ALTERNATIVE ENERGY OPTIONS FOR BANGLADESH

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"Because we are now running out of gas and oil, we must prepare quickly for a third change, to strict conservation and to the use of coal and permanent renewable energy sources, like solar power."

-Jimmy Carter
Televised speech, 1977

INTRODUCTION

Bangladesh (BD) is facing acute energy crisis due to shortage of fossil fuel reserve, chronic energy inefficiency and failure to harness alternative energy resources. She houses limited reserve of natural gas and coal, and imports huge quantity of petroleum products accounting billons of dollar to meet her energy need[1]. Till now BD couldn't source any alternative commercial energy. Many countries of the world are harnessing renewable energy (RE) to ensure sustained energy security. As per the International Energy Outlook 2009, RE alone contributed over 13.5 percent of world's total energy need in 2009[2]. Globally RE has added a new dimension in the energy sector providing green solution to energy crisis coupled with creating millions of green jobs. BD also has vast RE potential but couldn't yet explore this sector. Till now contribution of RE in BD is very minimal, and restricted to rural domestic needs only.

BD is basically a mono-fuel dependent country. About 90 percent of her electricity and 100 percent of urea fertilizer is produced using natural gas[3]. In all, country's 75 percent commercial energy is based on natural gas[4]. As of April 17, 2010, BD has a balance of proven gas reserve (P1) 6.93 Trillion Cubic Feet (TCF) and probable reserve (P2) is 5.5 TCF[5]. Under the present demand scenario, if P2 reserve could be converted into proved reserve, balance reserve is estimated to be sufficient up to the year 2014-2015[6].

1. UNB Report, June 01, 2010, At present, the BPC has to spend about US$ 2 billion annually for import of about 3 million tons of petroleum, at http://www.unbconnect.com/component/news/task-show/id-22164
2. M. Tariq Javed Biofuel: a cost-effective indigenous option, The Dawn Media Group, April 12, 2010, and Renewables 2010 Global Status Report, p.1, at http://www.ren21.net/globalstatusreport/REN21_GSR_2010_executive_summary.pdf
3. PETROBANGLA Annual Report 2009.
4. Prof. Dr. Md. Hossain Monsur, Chairman Petrobangla, Petrobangla and indigeneous natural gas and coal resources of Banglades, The Financial Express, May 08, 2010 at http://www.thefinancialexpress-bd.com/more.php?news_id=97578
5. Centre for Policy Dialogue (CPD), A Set of Proposals for the National Budget FY2010-11, April 17, 2010, p11 at, http://www.cpd.org.bd/downloads/Budget%20Proposals_FY2010-2011.pdf
6. Prof. Dr. Md. Hossain Monsur, Loc Cit and CPD Loc Cit

Bangladesh houses approximately 2,700 million tons of coal in five coal fields so far discovered, which is equivalent to about 37 TCF gas heat equivalents[7]. Globally, coal is the most abundant, least expensive energy source, and accounts for over 50 percent of US electrical energy, over 65 percent of Indian energy and over 70 percent of Chinese energy[8]. But BD yet couldn't explore her coal resources due to multiple reasons. If BD fails to exploit her coal resource shortly, she would face a severe energy crisis.

Energy inefficiency in BD is another issue that causes approximately 25 percent wastage of energy[9]. Energy inefficiency is evident in generation, supply, demand and end-users sides. Government of BD (GoB) immediately needs to check the energy inefficiency, and requires a gradual but rapid shift from gas to coal fuel for generating power. Simultaneously she should also harness RE energy resources. Under the present gas situation if the government does not secure alternative energy system at short, mid and long term basis, the country would soon plunge into energy insecurity.

ENERGY OVERVIEW OF BD: NONRENEWABLE

Gas Situation Analysis

SIZE OF THE GAS RESERVE IN BANGLADESH

Till now 23 gas fields have been discovered in BD. The estimated recoverable proved and probable (P1 + P2) reserve of the country is 21.05 TCF. Out of which, as of June 2009, a total of 8.37 TCF gas has already been produced and as such the left over proved and probable (P1 + P2) recoverable reserve is 12.43 TCF. The probable (P2) reserve needs to be converted into proved reserve (P1) through further appraisal/development drilling program. Summary of the remaining reserve is shown at Table 1.

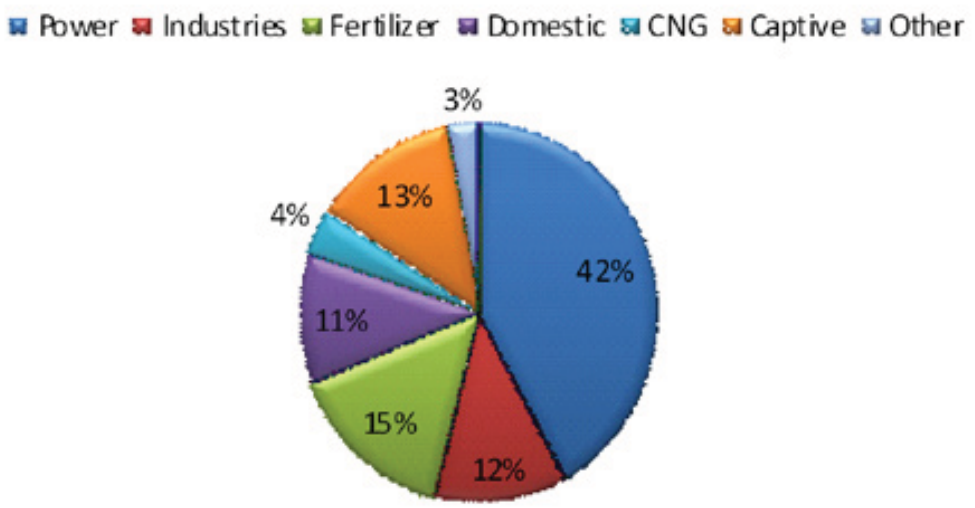
7. Ibid.
8. Ahmad Hafeezuddin, Posted by phulbarinews on July 12, 2009, at http://www.ep-bd.com/news.php?cat_id=33&archive=29&namee=ANNIVERSARY
9. Engr. A N M Obaidullah, Research Fellow (Energy Trade), SAARC Energy Centre, Harmonization of Appliances tandards and Lebeling Program in South Asia, p 48.

TABLE 1: SUMMARY OF GAS RESERVE			
Serial	Type of Reserve	Remaining Balance (TCF)	Remark
1	Proven (P1 with 95% probability)	6.93	Sufficient up to 2011
2	Probable (P2 with 50% probability)	5.5	Sufficient up to 2015
3	Possible (P3 with 10% Probability)	7.7	Sufficient up to 2019
4	Total	12.43	Excluding P3
5	Present requirement 0.7 TCF/year		
Source: Prof. Dr. Md. Hossain Monsur, Chairman Petrobangla, Financial Express, July 13, 2010 and Centre for Policy Dialogue (CPD), A Set of Proposals for the National Budget FY2010-11, April 17, 2010.			

Present Gas Demand Analysis. BD basically depends on natural gas as the prime source of energy[10]. Sector wise gas demand scenario is shown below at Chart 1. At present, average yearly gas demand of the country is approximately 0.7 TCF[11], and the projected demand growth is 10 percent[12].

10. Professor, M. Tamim, Petroleum Engineering, BUET, From an Energy Surplus Country to a Energy Deficit Country- BD case study, Energy and Power Magazine, June 16, 2010, p. 20.
11. PETROBANGLA Annual Report 2008 and Engr Khondkar A Saleque, Fuel Option, Energy & Power Vol 8, issue 4,
12. Petrobangla Annual Report 2008, p.37

Chart 1: Sector wise Gas Demand 2007-08



Source: PETROBANGLA Annual Report 2008

Present Gas Supply Scenario. As of April 2010, daily gas production capacity was about 2000 MMCFD against the daily gas demand of 2500(+) MMCFD, resulting in a daily gas shortage of about 500(+) MMCFD[13]. Presently BD's national power generation capacity is only 4000 MW against a peak demand of 6000 MW[14], causing a load shading of 2000 MW per day. Due to shortage of supply of gas 700 MW power generation is stranded.[15] Three of the fertilizer factories of BD are closed[16]. Production of all other industrial sectors is drastically reduced. Connection to new industries is stalled[17]. GDP has fallen down from 6.2 to 5.9[18]. Studies show that poor quality power supply costs the country as much as two percent in GDP growth each year[19]. According to a Dhaka Chamber of Commerce and Investment study (April 2010) at least 65 percent industries are victims of acute load shedding.

13. Prof. Dr. Md. Monsur Hossain, Bangladesh Indigenous Oil and Gas in Perspective, Energy and Power Magazine, Yearly Edition, June 16, 2010, p 29.
14. Mollah Amzad Hossain and Saleque Sufi, The Nightmare goes on, Energy and Power Mazagine, Yearly edition, June 16, 2010, p. 15.
15. Tamim M. Professor, Loc Cit.
16. Brigadier General Md. Anisuzzaman Bhuiyan, Power Crisis In Bangladesh – Is Nuclear Energy The Most Viable Option?, Dissertation Paper submitted in NDC, 2009, p.4.
17. Maqbul-E-Elahi Md, Wayout from Energy Debacle, Energy & Power Magazine, May 10,2010, p.20.
18. Asian Development outlook 2009,p.1, at http://www.adb.org/Documents/books/ADO/2010/BAN.pdf
19. Manzur ahmed, FTAC Prescription for Power, Energy and power Magazine, June 16, 2010, p.167

Coal Situation Analysis

Size of the Reserve. BD houses 0.26 percent of world's coal reserve amounting 2900 million tones[20]. As per the official report of May 08, 2010, the size of the reserve so far discovered, is about 2,700 million tons in five coal fields. Details of coal reserve are given below:

TABLE 2: COAL RESERVE IN BANGLADESH

Serial	Place/Field (Discovery)	Depth (Meter)	Area (Sq.km)	Proven Reserve (Million Ton)
1.	Barapkuria, Dinajpur (1985)	119-506	6.68	390
2.	Khalaspir Rangpur (1995)	257-483)	12.00	143(GSB), 685 (Hosaf)
3.	Phulbari, Dinajpur(1997)	150-240	30.00	572
4.	Dighirpar Dinajpur (1995)	327	Yet to be Known	200 (Partly evaluated)
5.	Jamal Ganj/Jaipur (1965)	900-1000	1600	1050
Total				3,040

Source: Professor M Tamim, PMRE Dept, BUET (mdtamim@yahoo.com), January 2009

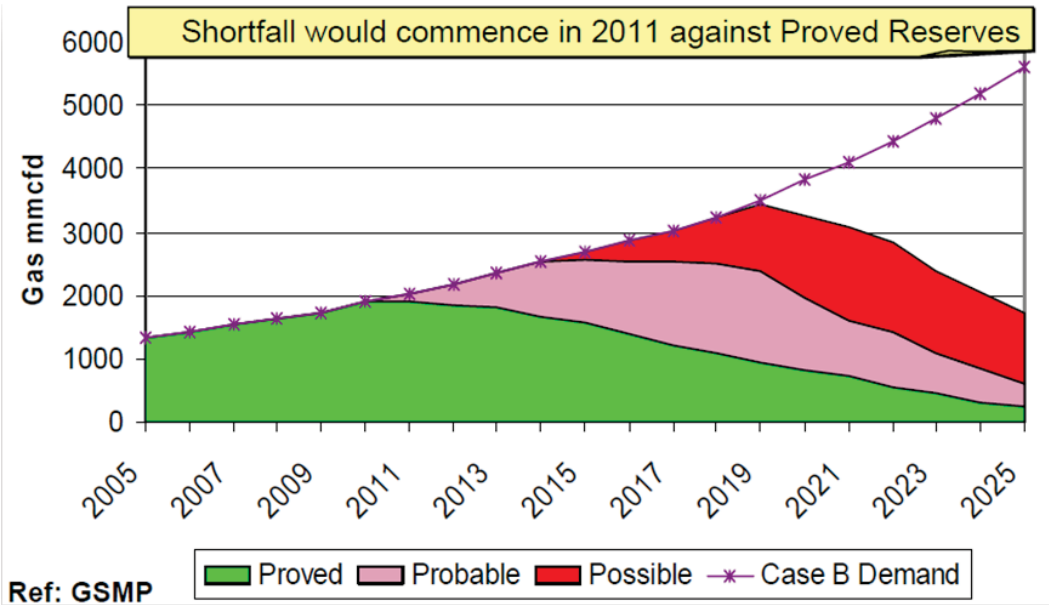
Coal Supply and Demand Analysis. So far BD could not explore her coal sector except for extracting 2.40 million metric tons. Most of the coal is being used in 2x125 MW mine mouth power plants and small portion are being used in coal based industries. Coal contributes to produce 250 MW power per day only. By achieving the full-targeted capacity, the coal will fire most of the commercial sector except for industries where gas is used as raw material.

20. 20 http://en.wikipedia.org/coal#world_coal_reserve, visited July 19, 2010.

Energy Sustainability Analysis

Demand and Supply Analysis. Projected demand and supply carve is shown at Chart 2 below.

Chart 2: Current Reserve Category: Supply and Demand Balance



Source: Professor M Tamim, PMRE Dept, BUET (mdtamim@yahoo.com), January 2009

From the chart it can be visualized that demand will continuously rise while gas reserve will be depleted. From 2011 the energy depletion will fall sharp. If new field is not discovered, the existing reserve will be exhausted by 2015.

Energy Sustainability Analysis. From the analysis it is evident that, under current scenario existing gas and coal reserve cannot meet the sustained energy need of the country beyond 2015. No gas from deep-water percentage sharing contract (PSC) can be expected within foreseeable short time. Again, it takes about five years to install a coal based PP, on the contrary a small RE PP takes only one year to be operational. If even the coal mining gets into full effect, yet the consumer sector e.g. power generation, industrial, transport and domestic etc are not ready to be fueled by coal. So the country has to harness alternative energy options to fuel her economy.

ENERGY SECURITY THROUGH ENERGY EFFICIENCY

Energy Security

Energy security is an umbrella term that covers many concerns linking energy, economic growth and political power[21]. Energy security has two key dimensions, reliability and resilience. Reliability means users are able to access the energy services when they require. Resilience is the ability of the system to cope with shocks and change[22]. Energy security is not a 'one day matter'. Long term measures to increase energy security center on reducing dependence on any one source, increasing the number of supplies, exploiting native fossil fuel or renewable energy resources, and reducing overall demand through energy conservation measures[23]. Indigenizing energy technology is also a key factor of energy security.

GoB has a vision to provide electricity to all by the year 2020[24]. But with its generation capacity, the estimated demand-supply gap is currently 2,000 MW in peak hours while gas shortages account for nearly half of this gap[25]. To connect all with electricity, estimated requirement in 2020 would stand 20,000 MW with need of additional 20 TCF gas39. But present reserve of gas would be exhausted latest by 2015. So, GoB is to devise a strategy to source alternative energy options whilst conserve the existing energy resources through EE, and diversifying the energy mix.

Energy Efficiency (EE)

Concept of EE. EE is defined as economic investments in energy generation, delivery and end-use equipment, facilities, buildings and infrastructure that deliver higher useful energy outputs or services[26]. EE is regarded as 'fifth fuel[27]" by the energy management experts. In essence, efficiency is the percentage of input to a system that comes out as useful output. EE is more important than generating energy since it does not involve fueling, and so has zero CO_2 emission. As per the opinion of Dr. Saiful Haque, Director RE Center, Dhaka University, 'one Negawatt (NW)[28] saved is equivalent to two MW generated'.

21. The New Energy Security Paradigm, World Economic Forum in partnership with Cambridge Energy Research Associates, Spring 2006, at http://www.weforum.org/pdf/Energy.pdf, (visited August 06, 2010)
22. www.med.govt.nz/templates/MultipageDocumentPage____32084.aspx (visited August 06, 2010)
23. http://en.wikipedia.org/wiki/Energy_security (visited August 06, 2010)
24. RE Policy, GoB, November 2008, paragraph 1.1
25. Tahsina, Rafa, Pioneering Renewables for Greener Life, Green Page, Energy and Power, Jun 16, 2010
26. Abdul Wadud, Former Managing Director, RPGCL, Energy Efficiency: It is a Need of the Day, Energy & Power Yearly Issue June 16, 2010, p 155.
27. Yameen Farook, The Fifth Fuel, Energy & Power Magazine, Yearly Edition, June 16, 2010, p.97
28. Negawatt (NW) - a measure of energy efficiency; a unit in watts of energy saved. The word "negawatt" was coined by Amory Lovins, a Harvard and Oxford-educated experimental …. "Every negawatt generated has the potential to increase our wealth and health as few other investments can. Negawatts enable us to do more with less and the opportunities are almost boundless. Energy efficiency is the great new energy resource of our future and a vital key to a sustainable environment."

But unfortunately the wastage of energy in BD is around 25 percent. The EU has identified EE as a key element in Green House Gas (GHG) emission reduction in the short run[29].

Approach to EE. Holistic energy conservation is a sustainable and green solution which can alleviate major part of BD's ongoing energy crisis. Expert opines approximately 700 MW can be saved readily through EE[30], while systematic management can save much more which is analyzed in subsequent studies. For systematic efficiency development effective energy auditing is necessary[31].

Major Inefficient Sectors in Bangladesh

Power Generation Sector. The study shows that, through efficiency improvement of the age old PPs, BD can target nearly 1000 NW as capacity improvement[32]. Introducing cogeneration system and managing transmission and distribution (T&D) loss, country can save 500 NW and 700 NW respectively[33]. In all EE in power sector can save about 2200 NW equivalent to 235 MMCFD of gas.

Fertilizer Sector. Compared to KAFCO, the government owned plants consume 30 to 300 percent more natural gas to produce one ton of urea[34]. If all the plants under BCIC could achieve KAFCO's performance, than 75 MMCFD of gas could have been saved per day or using CCGT more than 800 MW of electricity could be generated 48.

Paper and Sugar Mills. In a modern paper mill the steam consumption to dry one MT of paper is two MT whereas in many paper mills in BD about four MT of steam is required to dry one MT of paper[35]. The sugar mill in BD consumes more than four MT of steam to produce one MT of sugar whereas even in our neighboring country the consumption of steam is two MT to produce one MT of sugar[36].

29. RE-thinking 2050 –100% renewable energy by 2050 - let's invent tomorrow today at http://www.ren21.net/forum/forum.asp?id=27
30. Yameen Farook, Loc Cit.
31. Prof. Dr Ashraful Islam, Energy Audit and its Impact in BD, Key Note Speech in the Seminar organized in Military Institute of Science and Technology on October 09, 2010.
32. Dr. Ijaz Hossain, EE Improvement Potential in Power Generation and Fertilizer Plants, Energy & Power Yearly Magazine, June
33. Abdul Wadud no 38 and Yameen Faruk 39.
34. Abdul Wadud Op Cit p.158.
35. Abdul Wadud Op Cit, p158.
36. Ibid.

Miscellaneous Appliances. The technical and economic potential exists to save 20- 40 percent of energy from electric and electronic systems[37]. For study, if average 30 percent energy wastage is taken as the middle figure, it comes 900 NW. Because domestic sector consumes around 80 percent of total 400 MW electricity being supplied now[38], that equals to 3200 MW. Wastage is 30 percent of this 3200 MW accounts 960 NW or 900 NW as round figure. A study shows that replacing normal bulbs with energy saving bulbs alone can save 200 MW of electricity per day[39]. If quality reflectors can be fitted with the bulbs the reflector roughly doubles the optical efficiency of the fixture[40]. Thus actual saving would be 400 NW.

RE POTENTIALS AND OPTIONS FOR BANGLADESH

RE Potentials of Bangladesh

General. GoB is yet to determine her RE potential officially[41]. Some of the RE experts opine that around 80 percent of the country's energy demand for electricity could be addressed by using RE systems[42]. Different other experts made some estimation by sectors. Those are analyzed in subsequent study.

Status and Potentials of Solar Energy

Status of Solar Energy. GoB has planned to meet 10 percent of her energy requirement through solar source in the next five years which equivalents to 500 MW of electricity[43]. By now over 500000 SHS have been installed in rural villages and demand is growing[44]. About 20,000 Solar Home Systems are being installed per month[45]. But these are mostly standalone system, and so contribute hardly anything to the commercial energy requirement. Till now BD produces approximately 35 MW[46] per day. BD requires a commercial boom in this sector. Some experts of practical approach opine that it is possible to add 300 MW through solar energy by 2015, if right fiscal and regulatory initiatives are taken[47].

37. Ibid.
38. Shamin Ara Hasan, Zero Energy Building, Energy & Power Magazine, Yearly Issue 2010, P55
39. Energy and Power report by Shamsul Hoque Bipu, Tk 61 Billion Budget to Revamp Power, Energy (Statement of Minister for Finance, GoB), June 16, 2010, p. 187.
40. http://www.green-trust.org/wiki/index.php?title=Negawatt, and http://en.wikipedia.org/wiki/Negawatt_power
41. GoB RE Policy 2008 and Interview with Mr. Tapos Kumar Roy, no. 53.
42. Sajed Kamal, a scientist and teacher at Brandeis University, Massachusetts in the US, Energy & Power, August 8, 2010.
43. Statement of Mr. Subed Ali Bhuyian, chairman of the parliamentary standing committee on ministry of power, energy and mineral resources. And Wadud Abdul, Engineer, Solar Power, The Daily Star, January 18, 2010.
44. Dipal C Barua, A Solar Mision for BD, Energy and Power, Yearly Issue, June 16, 2010, p.114
45. Ibid
46. Statement of Mr. Subed Ali Bhuyian, no.73.
47. Dipal C Barua, A Solar Mision for Loc Cit

Solar Energy Potentials of BD. Experts in this discipline opine that BD has the potential to produce 10,000 MW of electricity daily from solar source[48]. Through Solar Agriculture GoB can save around 1000 MW. Some experts opine that installing solar PV on the rooftop in the urban areas, it is possible to harness 2000 MW[49]. Solar program alone can power more than 75 million rural people, and in process solar system can reduce huge burden from the national grid.

Cost Benefit Analysis. Some arguments say that solar energy is very expensive[50]. As the counter arguments one should analyze the subsidies given by GoB to the consumers and the supplier (rental PP)[51] and the pattern of global fossil fuel price rise along with environmental cost. At the same time, mass production and technological innovation will bring dramatic decrease in cost of solar energy. This is already happening. And the cost of solar power has decreased about 60 per cent from 1991 to 2003 and about 47 percent from 2006 to 2010[52] respectively.

Status and Potentials of Biogas in Bangladesh

Current Status of Biogas in BD. So far 25283 biogas plants have been installed in BD[53]. Except for 250 KW biomass based PP at Kapasia, Gazipur[54] most are used for domestic purposes.

Potentials of Biogas in BD. According to an estimate BD can obtain 29.7 billion meter3 of biogas from the livestock which is equivalent to 1.5 million tons of kerosene[55]. Apart from this, it is also possible to get biogas from human excreta, poultry dropping, waste, marine plants etc. If each family of BD can be associated with a biogas plant, then only human excreta will give about 10 billion meter3 biogas[56]. Another study denotes that, BD has the potentials of producing about 3.19109 meter3 of gas from cattle dung [57]. BD also has huge potentials to produce biogas from poultry waste. Utilizing the waste produced from Dhaka City alone, it is possible to produce 175.2 GWh (gross) of electricity annually[58].

48. Solar Power and Energy saving , Editorial, New Nation, July 17, 2006.
49. Dr. Saiful Op Cit
50. Shabbir A Bashar, Solar Power as a Prime Energy Source in BD, The Daily Star, December 26, 2009.
51. GURUMIA.COM at http://gurumia.com/2010/05/04/tk-5000cr-needed-in-subsidy-for-peaking-rental-power-plants/
52. Dipal C Barua, Op Cit, p.114
53. Patricia Stevens, Rural Electrification BD, Energy and Power, June 16, 2010, p.149
54. Brigadier General Md. Anisuzzaman Bhuiyan, no. 22.
55. Prof. A.K.M. Sadrul Islam, and Mazharul Islam, Status of Renewable Energy Technologies in Bangladesh, ISESCO Science and Technology vision, Volume 1 - May 2005, p.52
56. Ibid.
57. Banglapedia, National encyclopedia of BD, at http://www.banglapedia.org/httpdocs/HT/B_0520.HTM
58. Ibid.

Commercial Use of Biogas. Except for three biogas based electricity generation plants, till date, biogas produced in BD is used for cooking and lighting purposes of rural households. But there exists enormous potentials to use biogas as commercial source of fuel and electricity. Instead of CNG, biogas can be processed to power the cars[59]. BD has plenty of opportunity to use biogas at commercial basis to produce electricity[60]. Biogas can also be used commercially to produce bio-oil as a fossil fuel substitute[61].

Status and Potentials of Wind Energy

Present Status of Wind Energy. Till date there is no mentionable footprint of wind energy in BD. For the first time BPDB implemented a pilot project of 0.90 MW capacity of the grid connected wind energy in the Muhuri Dam areas[62]. BPDB installed another 1000 kWp capacity Wind-Battery Hybrid Power Project at the Kutubdia Island, Cox's Bazaar in 2006. LGED, BCAS supported by ODA launched WEST project in 1995 to monitor wind data. Without making any significant contribution the project was closed after one year.

Wind Energy Potentials in BD. RE experts opined that, if BD uses only five percent of the coastal areas and installs 2.5 MW size wind turbines, the total gross potentials of wind power is more than 25000 MW[63]. With only 25 percent Plant Load Factor of the wind power plants, then total energy generation potential is 54750 GWh per year[64].

Small Hydro and Bio-fuel Potentials in Bangladesh

Small Hydro Potentials. From the study it is evident that, out of existing 230 MW installed capacity at Karnafuli Hydro Station produces only 29 MW due to low height of water[65]. LGED initiated a micro-hydro power unit at Bamerchara, Chittagong. Due to low water level the project generates only four KW against installed 10 kW[66]. From the current situation it seems that, hydropower generation scope in BD is very limited[67], and the prospect is reducing day by day due to ill fate of the rivers.

59. Biogas as Vehicle Fuel A European Overview, by Stockholm, Trendsetter Report No 2003:3, October 2003, p.8, at http://213.131.156.10/xpo/bilagor/20040115134708.pdf
60. Bangladesh: Biogas Electricity Generation from Poultry Waste, at http://projects.wri.org/adaptation-database/bangladesh-biogas-electricity-generation-poultry-waste
61. Dinesh Mohan, Department of Chemistry, Mississippi State University, Pyrolysis of Wood/Biomass for Bio-oil: A Critical Review, at http://pubs.acs.org/doi/abs/10.1021/ef0502397
62. http://www.lged-rein.org/database.php ?pageid=67
63. Ibid.
64. Ibid.
65. http://www.lged-rein.org/gtz.php.
66. Ibid.
67. Md. Nehal Uddin, Country Presentation on Regional Clean Coal Partnership Programe at http://www.sari-energy.org/ PageFiles/What_We_Do/activities/Regional_Clean_Coal-Sep_2008/Clean_coal/Day1-session1/Session_I_Clean_Coal_Partnership-Bangladesh_perspective.pdf (visited October 13, 2010)

Bio-fuel Ethanol. GoB owned 14 sugar mills produce 70 thousand tons of bagasse per annum[68]. Setting appropriate technology, ethanol can be produced from this byproduct. Ethanol may be used to fuel the cars. Utilizing the total present byproducts, country can save Tk. 1.23 billion per annum[69]. GoB is considering setting up machinery with dual production, sugar and electricity[70].

Status and Potentials of Tidal Energy in Bangladesh

Tidal Power Potentials in BD. BD may harness energy from coastal tidal resources by applying low and medium head tidal movements[71] from Khulna, Barisal, Bagerhat, Satkhira and Cox's Bazar regions. The infrastructure needed for barrages and sluice gates is already present in these regions. The most favorable locations for tidal power application of this type are on the eastern side of the delta region (e.g. Sandwip).

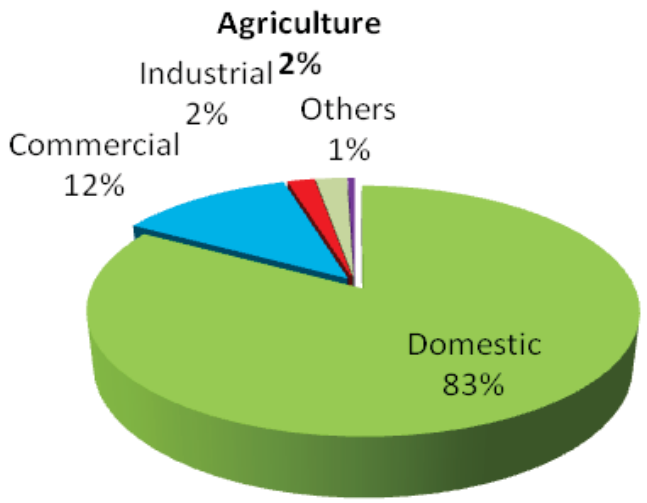
Financial Viability Analysis. Tidal PP has a potential life of more than 40 years[72]. Although the initial investment is high, but over the period the cost falls down since there is minimum maintenance cost. Basically the cost of electricity after the capital costs have been paid off in 15 or 20 years can be assumed to be nearly zero.

Zero Energy Building (ZEB) Thoughts

General. Building industry is one of the major areas where maximum energy consumption and GHG emissions take place. From Chart 3, it is seen that domestic sector consumes over 80 percent electricity. With ZEB concept GoB can save minimum 25 percent energy by 2020.

68. Md Mahtab Uddin, Prospect for Alternative Energy in BD, The Daily Observer, January 13, 2008.
69. Ibid.
70. Sugar Mills Plan to Generate Cane Power, Financial Express, February 08, 2010
71. Mahbubuzzaman, M. Shahidul Islam, Md. Mahfuzar Rahman, no.3, Low head tidal movements (2~5 m head) & Medium head tidal movements (> 5 m head).
72. M. Salequzzaman, Peter Newman, Mark Ellery and Brendan Corry, Thesis Document for Phd, on Prospects of Electricity from Tidal Power in Coastal Regions of Bangladesh, Murdoch University, Australia, 2005.

Chart 3: Percentage of Electricity Consumed in FY 2006-2008



Source: Energy & Power Magazine, Yearly Issue 2010

Concept of ZEB. A zero or low energy building can be defined as a built form, where the total energy consumed by it throughout its entire life cycle is generated by the building from renewable energy sources[73]. From above definition, it is clear that a ZEB will not be using any energy produced from fossil fuel to operate the building[74]. USA planned to reduce 28 percent electricity consumption applying ZEB concept[75]. Similarly BD can target minimum 25 percent electricity (1200 MW) savings adopting ZEB concept.

VIABLE ALTERNATIVE ENERGY OPTIONS AND IMPLIMENTATION STRATEGY

Viable RE Options

From the study it is evident that, BD has huge potentials of harnessing solar, wind, biogas, tidal, bio-fuel and bio-oil from in-house. These are financially viable, environment friendly, and offer guaranteed source of supply. Harnessing those potentials, BD can meet 80 percent of her electricity need. Through EE GoB can development her power up to 2016 without generating any electricity.

73. Shamim Ara Hasan, Associate Professor,Department of Architecture, BUET, Zero Energy Building, A new Benchmark for Building Industry, EP Yearly Issue, June 15, 2010, p.55
74. Zero-energy building, Wikipedia at http://en.wikipedia.org/wiki/Zero-energy_building (visited August 13, 2010)
75. American Society of Heating, Refrigerating and Air-Conditioning Engineers(ASHRAE) Journal, p 66, at http://www.ashrae.org/docLib/20081021_understanding_zero_eb.pdf

Due to ill fate of the river, mini hydro power potential is very limited now, and declining. So, mini/micro hydro power generation seems not viable for BD now. She has very limited tested potential of geothermal energy. Again, exploring geothermal energy involves a process short of mining, which might not be economically viable at this moment. Amongst the marine energy, only tidal power seems to be viable for BD now. Thus, harnessing geothermal energy and other forms of marine energy may be put under R&D.

Policy and Awareness Strategy for RE in Bangladesh

Policy Support. Following policy support is necessary to explore RE sector:

a. **Enactment of Laws.** It is necessary to enact laws on use of energy efficient plants and appliances for both suppliers and users' side[76]. BD Standard Testing Institute (BSTI) should set a minimum standard of EE before any plant is set and electric and electronic appliances are marketed. The law should also enforce all electricity users to produce minimum 10 percent of respective energy need. GoB should also bring ZEB concept mandatory for commercial and high rise buildings by laws.

b. **Financial Policy.** To attract the private entrepreneur in the RE sector, GoB should implement Feed-in tariff[77] policy. Dr. Saiful Haque of RE Centre, Dhaka University opines that, if net metering policy[78] is adopted in BD, in one year more than 500 MW power can be generated through private entrepreneur. He suggested the GoB to set the price of per unit electricity Tk. 30 and 10 generated from solar and wind power respectively.

Public Awareness. Most of the citizens of BD are not yet aware of the advantages of RE. GoB should launch comprehensive media campaign to encourage people for generating and using RE. The media campaign should highlight:

a. Energy security ranks after food and security in the priority agenda.

b. RE is a onetime investment.

76. Interview with Dr. Saiful Haque, August 14, 2010.
77. A feed-in tariff is a policy mechanism designed to encourage the adoption of renewable energy sources and to help accelerate the move toward grid parity. The cost-based prices therefore enable a diversity of projects (wind, solar, etc.) to be developed, and for investors to obtain a reasonable return on renewable energy investments. This principle was first explained in Germany's 2000 RES Act. Feed-in tariff, From Wikipedia, the free encyclopedia, at http://en.wikipedia.org/wiki/Feed-in_Tariff
78. Net metering is a low-cost, easily administered method of encouraging customer investment in renewable energy technologies. Net metering programs serve as an important incentive for consumer investment in renewable energy generation. Net metering enables customers to use their own generation to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity in excess of their demand. American Wind Energy Association, http://www.awea.org/faq/netbdef.html

c. After being connected with RE, no more load shedding.

d. RE involves no line rent.

f. No GHG emission, so there is no environmental cost.

g. Creates hundreds and thousands of green jobs especially in the job hungry rural areas.

h. Allows saving the fossil fuel as fixed deposit for next generation.

Suggested Strategy for RE Roadmap

General. Setting national RE targets can be an important part of a RE[79]. GoB may start harnessing, RE resources commercially. She should kick off with smaller projects. When RE technology (RET) will be matured and indigenous production will start in-house, public and private entrepreneur may install bigger plants in a joint venture. For sustained supply, minimum duel source hybrid generation service should be installed together. A suggested perspective plan is discussed in the subsequent paragraphs.

Short Term Plan (First Five years). GoB may enforce the EE law, and decommission all energy inefficient plants in phases. In the generation side, the strategy should be to install smaller plants (below 5 MW)[80]. The strategy should include:

a. Installing roof top solar panels and waste energy plants in the cities.

b. Solar and biogas plants in the towns and villages.

c. Tidal, wind and solar power in the coastal areas.

d. Producing ethanol fuel in the sugar mills.

e. Ongoing stand alone solar PV and biogas project should continue in the rural areas.

f. Important focus is required on capacity building. It is necessary to establish RET institutes to develop both technology and creating experts in RE sector.

g. Sufficient budget should be allotted in RE sector to support the roadmap.

h. Instead of installing gas based PP GoB may setup coal-fired and RE plants in future.

79. http://en.wikipedia.org/wiki/Renewable_energy_commercialization
80. Dr. Saiful Haque no. 106.

Mid Term Plan (Second Five Years). It is expected that global fossil fuel market will continue to increase reaching US $170 per barrel by 2030[81], while cost of RET will decrease. At this economic and technological lead point; GoB should launch medium size (five to 10 MW) plants. Whilst priority should still be on the private sector, GoB may launch projects in joint venture. BD should continue to develop indigenous RET and create RE expertise to be self-dependent.

Long Term. Considering the development in the RE sector in this 10 years, GoB should review the RE policy. However, in the long term GoB may install larger plant both at public and private sector. Meanwhile GoB is likely to create expertise in-house for further R&D. By that time geothermal and other forms of marine/ocean energy is likely to attain as a feasible option.

Supply Methodology

Experts and the government officials of this discipline opine that any distribution system other than existing one requires prior permission of the government[82]. As such, subject to approval following supply methodology may be adopted for guaranteed sell by the investors:

a. **Standalone System.** A standalone system can generate power for individual house appliances. It is feasible everywhere but mostly in rural areas.

b. **Off Grid[83].** Off-grid electrification can provide an alternative solution for many low-demand users, at lower cost than grid extension. It could be a growing market for small types of rural energy service companies in BD.

c. **Mini Grid[84].** In rural areas and remote settlements further from the national grid, mini-grid and off-grid solutions may be more attractive, since they can be deployed more rapidly than grid solutions[85]. GoB may connect cluster of village and buildings in the urban areas with mini grid.

81. Energy outlook 2009.
82. Discussion with Dr. Shawkat Akber and Mr. Rabindranath Roy Chowdhury, Joint Secretary, Ministry of Power, Energy and Mineral Resources, October 9, 2010.
83. http://www.drfn.org.na/pdf/energy_factsheets/offgrid_minigrid.pdf
84. Ibid.
85. Energy for a Sustainable Future, The Secretary-General's Advisory Group On Energy And Climate Change (Agecc) Report, New York, April 28, 2010

d. Smart Grid In the urban area, cluster of buildings can be connected to smart grid[86]. In the urban area, residents generally use the rooftop for domestic purpose. So solar PV can be installed using part of the rooftop, and be connected to smart grid for selling excess electricity. This rooftop PV panel project may potentially add 2000 MW to the grid[87].

e. **RE Certificate (REC).** In all distribution system, REC method of marketing may be followed to guarantee the supply and payback[88].

Investment Strategy

Globally, RE sector is explored by the private sector[89]. Government works as the facilitator, and provides policy, strategy and financial support. Thus GoB should attract private entrepreneur including NGOs to explore her RE sector commercially. Authority should look at how the cell phone companies have installed transmission towers on rooftop at rental basis. This gives a clear message of the possibility to install solar PV similarly. With correct policy support GoB may attract individual and small group investor to generate RE commercially.

RECOMMENDATIONS

Basing on the outcome of the study following recommendations are made to address the problem:

a. Considering the cost benefit analysis, implementation time, available RE technology and resource potentials, the study recommends GoB to explore RE sector at commercial basis in following order of priority:

86. A smart grid delivers electricity from suppliers to consumers using two-way digital technology to control appliances at consumers' homes to save energy, reduce cost and increase reliability and transparency. It overlays the electricity distribution grid with an information and net metering system. At Smart grid Wikipedia at http://en.wikipedia.org/wiki/Smart_grid
87. Dr. Saiful Haque Op Cit
88. A REC represents the property rights to the environmental, social, and other nonpower qualities of renewable electricity generation. A REC, and its associated attributes and benefits, can be sold separately from the underlying physical electricity associated with a renewable-based generation source……One REC is equivalent to one megawatt hour of electricity generation. ….. Basically, a REC is a form of renewable energy currency and through Energy Matters; you can sell your RECs to us and use the money as a point of sale discount on items you buy! And http://www.energymatters.com.au/carbon-trading/recs/index.php At, Green Power Partnership, at http://www.epa.gov/greenpower/gpmarket/rec.htm
89. Khan, M. Rezwan, Micro-grid for Rural BD; Cost and Benefit, Energy and Power Magazine, June 16, 2010. and 3TIER Testifies before U.S. Congressional Committee on Renewable Energy Forecasting, a press release, June 16, 2010, at http://www.3tier.com/en/about/press-releases/3tier-testifies-us-congressional-committee-renewable-energy-forecasting/

(1) Solar and biomass simultaneously.
(2) Wind energy.
(3) Ethanol and Biodiesel.
(4) Tidal power.

b. Under the existing gas crisis situation, instead of installing gas-based power plants GoB should explore coal sector and setup coal-fired power plants at priority basis.

c. To generate RE commercially, government should immediately introduce feed- in- tariff and net metering system to attract private sector for exploring the RE industries. Government should also establish off grid, mini grid and smart grid electricity distribution system to encourage the private entrepreneur.

d. Government should enact Energy Conservation Act to enforce energy conservation and lawfully implement EE.

e. Instead of giving subsidy in the price of electricity and reducing price of gas, government should pay additional subsidy to white certificate holders both individual and organization level. This option will encourage EE, save energy and increase energy tariff for the government.

f. Instead of giving subsidy in electricity, government may grant loan without interest to the builders for encouraging the construction of ZEB. It should be compulsory for high rise and commercial buildings forthwith while for any construction in metropolitan cities may be obligated to follow ZEB code in next five years. This option would save about 1000 MW per day.

CONCLUSION

Amongst fossil fuels Bangladesh is endowed with only limited reserve of gas and coal. Natural gas is the only indigenous source of commercial energy in BD. She houses about 2.7 billion MT of coal. Due to multiple uncertainty she could not yet explore the coal sector at optimum pace. Failing to explore coal sector, she developed a gas dependent energy system, thus caused early depletion of the reserve, leaving only about 12 TCF remaining. With present consumption rate this reserve may be sufficient for next three to four years. Presently the country is facing about 33 percent power deficiency where gas shortage accounts half of the shortfall. Few of the gas-based fertilizer factories are closed, power connection to new industries is stalled and production of all other industrial sectors is drastically reduced due to energy crisis. Poor quality power supply costs the country as much as two percent in GDP growth each year.

Under this crisis situation, it is essential for the country to explore alternative energy options to meet her growing energy need. Despite having vast renewable energy potentials, she could not yet commercialize the harnessing process. Renewable energy is mostly being used in the rural areas meeting domestic needs only. The research denotes that, about 80 percent electricity need of the country can be tapped systematically from renewable sources. At the same time energy efficiency improvement can give green solution to country's growing energy need now and for few contemplated years without additional generation.

About 30 percent of energy wastage occurs in BD combining supply and demand side together. Most of the power plants, fertilizer industries, paper, sugar and cement factories and other industrial and domestic sectors waste energy which accounts about 3100 NW of electricity per day. Through managerial solution GoB can save another 600-700 MW. In all, the country can save about 4000 NW through EE. Thus it is evident that, through EE, GoB can meet the growing energy need till 2014 without installing any additional capacity and causing no dipping to her energy reserve. This option will give green solution to the rapid energy depletion, and allow lead time to source alternative energy options.

It is to be noted that, sustainable energy includes energy conservation, EE and alternative energy options. To conserve energy and achieve EE, GoB needs to enact Energy Conservation Act. The act should obligate all grid users to generate minimum 10 percent of his energy requirement from RE source. The act should also enforce ZEB concept for commercial and high rise buildings forthwith while for all building in the municipal corporation in next five years. GoB needs to maintain minimum standard of EE through S & L process. Instead of giving subsidy in the cost of electricity and gas at flat rate to all, GoB may give maximum leverage to the white certificate and REC holders only.

To encourage both use and generation of RE, massive public awareness program is necessary. If the advantages from users' point of view and benefit from generation point of view are communicated to the citizens, they will be encouraged to use and invest at individual and entrepreneur level for commercial generation. But as the upfront investment and production cost is more than conventional grid electricity, GoB needs to introduce feed in tariff and net metering system.

For commercial beginning of RE, a long term perspective plan is essential. To meet the ongoing energy crisis, as a short term measure, GoB may install small RE plants with capacity of less than five MW through private sector. The order of priority should be solar and biomass, wind, bio-fuel and tidal power. As

mid-term strategy, BD should install plants with capacity up to 10 MW through private sector and in joint venture with private and public sector. In the long term GoB should install larger plants both by private, public and joint venture. By this time R&D should be able to develop new technology and source.

For commercial distribution GoB may introduce off grid supply for localized rural area, mini grid for cluster of villages and buildings in urban areas. GoB may also introduce smart grid distribution system in the city areas. If GoB can ensure proper policy and financial support side by side sound distribution and accounting procedure, it can fulfill the vision of achieving 10 percent energy need from RE by 2015. While in the mid and long term, she can meet 80 percent electricity need from RE sector.

It is to be remembered that, sustained energy security includes guaranteed source of energy, efficient generation and supply system, indigenous technology and expertise and diversified energy options. Imported energy, technology and expertise may not work in case of emergency. Similarly, natural gas as single source now and coal in future cannot ensure lasting energy security. RE options are abundant in-house but technology and expertise are inadequate in BD. So, GoB needs to conserve natural gas, explore coal and RE sector and develop RET and expertise keeping it on the top of national development agenda.

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