage of renewable heat and electrical power has a price in terms of energy losses and costs. Developing renewable energies means to combine local and regional flows rather than stocks. Daily and seasonal flows should approximate demand and they can be optimized by transportation and storage. This optimization is not an easy task, even more in an environment of fast falling prices. Regional frameworks and master plans are needed for regional exploitation and transport, including regulatory rules for non-equal resource qualities, storage management and back-up power. The one dimensional merit order of conventional power plants is dysfunctional when must-run facilities have to be integrated and absorbed by a fluctuating demand. The overall management of this might look a complex affair. However, once basic rules are defined such as priority access, transportation cost allocations, storage, back-up duties and a smarter grid with flexible rates; it can work more robust than the conventional system with its supply risks and its environmental hazards. In the New Policies Scenario, the share of renewables in global electricity generation increases from 19% in 2008 to almost a third in 2035[1]. Investment needs in renewable energy to produce electricity are estimated at $5.7 trillion (in year-2009 dollars) over the period 2010-2035 [1]. Biofuels need another $335 billion [1]. Therefore, to ensure such a huge investment in renewable industry is the main challenge. The other challenges for the switch to renewables include

- Fair remuneration for non-polluting power
  - Coverage of investment costs and risks over a facility's life time
  - Integration of high, medium and low profile supply avoiding windfall profits
  - Stability of regulatory frameworks for cost reduction of the manufacturing industry
- Access to the grids and grid extensions

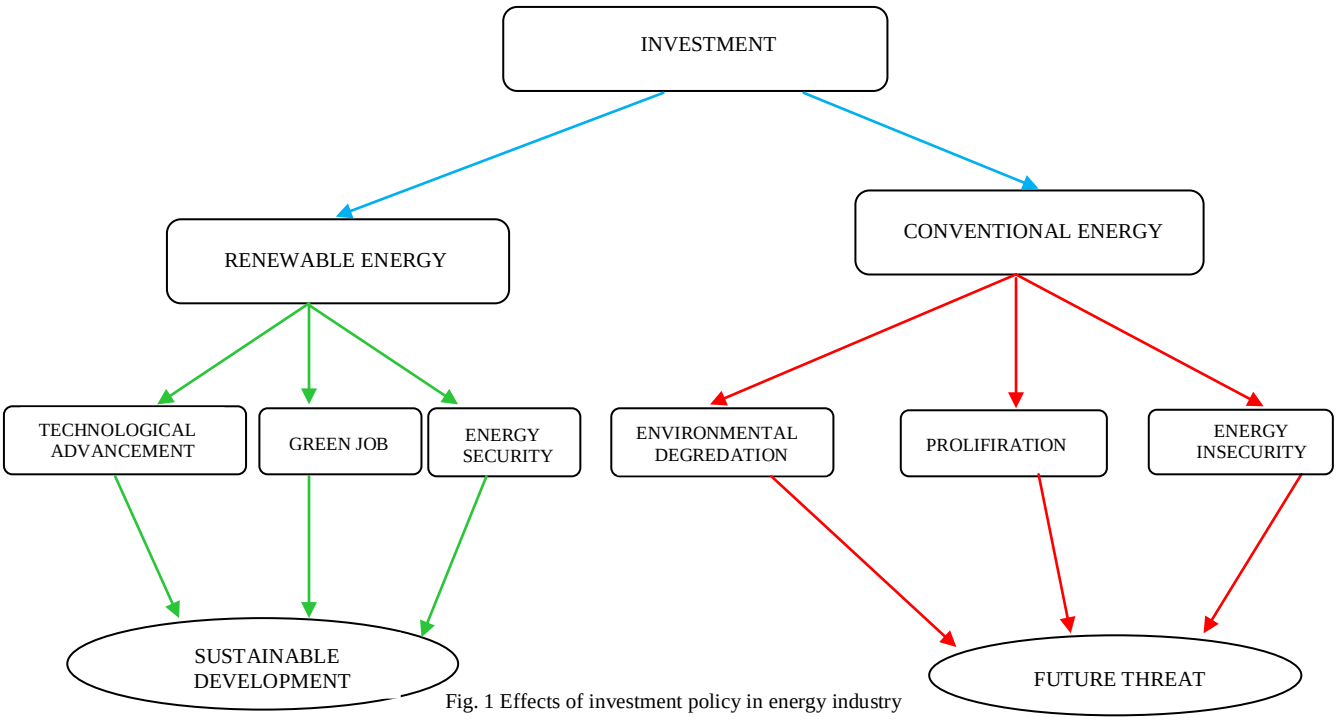

Fig. 1 Effects of investment policy in energy industry

  - Free, non-discriminating access to grids and consumers with priority for non-polluting power
  - Interconnection of different weather zones and technologies
  - Transparent grid codes
- Grid and backup management

- Creation of new transportation lines for power and heat
- Forecasting of demand and supply
- Storages for short, medium and long term backup (biomass, hydro, batteries)
- Creation of intra-day and intra-hour markets for power exchange
- Fair compensation of idle back-up capacities
- Storing fossil fuels as "lenders of last resort"

- Environmental care
  - Minimizing environmental impacts while mobilizing natural resources by incentives and regional planning obligations
  - Fair and sensitive planning of renewable energies and grids with a 100% approach in mind
  - Protection of rare species, natural rivers, exceptional landscapes

TABLE IV POSSIBLE GOVERNMENT SUPPORT TO BE UNDERTAKEN FOR PROMOTING RENEWABLE ENERGY SECTOR

Support scheme	Description
Feed-in tariffs (FITs)	FITs are granted to operators for the renewable electricity they feed into the grid. They take the form of a fixed price per MWh, which reflects the cost of the technology.
Production tax credit (PTC)	Direct reduction in tax liability.
Investment tax credit (ITC)	Direct reduction in tax liability.
Green certificates (GC)	A green certificate is a tradable commodity proving the production and the use of a certain amount of renewable energy.
Premiums	Premiums are a sort of bonus and are paid to the producers on top of the electricity price (market-driven or regulated).

X. CONCLUSION

We are facing a planetary emergency, which if not solved, would exceed anything we've ever experienced in the history of humankind. The reduction of use of dirty fuel is very much needed. International action to stop climate change surely would not come cheaply. We know how to avert most of these damages through strong national and international action to reduce the emissions that cause global warming. But we must act now. The longer we wait the more painful and expensive the consequences will be. Curbing global warming pollution will require a substantial investment in clean energy sector, innovative idea generation, technological advancement and mass people awareness but the cost of doing nothing will be far greater. Creating a new renewable energy based economy isn't just a challenge to meet; it's an opportunity to seize, an opportunity that will create new businesses, new industries, and millions of new jobs. Immediate action can save lives, avoid trillions of dollars of economic damage, and put us on a path to solving one of the greatest challenges of the 21st century. Therefore, we have to eradicate subsidies to fossil fuel, stop further exaggeration regarding nuclear energy and take necessary steps to make renewable energy as our main source of energy in future.

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REFERENCES

[1] International Energy Agency, World energy Outlook 2010. Available: http://www.iea.org.

[2] H.J.D. Boeck, C.M.H. M. Lemmens, B. Gielen, H. Bossuyt, S. Malchair, M. Carnol, R. Merckx, R. Ceulemans and I. Nijs, "Combined Effects of Climate Warming and Plant Diversity Loss on above and below Ground Grassland Productivity," Environmental and Experimental Botany, Vol. 60, No. 1, 2007, pp. 95-104. doi:10.1016/j.envexpbot.2006.07.001.

[3] Boer, Y.D., 2009. Adaption: A critical part of future action on climate change. Statement at the Congress: Adaption of Society to Climate Change, UNFCCC.

[4] Intergovernmental Panel on Climate Change (IPCC), 2007. Climate change 2007: impacts, adaption and vulnerability, Contribution of Working Group II to the Fourth Assessment Report of IPCC. Cambridge, UK.

[5] Jilani, T., Gomi, K., and Matsuoka, Y., 2011. Integration of sustainable and low carbon society towards 2025 in Bangladesh, In International Conference on Climate Change Effects and Energy Development in Bangladesh, Germany.

[6] Mondal, M.A.H., Denich, M., 2010. Assessment of renewable energy resources potential for electricity generation in Bangladesh, Renewable and Sustainable Energy Reviews, vol.14, pp. 2401-2413.

[7] Earth Policy Institute from BP, 2009. Statistical Review of World Energy, London.

[8] Petit JR, Jouzel J, Raynaud D, Barkov NI, Barnola JM, Basile I, Bender M, Chappellaz J, Davisk M, Delaygue G, et al. (1999) Nature 399:429–436.

[9] Siegenthaler U, Stocker TF, Monnin E, Luthi D, Schwander J, Stauffer B, Raynaud D, Barnola J-M , Fische H, Masson-Delmotte V, et al. (2005) Science 310:1313–1317.

[10] Pearson PN, Palmer MR (2000) Nature 406:695–699.

[11] Beier, B.A. Emmett, J. Peñuelas, I.K. Schmidt, A. Tietema, M. Estiarte, P. Gundersen, L. Llorens, T. RiisNielsen, A. Sowerby and A. Gorissen, "Carbon and Nitrogen Cycles in European Ecosystems Respond Differently to Global Warming," Science of the Total Environment, Vol. 407, No. 1, 2008, pp. 692-697. doi:10.1016/j.scitotenv.2008.10.001.

[12] L. Hassan, "Climate Change and Food Security: Sustainable Agricultural Production System for Reducing Food Insecurity in Bangladesh," in International Conference on Climate Change Effects and Energy Development in Bangladesh, Germany, July 2011.

[13] F. Georgios and C. Paul, "Global Warming and Carbon Dioxide through Sciences," Environment International, Vol. 35, No. 2, 2009, pp. 390-401. doi:10.1016/j.envint.2008.07.007.

[14] IAEA Power Reactor Information System, October 2008. Available (online): http://www.iaea.org/programmes/a2/.

[15] BP Statistical Review of World Energy, 2009.

[16] Central Intelligence Agency (CIA), The World Factbook. Available: http://www.cia.gov, accessed on 14th December, 2011.

[17] Martín, M.Á.P., 2010. Geo-Economics in Central Asia and the 'Great Game' of Natural Resources: Water, Oil, Gas, Uranium and Transportation Corridors (WP), Real Instituto Elcano (online). Available: http://www.realinstitutoelcano.org, accessed on 14th December, 2011.

[18] V. Smil, "Energy at the Crossroads," OECD Global Science Forum Conference, Paris, 17-18 May 2006.

[19] United Kingdom, HM Treasury, Stern Review on the Economics of Climate Change, 30 October 2006, ES-v.

[20] Based on 2007 global GDP of $54,583,788 million. World Bank, World Development Indicators database, Gross Domestic Product 2007 [fact sheet], revised 24 April 2009.

[21] Frank Ackerman, Elizabeth A. Stanton "The Cost of Climate Change," Natural Resources Defense Council, 2008, Available: http://www.nrdc.org/globalwarming/cost/cost.pdf.

[22] Energy Technology Perspectives 2008, IEA/OECD, June 2008.

[23] A. Ward, "REC Predicts Bright Future for Solar Energy," 2011. Available (online): http://www.ft.com/cms/s/0/38f2c9fe-b227-11e0-9d80-00144feabdc0.html#axzz1ShA8S5Ju.

[24] G. Metcalf, "Designing a Carbon Tax to Reduce US Greenhouse Gas Emissions," Review of Environmental Economics and Policy, Vol. 3, No. 1, 2009, pp. 63-83. doi:10.1093/reep/ren015.

[25] R. L. Hirsch, "The Inevitable Peaking of World Oil Production," 2009. Available:http://www.acus.org/docs/051007Hirsch_World_Oil_Production.pdf.

[26] A. McMichael, R. Woodruff and S. Hales, "Climate Change and Human Health: Present and Future Risks," The Lancet, Vol. 367, No. 9513, 2006, pp. 859-869. doi:10.1016/S0140-6736(06)68079-3.

[27] D. Kammen, K. Kapadia, and M. Fripp, "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Create?" UC Barkeley: Renewable and Appropriate Energy Laboratory (RAEL), 2004. Available: http://rael.berkeley.edu/files/2004/Kammen-Renewable-Jobs-2004.pdf.

[28] Human Development Report 2007/08, UNDP.

[29] Human Development Index and Electricity Use in Asia and the Pacific, 1995 and 2002, UNDP 2006.

[30] Patrick Hearps, Dylan McConnell, "Renewable Energy Technology Cost Review" Melbourne Energy Institute, pp. 1-58, March, 2011.

Mowdudur Rahman Dewan received his bachelor degree in Electrical Electronic and Communication Engineering from Military Institute of Science and Technology, Bangladesh in 2011. His undergraduate thesis was subjected to find out the prospects of renewable energy and its status in Bangladesh. One of his research papers has been published in ICCEB-2011 proceedings. He has conducted research on nuclear energy feasibility in the long run and renewable energy development aspect to ensure sustainable development in future and these researches have already been published in several internationally recognised peer reviewed journal. He is now working to develop an energy scale in relation with GDP growth. His research interest includes energy development policy and renewable energy.

Mahmudur Rahman received his bachelor degree in Computer Science and Engineering from Bangladesh University of Engineering and Technology in 2011. His undergraduate dissertation title was 'Human identification system using biometric characteristic recognition'. Currently he is working as an IT professional. Having different track record he is very much enthusiastic about energy management especially about the renewable energy. Now he is working to promote renewable energy to ensure its diversified use as a self-regulating researcher and trying to develop a software of sun tracking system to efficiently use the solar panel in Bangladesh.

Riasad Amin received his bachelor degree in Electrical Electronic and Communication Engineering at Military Institute of Science and Technology, Bangladesh in 2011. His undergraduate dissertation title was 'Power generation and efficiency enhancement of solar panel using double sun photovoltaic solar concentration method'. By that project he was able to increase solar panel efficiency significantly. His research interest includes renewable energy and power engineering.

Navid Bin Sakhawat received his bachelor degree in Electrical and Electronics Engineering at BRAC University, Bangladesh in 2012. His research area includes advance communication system, low speed efficient wind turbine design and renewable energy.