BIOGAS DEVELOPMENT IN RURAL AREAS OF PAKISTAN: A SUSTAINABLE OPTION FOR DOMESTIC ENERGY

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ABSTRACT

All those developmental activities that meet the needs of the present generation without jeopardizing those of the future are sustainable in terms of social, economic and environmental parameters. Energy, a major 'agent' of development, is mostly produced from fossil-fuels that are not only finite and costly to extract but also contribute to polluting the environment. Renewable energy sources, on the other hand, offer environment-friendly and economically viable options for energy generation in the rural areas. Biogas offers an opportunity for decentralized energy-generation in rural areas to all those potential households possessing livestock.

Rural communities traditionally use fuel-wood and cow-dung cakes as a source of energy in Pakistan. It has been reported that the annual per capita fuel-wood requirement is 0.52 m³ that implies a consumption of 5.20 m³ of fuel-wood for a family of 10 per year. Thus, a single family may cut three to four fully grown trees in a year just to meet its domestic energy needs. Over the years, this has been leading to degradation of natural forests, besides depriving the agricultural fields from decomposed organic manure.

Possessing a huge potential in the form of 10 million livestock for biogas development, Pakistan can produce 150 million m³ of biogas per day, i.e. 54,000 million m³ per annum. This huge untapped potential can prove to be a major source of income generation in rural areas through energy production, organic farming and trading carbon credits that could be earned under the Clean Development Mechanism (CDM) of the Kyoto Protocol, besides reducing emission of greenhouse gases in the atmosphere.

It would be advisable that the relevant policy-making organizations may work for devising a policy that encourages biogas development and promotion. One of the best ways to this end is to completely stop extension of natural gas pipelines to the rural areas in future and divert the cost of establishing such pipelines/networks to the development and promotion of biogas technology in rural areas of Pakistan.

1. INTRODUCTION

Sustainable development encompasses interventions that are socially acceptable, economically viable and environmently-benign and, thus, offers great prospects for future development, without leaving any environmental footprints. Countries or States that have adopted sustainable development agenda are in fact on the right path towards achieving their national development objectives. Renewable-energy development is an excellent means to sustainable development as, on the one hand, it can replace the fossil-fuels with a clean and environment-friendly source of energy and on the other hand, it offers cheap alternatives to fuel-wood in rural areas.

Pakistan is currently facing its worst ever energy-crises, as the energy demand and supply exhibit a great and increasing gap. Therefore, the Government of Pakistan implements load-management of electricity and natural-gas supply. The domestic and commercial consumers are consequently suffering badly. This situation has forced the policy-makers and planners to opt for various alternative sources of energy in Pakistan that are economically viable. One such option is the development of biogas technology, using cow-dung to produce biogas for domestic and commercial uses. Like other parts of the world, decentralized energy production based on biogas sources has been successfully demonstrated and adopted on large scale in rural areas of Punjab, Khyber Pakhtunkhawa and Azad Jammu & Kashmir (AJK). Hundreds of Chinese-style dome-shaped fixed concrete biogas plants of eight to 20 cubic metre capacity have successfully been demonstrated in supplying biogas for meeting domestic energy-needs during the past few years.

2. DOMESTIC ENERGY SOURCES

Currently, rural communities in Pakistan use fuel-wood and cow-dung as sources of domestic energy. Traditionally, rural households are used to keeping five to 10 heads of livestock (mostly buffaloes and cows) for their agro-pastoral livelihood activities. It has been estimated by FAO (2004) that about 50% of animal-droppings in the country are collected. Of this recovered quantity, about 50% is used as fuel for cooking, resulting in barely a quarter of the animal-droppings being available for use as organic fertilizers. The animal-droppings, together with an equal quantity of stable bedding material, left-over fodder and household-waste, provide for the total quantity of farmyard manure (FYM) available. About 50% of the farmers reported that they use FYM on one crop or another. Mostly, the communities pile up the cow-dung in their courtyard, which not only creates unhygienic

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conditions and emits green-house gases (GHG) into the atmosphere leading to global warming, but also serves as a breeding place for mosquitoes and flies. Burning of cow-dung cakes as a source of domestic energy pollutes the indoor environment by emission of dangerous gases, like carbon monoxide, that may cause various diseases. Cutting of trees for fuel-wood in rural areas is a major cause of deforestation and desertification in Pakistan, as 0.52 m^3 of wood-per-capita is used for meeting domestic energy-needs every year. Poultry farms also produce a huge quantity of poultry-waste that can potentially produce biogas but, currently, it is being dumped out in the open, causing pollution in the surrounding environment, and emission of greenhouse gases.

Traditionally, fuel-wood claims the largest proportion of biomass fuels used in developing countries (in some regions up to 90%), where about 40% of the total wood-cut annually is used for domestic purposes (cooking and heating). Estimating an average per capita consumption of 3 kg of wood per day for energy (cooking, heating and boiling water) in rural areas of Asia and Africa, the daily per capita demand of energy equals 10-15 kWh, which could be covered by about 2 m^3 of biogas. A biogas plant, therefore, directly saves forests, assuming that even deadwood is collected for fuel.

A biogas digester uses cow-dung and even poultry-waste in slurry form, and produces biogas and decomposed solids as organic manure. Pakistan possesses 63 million buffaloes and cows that yield 990 million kg of cow-dung per day. About 6 kg of cow-dung can produce 1 m^3 of biogas (natural gas). Thus, Pakistan possesses the potential of producing over 150 million m^3 of biogas per day and over 54,000 million m^3 per annum.

Pakistan has tremendous potential of developing small, medium and large-size decentralized biogas plants for domestic energy, as it possesses 10 million potential livestock-owning households. This huge untapped potential can prove a major source of income-generation in rural areas, through energy-production, organic farming and trading carbon-credits that could be earned under the Clean Development Mechanism of the Kyoto Protocol, besides reducing emission of greenhouse gases into the atmosphere. It is estimated that by developing biodigester, a family can actually earn PkR 3,150/- per month in the form of various products and, thus, the programme can help alleviate poverty in rural areas of Pakistan.

3. BIOGAS ENERGY TECHNOLOGY

Biogas typically refers to the gas produced by the biological breakdown of organic matter in the absence of oxygen, i.e. anaerobic fermentation. Biogas is the product of food-chain, in which the Sun's energy is trapped by green plants that are eaten by livestock as fodder to produce energy, fats, carbohydrates and proteins that the animals' body uses. The waste-products that are disposed of contain a lot of carbohydrates and other food nutrients and fibers, which are the major source of methane (CH_4) produced during the process of dung-fermentation by anaerobic respiration of bacteria.

Biogas originates from biogenic material and is a type of bio-fuel, which primarily consists of methane and carbon dioxide. Biogas can be used as a low-cost fuel for heating, cooking and power generation. Biogas can also be compressed, much like natural gas, and used to power motor vehicles. Being a renewable source of energy, biogas qualifies for renewable energy subsidies in some parts of the world. Biogas consists of the following gases:

Methane (CH_4)	50-75%
Carbon dioxide (CO_2)	25-50%
Nitrogen (N_2)	0-10%
Hydrogen (H_2)	0-1%
Hydrogen Sulphide (H_2S)	0-3%, and
Oxygen (O_2)	0-2%

Biogas offers a highly cost-effective and decentralized energy-production option at community and household levels. During 1970s, efforts were made to have large scale biogas production for energy use, but these efforts did not bring the expected results due to lack of technological capacity and awareness among the communities. However, recent technological advancements in biogas digesters have greatly helped in developing a highly efficient, economically viable, environment-and user-friendly biogas plants. The Chinese model of dome-shaped concrete biogas plant is successfully being used in China, India, Thailand, Vietnam, and, recently Pakistan, for biogas production from cow-dung. In rural China, anaerobic digesters are used to produce biogas energy for households, as well as organic fertilizers. Other benefits of this system include improved sanitation and conservation of environment. In China, approximately 5 million households are using anaerobic digesters.

A small and medium-scale domestic biogas plant

constructed in the courtyard of a rural house costs not more than PkR 50,000/- to 70,000/-. It can generate 10 to 20 m^3 of biogas, which contains 50 to 75% methane, a major source of energy that burns and produces heat energy instantly. Biogas could also be used to produce electricity, using common petrol based generators with little alteration. This clean source of domestic energy can replace the use of fuel-wood and cow-dung cakes, normally used as a source of domestic energy in rural areas. As a result, not only forests would be saved from cutting of fuel-wood but also cow-dung use in the biogas digesters will produce organic manure – a rich organic fertilizer.

4. SIZES AND COSTS OF DOMESTIC BIOGAS PLANTS

Depending on the requirements of biogas energy and the number of livestock heads that a typical rural family possesses, a domestic biogas plant with capacities of 8 m^3, 10 m^3 and 20 m^3 could be developed. For 8 m^3, three buffaloes; for 10 m^3, four buffaloes; and for 20 m^3, six buffaloes or their equivalent cow-dung is required for biogas production on a regular basis. The cost of developing domestic biogas plants depends on the location and varies from PkR 65,000/- to Rs. 140,000/- (US$ 700 to US$1,500) for these sizes. It has been observed that the investment can be recovered in about 15 months. The construction material is mostly indigenous and may not require any imported material.

5. DESIGN OF THE CHINESE DOME-SHAPED BIOGAS PLANT

Though the design and construction of the Chinese dome-shaped biogas plant is highly technical and may require the services of specialized experts and firms. The design of the smallest domestic biogas plant (8 m^3) is given in Figure-1.

6. SOCIAL BENEFITS OF BIOGAS PRODUCTION

As the biogas digester produces decentralized natural gas in the courtyard of a household, this innovation can bring about a revolution in the rural society in terms of improved cleanliness, health and hygiene, as well as environment conservation. Women, mostly responsible for cooking, dish-washing, fuel-wood collection and making cow-dung cakes, will greatly be relieved from the agonies of: cutting wood from far off places and their transportation on head; dirty and unhygienic process of making cow-dung cakes and; above all, reduced exposure to indoor health hazards due to emission of smoke from burning of wood and cow- dung.

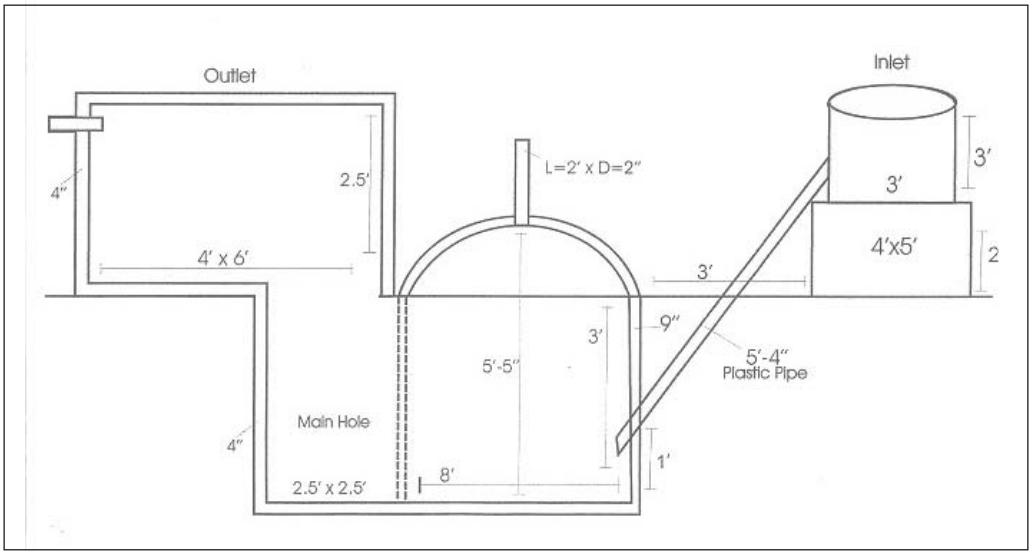

Figure - 1: Dome-Shaped 8M^3 Biogas Plant

Emission of smoke from burning cow-dung cakes increases the chances of tuberculosis. These chances can be completely eliminated if a household shifts to biogas plants. Heaps of cow-dung, normally dumped in the courtyards of rural households – a major source of diseases, insects and pests – will no longer exist, as cow-dung will be dumped in the biogas digesters on a

daily basis. In addition, use of organic manure in agriculture will result in high yields and reduced health-bill.

7. ECONOMIC BENEFITS OF BIOGAS

The economic impact of biogas production on a rural family (with an average seven to 10 members) is a saving of Rs. 3,150/- per month spent on two cylinders of LPG, three mounds of fuel-wood, cow-dung cakes and cost of chemical fertilizer. Such saving is a big economic gain for a rural family and can help in poverty reduction in rural areas of Pakistan. In addition, adoption of this technology can also help in improvement of social, health and environment indicators of these areas.

Adoption of this simple technology can increase the income of poor rural communities, besides increasing organic energy production. Organic agricultural products can reduce the health-bill of rural communities and, thus, help in promoting sustainable production and consumption. These decentralized energy-production units can bring self-sufficiency to the rural households, save forests and provide organic fertilizers for the soil, increasing its productivity. The Government of Pakistan, local and international donor agencies interested in poverty-alleviation and decentralized organizations working for alternative-energy development may consider tapping this huge alternative-energy potential in Pakistan. This will greatly help in reducing the energy crisis in the country in the shortest possible time. The estimated economic impact of biogas production on a rural family (average 10-12 members) is given in Table-1.

8. FOREST PROTECTION/ENVIRONMENTAL BENEFITS

Communities in rural areas traditionally use fuel wood and cow-dung for cooking and heating. Apart from other environmental benefits, the most important environmental indicator of the project is conservation of natural forests. Based on the per capita fuelwood demand of 0.52 m³ per annum, an average family of eight members will need 4.0 m³ of fuel-wood to satisfy their annual domestic energy needs. Thus, at least four mature coniferous trees, or equivalent volume of other tree species, would be cut to satisfy this demand. The fuelwood supply sources are mostly State or community-owned forests. Consequently, this huge demand for fuel wood leads to rapid deforestation. By installing a single biogas plant, 10 mature trees will be saved from being cut to be consumed as a source of fuelwood annually.

Moreover, the annual demand of cow-dung for cooking alone ranges between 3,000 to 4,000 kg. Consequently, agricultural land is deprived of an enriched source of organic manure. The organic manure from the biogas plants, which is otherwise burnt as a source of domestic energy, would be used as rich organic manure that can increase soil fertility. It has been observed that using organic manure produced by the anaerobic digesters has increased the yield of various crops (almost three-fold), besides increasing soil moisture, improving soil-texture and producing organic products – a source of healthy food.

9. RECOMMENDATIONS FOR DEVISING AN IMPLEMENTATION STRATEGY

Biogas energy offers the most cost-effective and sustainable source of renewable energy in the rural areas of Pakistan. A huge untapped potential exists all over the country, especially in the Punjab. However, so far no serious effort has been made to make legal framework, institutional arrangements and provide incentives to the private-sector for duly exploiting this huge potential. Pakistan is already experiencing shortage of gas and electricity, and is resorting to load-management in both domestic and commercial sectors. Consequently, developmental activities aiming at income-generation in rural areas are being adversely affected. It is high time to devise policies and regulations for exploiting the available potential. In view of the above exposition, the following recommendations are made:

It is advisable that the relevant policy-making

Table - 1: Monthly Energy and Fertilizer Budget

	Cost before Biogas Plant (Rs.)	Cost After Biogas Plant (Rs.)
LPG=2 cylinder	1,800	0
Fuel-wood=3 maund	750	0
Dung cakes	Daily labour cost	0
Chemical fertilizer	600	0
Approx. Total Cost	**3,150/-**	0

organizations work for devising a policy that encourages biogas development and promotion, based on the following:

- Creation of awareness among the communities in rural areas for the promotion of biogas energy technology;
- Encouragement of participation of the private sector in biogas energy development in Pakistan; incentives and public-private partnership arrangements need to be made;
- Extension of natural gas pipelines to the rural areas in future, and diverting the cost of establishing such pipelines/networks to the development and promotion of biogas technology in rural areas of Pakistan;
- Enforcement of laws, rules and regulations for domestic, commercial and even compressed biogas energy technology development in Pakistan need to be made.