Improved cookstove and biogas programmes in Bangladesh

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1. The energy scene in Bangladesh

Bangladesh, with a total surface area of about 147,570 km^2, is inhabited by about 140 million people, making it one of the most densely populated countries in the world. The total annual per capita energy consumption of the country in 1995 was estimated at 8.467 GJ. The shares of commercial energy (coal, oil, gas and hydropower) and biomass fuels were estimated at 3.203 and 5.264 GJ respectively [Islam, 2001]. This is among the lowest per capita energy consumption rates in the world. Commercial energy comprising oil, natural gas, coal and hydroelectricity accounts for about one-third of the total energy consumption. The remaining two-thirds is attributed to non-commercial renewable sources. Out of the different renewable sources, biomass, peat, solar radiation, wind and hydropower can be effectively used in Bangladesh.

Biomass comprises material of tree origin, such as fuelwood, charcoal, twigs and leaves; agricultural residues (mainly from rice and wheat plants), paddy husk and bran, bagasse, jute sticks; and animal (cattle) dung. The total amount of biomass fuel consumed in the country in the year 2000 was approximately 45 million tonnes (Mt). The country has sizable deposits of natural gas. According to Petrobangla (the state-owned petroleum company), the total recoverable reserves of natural gas in 22 known gas fields are 439 billion m^3 (Gm^3) of which 110 Gm^3 was produced up to June 2000. Net recoverable reserves in July 2000 were 329 Gm^3 [Islam, 2001]. Although the gas being used has an impact on the national economy through fertilizer manufacture, electricity generation and direct energy use in some industries, it will not be economically feasible to supply the gas to the rural areas through pipelines in riverine Bangladesh [Khan, 2002]. The country uses petroleum products predominantly for transport and rural lighting. The total consumption of petroleum in 2000 was 3.23 Mt, all of which was imported.

In Bangladesh the total coal deposits are 1.75 Gt (billion tonnes), broken down as follows: at Jamalgonj 1 Gt, at Barapukuria 300 Mt and at Khalispir 450 Mt [Islam, 2001]. Mining of the coal deposits has started on a small scale and commercial production is expected to start next year. The coal being situated at a depth of over 900 m, its mining cost is high. Therefore, a sizable quantity of Jamalgonj coal may not be available in the near future for widespread use. The average yearly consumption of coal in the country is over 1 Mt, which is met by imports and is almost exclusively used for brick-burning. The total peat deposits of the country are 171 Mt of which 150 Mt is located in Faridpur, 8 Mt in Khulna and 13 Mt in Sylhet. As these areas remain under water for almost half the year, the mining cost of peat will be high unless a technology suited to local conditions can be developed.

The country, being flat, is not very favourably endowed with hydroelectric potential. According to the Power System Master Plan (PSMP), the total hydropower potential of the country is 755 MW and the total installed capacity at Kaptai Dam is 230 MW [Islam, 2001].

The important points regarding the relative contributions of commercial and biomass fuels to the national energy economy are:

1. Biomass fuels account for 54 % of the total energy consumption of the country, the remaining 46 % being met by commercial fuels, namely natural gas, oil, electricity and coal.
2. Among biomass fuels, agricultural residues overwhelmingly dominate, contributing 45 % of the national total while fuels derived from trees contribute only 15 %.
3. The domestic sector's biomass consumption is *42 % of the total energy consumed.*
4. Industrial uses of biomass fuels account for 11.4 % of the total national energy consumption.

2. Use of biomass energy in Bangladesh

In Bangladesh biomass is used as food, fodder, building materials, fuel and manure. Only a fraction of the total biomass produced by photosynthesis process is used as fuel. The commonly known biomass fuels in Bangladesh are: fuelwood including tree wastes, agricultural residues and animal dung [Eusuf, 1989].

Bangladesh is an agricultural country and more than 85 % of its population lives in villages. The rural population consume a large amount of traditional fuels for cooking and other heating purposes. These practices are causing rapid deforestation and consequently a change in the ecosystem, leading to soil erosion and change in the climatic pattern. In Bangladesh the forests cover only 7-9 % of the total land area and this figure is further rapidly decreasing because of population growth and industrialization [Eusuf, 1995a].

Conservation of the traditional sources of fuels has, therefore, become a necessity to preserve our forest wealth and also to provide raw material for industries. In order to combat this situation the Bangladesh Government has undertaken some programmes for afforestation, improved cookstoves and biogas plants in the country. But these programmes are limited in scale. Large-scale countrywide long-term programmes should be undertaken to protect the country's ecosystem.

3. Traditional stoves

About 90 % of all families in Bangladesh use traditional stoves for cooking and other heating purposes. A traditional stove is usually a mud-built cylinder with three raised points on which the cooking utensil rests. One opening between these raised points is used as the fuel-feeding port and the other two for flue gas exit. The stove may be built under- or overground. In some cases two potholes are joined together and a single fuel-feeding port is made for common use.

The traditional stove allows excessive loss of heat for the following reasons.

1. The large distance between the pot and fuel bed (depth ranging from 30 to 60 cm) causes heat transfer to the cooking pot to be considerably reduced.
2. Because of the large size of flue gas exits between the cooking pot and stove much of the hot flue gas exits the stove without coming into contact with the cooking pot, thus reducing the convective heat transfer.
3. Since air cannot reach the bottom of the stove, a considerable amount of cooking fuel accumulates at the bottom as charcoal.

The efficiencies of these stoves vary between 5 and 15 %, depending on the depth of the stove and size of the flue gas exits [Khan et al., 1995].

4. Improved cookstoves

The Institute of Fuel Research and Development (IFRD) of the Bangladesh Council of Scientific and Industrial Research (BCSIR) has been pursuing R&D activities on stove technology since 1978 [Eusuf, et al., 1990; Eusuf et al., 1993] and has developed a series of models of improved stoves and their accessories [Hossain, 1995] to suit the needs of the user in respect of biomass fuel, shape of the cooking pot and cooking habits. These models may be grouped into 3 categories: (1) improved stoves without chimneys; (2) improved stoves with chimneys; (3) improved stoves with waste heat utilization. These improved stoves save 50-65 % fuel and cooking time compared with traditional stoves.

In the chimney stove, fuel is burnt in the first combustion chamber over a grate where cooking is done by direct heat, and cooking in the other pothole is done by the hot flue gases coming from the front chamber. The stoves are so designed as to maximize heat transfer to cooking utensils. This model decreases the time of cooking and also makes the kitchen free of smoke and hot air. It can be easily made from mud.

5. Dissemination of improved stoves

R&D activities are being carried out by IFRD and so far 31 updraft and 9 downdraft models of improved stoves have been developed [BCSIR, 2000]. To popularize the improved stoves in the country, the IFRD has chosen five different models of updraft improved stoves: improved single-mouth cooking stove (portable); improved single-mouth cooking stove (half-underground); improved double-mouth cooking stove coupled with chimney (on the ground); improved double-mouth cooking stove coupled with chimney (half-underground); and improved double-mouth cooking stove coupled with chimney suitable for large-scale cooking and other heating purposes. The following strategies were adopted for the programme.

1. Advertisements in mass media.
2. Seminars
3. Training courses
4. Demonstrations

The Ministry of Science and Information & Communication Technology since its inception has being putting its best efforts into popularizing the renewable energy technologies developed by BCSIR in the country. The ministry has been regularly arranging seminars on "Application and dissemination of appropriate technologies developed in the country" since 1986 at the district/*upazila* (sub-district) administrative levels of the country. During these seminars, along with other technologies improved stove technology is being exhibited to the common people.

To popularize the improved stoves, IFRD has developed two training course manuals on "Improved stoves". One course is of 1-week duration and the other of 4-day duration. Scientists of IFRD have till now conducted over 215 training courses on improved stove technology and trained about 10,000 men and women from different government, semi-government and non-governmental organizations of the country. Most of the trained personnel are now engaged in dissemination of improved stoves in different parts of the country [Khan, 2002].

IFRD has successfully completed two Annual Development Programme (ADP) projects on dissemination of improved cookstoves in the country. Both the projects were implemented jointly by BCSIR, Ansar-VDP (VDP means Village Defence Party) and Bangladesh Rural Development Board (BRDB), as detailed in Table 1. Some of the main objectives of the projects are given below.

1. To save traditional fuels by popularizing the improved stoves and eliminate air pollution in rural areas of Bangladesh.
2. To develop skilled manpower for dissemination of improved stoves through training courses.
3. To create awareness about the effectiveness and usefulness of improved stoves through massive advertisement campaigns using various media.
4. To reduce deforestation and maintain the ecological balance of the country through the massive use of improved stoves.
5. To involve various government, semi-government and non-governmental organizations in dissemination programmes of improved stoves.
6. To improve hygienic conditions in the kitchen.

At present, the dissemination of improved cookstoves is being carried out by IFRD, along with its R&D activities. Some government, semi-government and non-governmental organizations are also carrying out dissemination in a limited way throughout the country.

6. Potential of biogas in Bangladesh

The break-up of the usage of dung in the country is: fuel 34 %, manure 46 %, building materials 5 %, and waste 15 %. The share used as fuel and fertilizer may be combined and made available for use in biogas plants to provide gas and fertilizer. About 80 % of the total dung from over 22 million head of cattle can therefore be made available for biogas production. An estimate of the total biogas potential in the country is presented below [Khan, 2002].

Table 1. Government of Bangladesh projects for dissemination of improved cookstoves

Name of the project	Duration	Budget (Tk. million)	Project areas (3 *upazilas* in each district)	Number of persons trained	Number of improved stoves installed	Number of improved stoves installed by each of the 3 organizations
1. Dissemination of improved stove (1st Phase)	1994-1997	15.10	105 *upazilas* of 35 districts	1000	62,848	BCSIR: 12,577 Ansar-VDP: 32,932 BRDB: 17,000
2. Dissemination of improved stove (2nd Phase)	1998-2001	42.18	92 *upazilas* of 29 districts	1171	1,17,573	BCSIR: 46,597 Ansar-VDP: 31,555 BRDB: 39,421

1. Cattle dung:
Total cattle population of Bangladesh = 22 million
Dung available = 220 million kg/day
Gas that may be obtained = 2971 million m^3 (Mm^3)/year
(1 kg of dung yields = 0.037 m^3 gas
Each cow yields = 10 kg dung/day)
2. Poultry litter:
Total poultry population of Bangladesh = 75 million
Total poultry litter that may be obtained = 7.5 million kg/day
Gas that may be obtained = 202 Mm^3/year
(1 kg litter yields = 0.074 m^3 gas
Each bird yields = 0.1 kg litter/day)
3. Human excreta:
Total human population of Bangladesh = 120 million
Excreta available = 48 million kg/day
Gas that may be obtained = 1297 Mm^3/year
(1 kg excreta yields = 0.074 m^3 gas
Excreta per person = 0.4 kg per day)
Therefore total biogas potential in the country = 4470 Mm^3/year.

7. R&D work on biogas technology

IFRD has been conducting R&D on biogas technology since 1973 [Eusuf, 1995b]. Before this, Bangladesh Agricultural University (BAU) had started work in this field by setting up a biogas plant on its campus in 1972 to study the gas production characteristics and later set up a family-size plant (6 m^3 digester volume) to provide gas for cooking and lighting for a family of 6.

On the basis of laboratory results, a family-size biogas plant (6.3 m^3 digester volume and 2.3 m^3 gas-holder volume) was first constructed by IFRD, following the design of India's Khadi and Village Industries Commission (KVIC), on the BCSIR campus in 1976 at a cost of Tk. (taka) 12,000. Since then, after long research, IFRD has developed the following two types of biogas plant suitable for Bangladesh:

1. floating-top biogas plant; and
2. fixed-dome biogas plant.

The fixed-dome biogas plant has been found to be suitable and popular in this country.

IFRD has successfully converted locally available petrol-run generators and reconditioned petrol engines to run on biogas. Generators having capacities of 1-5 kVA are used for domestic purposes and converted reconditioned petrol engines coupled with alternators are used mainly for medium-scale electricity generation (5-30 kVA) suitable for poultry farms, diary farms, etc. It is worth mentioning that to generate 1 kWh of electrical energy 0.75 m^3 gas is required, which can be produced from 20 kg of cowdung, obtained from 2 cows. To date about 16,000 biogas plants have been installed in poultry and dairy farms in the country. The owners of the farms meet their daily fuel requirement from the gas obtained from the biogas plants.

8. Dissemination of biogas plants

In 1983, with a view to speeding up the dissemination of biogas technology, IFRD, for the first time in the country, introduced two-week duration training courses on construction, operation and maintenance of biogas plants. During that time 60 nominees from Bangladesh Small and Cottage Industries Corporation (BSCIC), BRDB and the World Bank had been trained on biogas technology. These trainees motivated the people and helped to set up biogas plants with the guidance of experts of IFRD.

In 1983, Environmental Pollution Control Department (EPCD) (now Department of Environment, DOE) also started a programme under a government grant and installed 110 fixed-dome and over 150 floating-top plants through hired contractors. All the plants were supplied free of cost.

In the early '90s two separate MOUs were signed between BCSIR and Local Government and Engineering Department (LGED) and BCSIR and Department of Livestock Services (DLS) for dissemination of biogas technology in the country. Under these MOUs 30 LGED engineers and 25 DLS engineers were trained for construction, maintenance and use of biogas plants.

In 1992, BCSIR in collaboration with Dhaka City Corporation built an experimental biogas plant of 85 m^3 digester volume at Saidabad, Dhaka, for treatment of city garbage. Per day on the average, charging of 525 t of garbage plus 2 t of cowdung produced 57 m^3 of biogas and 40 t of residue (bio-fertilizer) rich in plant nutrients over a period of two months. The residue had no bad smell.

9. ADP projects on biogas technology

Under a fuel-saving project approved by the government during 1988-92, 141 floating-top biogas plants have been installed in different parts of the country with the collaboration of NGOs.

During 1995-2000, an ADP project entitled "Biogas Pilot Plant" of total budget Tk. 91.3 million had been successfully implemented by IFRD. To implement the project, 128 diplomate civil engineers were recruited and were given two weeks' intensive training on biogas technology. They installed 4,664 biogas plants all over the country during the project period. About 900 local youths, selected on the basis of two persons from each *upazila,* from government organizations, semi-government organizations, NGOs and individuals, were also trained in biogas technology. They helped the biogas engineers during the installation of biogas plants in different parts of the country. According to a report, after the completion of the project it was seen that 99 % of the biogas plants installed under the project were in operation and 91 % of the owners could meet their household fuel demand from the plants.

Recently a project entitled "Biogas Pilot Plant (2nd Phase)" having a budget of Tk. 342.51 million has been approved by the government and is being implemented around the country by IFRD. The duration of the project is 4 years (2000-2004). To implement the project 128 diplomate (electrical/civil/mechanical) engineers have been recruited. Under this project 20,000 biogas plants will be installed both by agency-holders and biogas engineers employed on the project. To date, approximately 12,000 biogas plants have been installed under the project in the country.

10. Conclusion

Improved cookstove and biogas technologies are proven technologies. Improved cookstoves save fuel while biogas plants provide an alternative fuel. Additionally, these two technologies keep the kitchen environment clean, offer health benefits, help preserve forests and enhance crop production in the country. The message of the benefits of improved cookstoves and biogas have reached the people. Currently, with the increasing number of poultry and dairy farms there is a great demand for these technologies throughout the country. The existing programmes undertaken by the government, semi-government and non-governmental organizations to disseminate these technologies are not enough to fulfil the demand. Therefore, greater effort should be made to more effectively disseminate these technologies. ■

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