THE BANGLADESH MICRO-GENERATION ENERGY MODEL: LESSONS FOR DEVELOPING COUNTRIES

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ABSTRACT

Lack of access to sufficient and affordable energy is one of the major challenges for a large population in the developing countries. Renewable energy is an appropriate option to meet the energy requirements of people in these regions. In this respect, many countries in Africa, Asia and Latin America have initiated micro-generation renewable energy programmes. In Bangladesh, the renewable energy programmes based on micro-credit have experienced an unprecedented success. The Bangladesh model was pioneered by Grameen Shakti – the largest and most successful organization in the country – that is now installing over 20,000 solar- home systems per month. Other developing countries can learn a lot from the best practices of the Bangladesh micro-generation model. By highlighting the prominent features of the Grameen Shakti programme, this article reflects upon the important lessons that can be learnt from the Bangladesh model, for launching similar programmes in other developing countries.

Keywords: *Renewable energy, micro-generation, solar home systems, Grameen Shakti .*

1. INTRODUCTION

Energy is one of the fundamental commodities in the present age. It is a pre-requisite for the economic, social, industrial, agricultural and infrastructural growth of every nation. Since the advent of the industrial revolution, fossil-fuels have been the backbone of the world energy-supply base. Presently, the three main types of fossil-fuels – coal, oil and gas – collectively contribute to over 80% of the total supplies (IEA, 2009). Continuation of the use of fossil-fuels is, however, set to face multiple challenges: depletion of fossil-fuel reserves, global warming and other environmental concerns, geo-political and military conflicts and, of late, continued and significant fuel-price rise. These problems indicate an unsustainable situation. Renewable energy is a solution to the growing energy-challenges. Renewable energy resources, such as solar, wind, biomass, and wave and tidal energy, are abundant, inexhaustible and environment-friendly.

There is a great deal of disparity in the world, in terms of availability of energy. The developing countries have very limited access to electricity and other refined forms of energy, in comparison with the developed countries. Since the 1970s, attempts have been made to employ renewable technologies, like solar photovoltaic and biogas systems, for the benefit of rural communities in the developing countries. Over the last couple of decades, a number of developing countries around the world have initiated micro-generation renewable-energy programmes. Examples of such programmes can be seen in Asian, African and Latin American countries. However, in many cases, owing to various technical and socio-economic constraints, these initiatives have fallen short to achieve the desired purpose.

In four South Asian countries, Bangladesh, India, Nepal and Sri Lanka, micro-generation programmes dealing with technologies like solar home systems (SHS) and biogas systems have experienced considerable success. Owing to their innovative and distinctive business-model, the micro-generation programmes of Bangladesh, however, are far more successful than similar programmes elsewhere in the world. Grameen Shakti is the first and most successful micro-generation programme in Bangladesh. This article explores the salient features of the Bangladesh micro-generation model, taking Grameen Shakti as the reference case.

2. ENERGY AND SUSTAINABLE DEVELOPMENT

Energy is the backbone of all human activities. The accomplishments of civilization have largely been achieved through the increasingly efficient and extensive harnessing of various forms of energy, to extend human capabilities and ingenuity. Providing adequate and affordable energy is thus essential for eradicating poverty, improving human welfare, and raising living standards worldwide. The per-capita energy-consumption is an index used to measure the socio-economic progress in any society — the Human Development Index (HDI) of a country has a strong relationship with its energy prosperity (WEO, 2004). A direct correlation exists between access to electricity and economic well-being in a range of countries (Weynand, 2007).

Poverty, hunger, disease, illiteracy, and environmental degradation are amongst the most important challenges being faced by the world. Poor and inadequate access to secure and affordable energy is one of the crucial factors behind these issues. For example, electricity is vital for providing basic social services, such as education and health, water supply

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and purification, sanitation and refrigeration of essential medicines. Electricity can also be helpful in supporting a wide range of income-generating opportunities.

There appears to be a global consensus that the provision of secure, affordable and socially acceptable energy-services is a pre-requisite for eradicating poverty, in order to achieve the Millennium Development Goals (MDGs). The Earth Summit 2002 strongly urged the nations to:

> "Take joint actions and improve efforts to work together at all levels to improve access to reliable and affordable energy-services for sustainable development, sufficient to facilitate the achievement of the MDGs, including the goal of halving the proportion of people in poverty by 2015, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty."

The United Nations also acknowledges that 'without increased investment in the energy sector, the MDGs will not be achieved in the poorest countries' (UNDP, 2006). It is estimated that if the MDG's target is to be achieved, 500 million more people would need to be provided with electricity by 2015 (WEO, 2004).

With the growing world-population and people's innate aspirations for an improved life, a central and collective global issue, in the new century, is to sustain socio-economic growth within the constraints of the Earth's limited natural resources while preserving the environment. The target of sustainable development can only be met by ensuring sustainability of energy.

3. ENERGY AND ENVIRONMENTAL CHALLENGES FACING DEVELOPING COUNTRIES

Energy drives human life and is crucial for continued human development. Throughout the course of history, with the evolution of civilizations, the human demand for energy has continuously risen. The global demand for energy is rapidly increasing with increasing human population, urbanization and modernization, and is projected to rise sharply over the coming years. The world heavily relies on fossil-fuels to meet its energy requirements; fossil-fuels, such as oil gas and coal, are helping to meet almost 80% of the global energy demand. On the other hand, presently renewable energy and nuclear power are only contributing 13.5% and 6.5% of the total energy needs, respectively (IEA, 2009).

This enormous amount of energy being consumed across the world is having adverse implications on the ecosystem of the planet. Fossil-fuels, the main source of energy, are inflicting enormous impacts on the environment. Climatic changes driven by human activities, in particular the production of greenhouse gas emissions (GHG), directly effect the environment. According to the World Health Organization (WHO) estimates, as many as 160,000 people die each year from the side-effects of climate-change and the number could almost double by 2020. These side-effects range from malaria to malnutrition and diarrhea that follow the occurrence of floods, droughts and warmer temperatures (Asif, 2011).

The presently employed energy-systems will be unable to cope with future energy requirements as fossil-fuel reserves are depleting, and the developed countries predominantly employ nuclear power. Production and consumption of fossil-fuels are closely linked to environmental degradation that threatens human health and quality of life, and affects the ecological balance and biological diversity. It is, therefore, clear that if the rapidly increasing global energy-needs are to be met without irreparable environmental damage, there will have to be a worldwide drive to exploit energy-systems that do not endanger the life of current and future generations and do not exceed the carrying capacity of eco-systems. Renewable energy sources that use indigenous resources have the potential to provide energy-services, with almost negligible emissions of both air pollutants and greenhouse gases.

Access to sufficient and affordable energy is a much greater challenge for the under-developed countries. Statistics suggest that the average value of the per-capita energy-consumption in industrialized and developed countries is almost six times greater than that in the developing countries. For the latter, the situation with electricity, one of the most refined and useful forms of energy, is even more complicated. Although, during the last twenty-five years, over 1.3 billion people living in developing countries have been provided access to electricity, more than 1.4 billion people (over 21 per cent of the world's population) do not have access to it (UNDP, 2007-08). Furthermore, around 2.4 billion people rely on traditional biomass, including wood, agricultural residues and dung for cooking and heating. Statistics also suggest that more than 99 per cent of people without electricity live in the

Table - 1: Countries with a Large Population having no Access to Electricity

Country/region	Population without Electricity	
	Millions	% of world total
India	487.2	34.6
Bangladesh	96.2	6.8
Indonesia	101.2	7.2
Nigeria	71.1	5.0
Pakistan	71.1	5.0
Ethiopia	60.8	4.3
Congo	53.8	3.8
Myanmar	45.1	3.2
Tanzania	34.2	2.4
Kenya	29.4	2.1
World Total	1410	100.0

Source: *UNDP, 2007-2008*

developing countries and four out of five live in rural areas of South Asia and sub-Saharan Africa (RU, 2010). The leading countries in the world, in terms of population without access to electricity, are shown in Table-1(UNDP, 2007-08).

4. RENEWABLE ENERGY: KEY TO ENERGY SUSTAINABILITY

Renewable energy, as the name implies, is the energy obtained from natural sources, such as wind power, solar energy, hydropower, biomass energy and geothermal energy. Renewable energy sources have also been important for humans since the beginning of civilization. Biomass, for example, has been used for heating, cooking and steam-production; wind has been used for moving ships and both hydropower and wind have been used for powering mills to grind various grains. Renewable energy sources that use indigenous resources have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Renewable energy resources that are abundant in nature and are presently meeting almost 13.5% of the global primary energy-demands are acknowledged as a vital and plentiful source of energy that can indeed meet the entire world's energy demand. Renewable energy sources have enormous potential and can meet many times of the present world energy-demand. They can enhance diversity in energy-supply markets, secure long-term sustainable energy-supplies, and reduce local and global atmospheric emissions. They can also provide commercially attractive options to meet specific needs for energy-services (particularly in developing countries and rural areas), create new employment-opportunities, and offer possibilities for local manufacturing of equipment.

Renewable energy is growing at a very healthy rate across the world. Wind power is one of the fastest growing renewable energy technologies. In the recent past, the annual market for wind-energy has continued to increase at a staggering rate of over 25 per cent per annum following the 2005 record year, in which the market grew by 41 per cent. Over 27GW of wind power was installed in 2008, led by the US, China and Spain,

Table - 2: Top 10 Countries in the World, in Terms of Installed Wind-Power Capacity

Country	Installed Capacity (GW)
United States	25.4
Germany	23.9
Spain	16.7
China	12.2
India	9.6
Italy	3.7
France	3.4
United Kingdom	3.3
Denmark	3.2
Portugal	2.8

Source: *OE, 2011*

bringing world-wide installed power capacity to 120.8 GW. The top five countries in terms of installed power capacity are the US (25.4GW), Germany (23.9GW), Spain (16.7GW), China (12.2GW) and India (9.6GW), as shown in Table-2 (OE, 2011).

Solar water-heating is also growing at a remarkable rate. Since 2002, it has been experiencing a rapid growth across the world, including Asia, EU and the North America. Despite the global economic downturn, the international market for solar water-heating grew at a remarkable pace in 2008. Statistics suggest that in China, where almost 75% of the world's total capacity exists, the solar water-heating market during 2008 grew by 28%. With an annual addition of 23.4 million square meter of the collector area, China's solar water-heaters have covered around 108 million square meters of area. In 2008, EU's solar water-heating market jumped by 60% (Asif & Muneer, 2007).

5. THE BANGLADESH MICRO-GENERATION MODEL

Bangladesh is one of the developing countries, which faces serious energy-challenges, as it has limited indigenous resources. The per-capita commercial energy-consumption of the country is about 200 kg of Oil Equivalent (kgOE), around 66% of which comes from natural gas, with the remainder being mainly contributed by oil, coal and hydropower (Nes, Boers and Islam, 2005). The installed power generation capacity in the country is 5,269 MW. More than 97% of the electricity is generated from thermal power, while the rest is contributed by hydropower. Lack of access to electricity is one of the major issues affecting the socio-economic conditions of people. According to International Energy Agency statistics, nearly 96 million people, making up 58% of the total, do not have access to electricity (EIA, 2010). In terms of per-capita electricity-consumption, the country has a ranking of 177 in the world, with an annual value of 148kWh (Nationmaster, 2011 & SEC, 2011). The poor availability of electricity is a major hindrance towards economic prosperity in the country.

To overcome the issue of lack of access to energy, Bangladesh has seen a large number of micro-generation renewable-energy programmes emerging on the scene in recent years. The first micro-credit based renewable energy programme was established by Grameen Shakti in 1996. Presently, there are more than 30 organizations in operation, with similar micro-credit based programmes. The basic business-model, pioneered by Grameen Shakti and now followed by the other organizations, can be regarded as the Bangladesh model. As of December 2010, over 800,000 solar-home systems have been installed in Bangladesh, of which more than 520,000 have been installed by Grameen Shakti alone (IDCOL, 2011 & GS, 2011).

5.1 Grameen Shakti Programme

Grameen Shakti is one of the world's largest micro-generation renewable energy programmes. Grameen Shakti was established in 1996 as a not-for-profit organization, with the aim of providing environment-friendly and affordable energy to the people of Bangladesh. The main emphasis of Grameen Shakti is on addressing the needs of people living in rural and remote areas, without access to national electricity and gas networks. The electricity grid has a weak penetration in Bangladesh, especially in rural areas, where only 10% of the population has access to it. People without access to electricity rely mostly on kerosene lanterns for lighting needs. Having realized

Figure - 1: A Solar Home System being Installed in Bangladesh

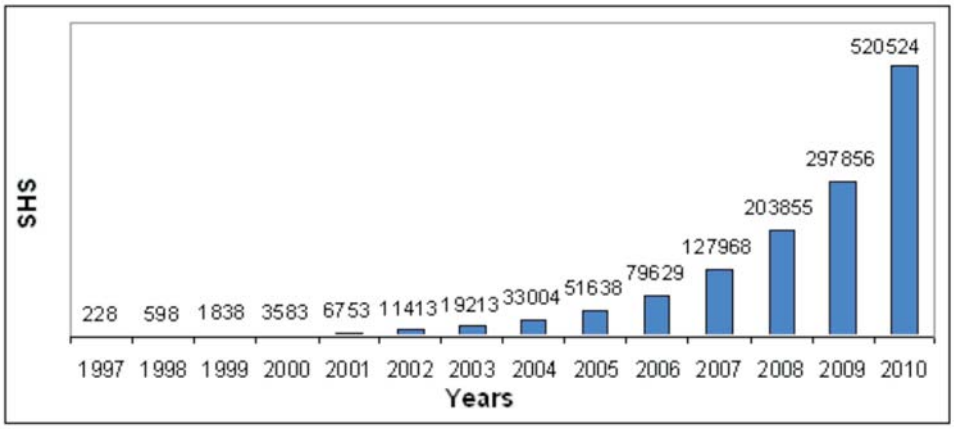

Figure - 2: Cumulative Growth of Installed Solar Home Systems

the importance of electricity for the socio-economic well-being of people, Grameen Shakti initiated the solar home systems (SHS) programme in 1996. Figure-1 shows the installation of a solar home system.

It started to deal with biogas and improved cooking stove (ICS) in 2005 and 2006, respectively. Grameen Shakti, is now one of the largest and fastest growing micro-generation programmes in the world. As of December 2010, Grameen Shakti has installed 520,000 solar-home systems, 14,353 biogas systems and 172,516 improved cooking stoves, as depicted in Figures-2 to 4. Owing to its rapidly expanding capacity in terms of trained human resource and infrastructure over the years, these technologies have experienced a remarkable growth. It is estimated that around 3.5 million people are benefiting from the services of Grameen Shakti. Some of the most important infrastructural features of Grameen Shakti programme that have contributed to its success are described below.

5.1.1 Vast Operational Network

In order to support its typical business-model and growth-strategies, Grameen Shakti has ensured its expansion in terms of not only human resource but also infrastructure. Its employee-base has grown from around 50 in 2001 to over 8,500 in 2010. Since 2001, a great emphasis has also been placed on the extension of operational/field network across the country. Having operated from its headquarters in Dhaka for the first 5 years, Grameen Shakti decided to expand its network in 2001, setting up 49 branch offices across the country by the following year.

The primary aim of branch offices was to improve the sales and after-sales services. Regional offices were also established to coordinate the newly created branch offices. Gradually, many of the functions of the headquarters were decentralized to the regional offices. Presently, there are 972 branch offices across the country, which are coordinated by 128 regional offices, as indicated in Table-3 (GS, 2011).

Table - 3: Network-growth of Grameen Shakti

Year	Employees	Branch Offices	Regional Offices
2002	88	49	8
2003	134	79	10
2004	201	105	17
2005	392	125	20
2006	906	227	32
2007	1683	340	55
2008	3155	515	77
2009	5053	670	104
2010	8510	972	128

Source: *GS, 2011*

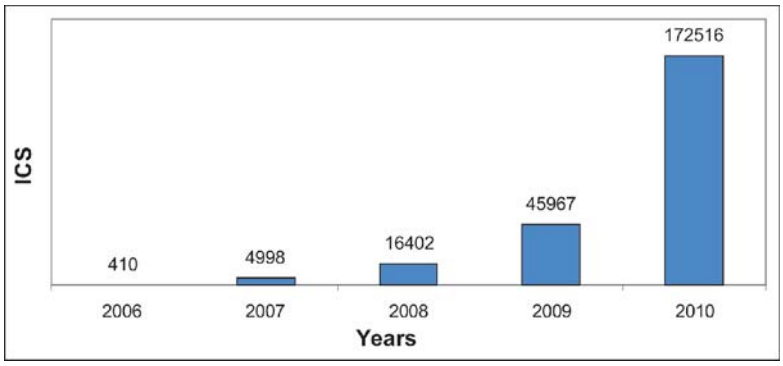

Figure - 3: Cumulative Growth of Installed Improved Cooking Stoves

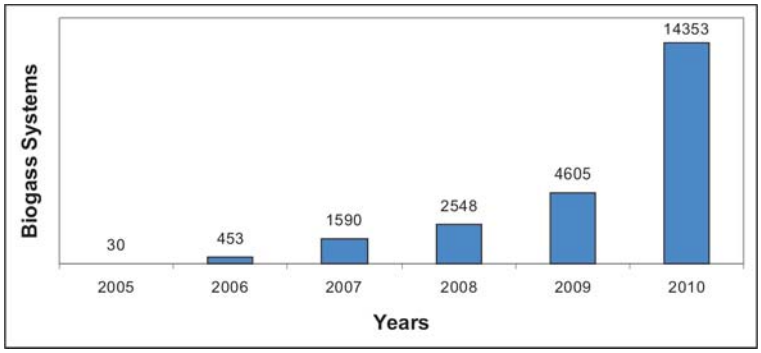

Figure - 4: Number of Biogas Systems Installed

5.1.2 Grameen Technology Centres

Grameen Shakti has established a wide network of technology centres, called Grameen Technology Centres (GTCs). The key objectives of GTCs include development of trained human resource, training of customers, improved after-sales services. The establishment of GTCs has been a very successful initiative and there are now 46 GTCs across the country. These centres have greatly contributed to the rapid growth and expansion of Grameen Shakti in the recent years. GTCs have already trained over 3,000 female technicians, who are either working at these centres or are working as renewable-energy entrepreneurs (GS, 2011).

5.1.3 Micro-utility Systems

In order to adopt the customers that cannot afford a solar-home system or a biogas system of their own, Grameen Shakti has introduced micro-utility models of these technologies. In this case, the system is owned by an individual customer who becomes a micro-utility by selling the generated electricity/gas to neighbours. There are now more than 10,000 micro-utility systems, which are mostly used within the commercial sector (GS, 2011).

5.1.4 Cost Optimization through Indigenous Production

In order to develop its renewable-energy systems at a lower cost, Grameen Shakti aims to develop

Table - 4: Financial Options Available to Grameen Shakti Customers

Package	Down Payment	Monthly Instalments	Service Charge (Flat Rate)
1	15%	36	6%
2	25%	24	4%
3 (for micro-utility)	10%	42	None
4	100% cash payment with 4% discount		

Source: *GS, 2011*

of the constituent components locally to the extent possible. In this respect, it has set-up a strong base of manufacturing and assembling facilities. In case of solar-home systems, for example, it locally develops a number of auxiliary components, including charge-controllers, lights and mobile chargers. Ultimately, the benefit of this strategy helps the customer, in terms of reduced system-cost. It has also helped Grameen Shakti develop a large pool of green technicians in the country.

5.1.5 Micro-credit Based Financial Model

One of the key-drivers behind the success of Grameen Shakti is its supportive financial model. The vast majority of its targeted customers-base–households and businesses in rural areas–cannot afford to purchase SHS or biogas systems on their own. Through its micro-credit programme, Grameen Shakti offers a range of financial and technical support-packages, to make renewable-energy affordable for its customers. Presently, Grameen Shakti is offering four alternate options to its customers, as shown in Table-4 (GS, 2011).

6. CONCLUSIONS

Lack of access to sufficient and affordable energy remains a major hindrance in the socio-economic progress of the developing countries. Owing to the limited economic and infrastructural resources in these countries, the extension of national grid is taking place at a very slow rate. Renewable energy is, therefore, considered as an appropriate alternative to meet the energy requirements in the areas far from grid. Bangladesh has established a micro-generation renewable-energy model that can be adopted by other developing countries as a role model. Grameen Shakti pioneered this micro-credit based model in Bangladesh.

The Grameen Shakti programme has grown at a remarkable rate, since its inception in 1996. Having installed 520,000 solar-home systems, 14,900 biogas systems and 195,000 improved cooking-stoves, Grameen Shakti has reached out to around 3.5 million people. The credit of its accomplishments goes to its innovative business-model. The key drivers of its success include financial model based on micro-credit, vast operational network, cost-effective production, Grameen Technology Centres (GTCs) and micro-utility systems.

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