RESEARCH & DISCUSSION SERIES

Renewable Energy: *Biogas*

PPAF

پی پی اے ایف

Pakistan Poverty Alleviation Fund

The effect of carbon emmissions, global warming and fragility of ecosystems, is captured in the frayed edges of planet earth. The potential of renewable energy in arresting depletion of natural resources and fossil fuels is expressed in a kaleidoscope of colors: yellow/orange (solar), light/dark blue (hydel), light/dark green (biomass), light/dark brown (geothermal), blue/aquamarine (tidal) and whirling white (wind).

Contents

Foreword

Pakistan Poverty Alleviation Fund has launched a Research and Discussion Series to commemorate completion of ten years of operations. The R&D series aims to foster debate and discussion on poverty and its reduction with special reference to community driven grassroots development. The initial theme selected for this purpose is renewable energy.

This study, the first in the series, explores and highlights potential of biogas technology as an economic and environmentally sustainable alternative to conventional fossil fuels. It focuses on gauging technical and output efficiencies resulting from temperature differentials and seasonality given Pakistan's agro climatic location. It assesses biogas digesters installed by a PPAF partner organization in Southern Punjab with local corporate support. A random sample of 50 per cent plants, installed and functional at the time of survey, was drawn. A specifically designed household based questionnaire was administered, complemented by physical inspection of plants.

This assessment exercise was designed and conducted by Muhammad Muslim Nabeel (Evaluation, Research and Development unit) under supervision of Ahmad Jamal (Chief Strategy Officer), in close collaboration with Community Physical Infrastructure unit. Editorial assistance was provided by Madiha Mumtaz (CSO Office).The proactive facilitation and logistic support extended by National Rural Support Programme is gratefully acknowledged.

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Chief Executive/Managing Director

1 Introduction & Overview

Rural areas of Pakistan are characterized by scarcity of opportunity and therefore higher incidence of poverty compared to more urbanized regions. They are home to about 70 per cent of the total population of Pakistan. Current economic recession in general and energy crisis in particular has affected the rural economy quite substantially.

Shortage of electricity and fluctuating oil prices have increased reliance on natural gas, especially as automobile fuel and means for power generation. Consequently, rising demand for energy in the industrial sector has diverted focus of policy regime towards commercial users. As a result, current domestic consumers are facing a shortage in supply and further extension of this facility to new locations, especially to remote rural areas, is unlikely particularly in the short term. On the other hand, Pakistan faces dual constraint of resource insufficiency in both fossil fuels and forest reserves[1], and lack of an effective policy to meet energy requirements of the country. Therefore, shortage of energy, more pronounced across rural areas, is evident throughout the national canvas. Not surprisingly poor households tend to spend more on fuel and lighting as a percentage of their income, and tend to be more vulnerable to rising prices and shortages in supply (PSLM, 2008).

Given the status of energy demand and GDP growth over last 10 years there is a large gap between demand (current and projected) which will have to meet through fossil and renewable sources of energy (PSY, 2005).

This situation has led public and private development related agencies to jointly devise strategies for exploring and providing means to supplant conventional energy sources with relatively inexpensive, feasible and sustainable alternatives. The civil society, owing to better linkages and access to the grassroots, can effectively play its catalytic role in supplementing Government's efforts.

Pakistan Poverty Alleviation Fund (PPAF), as an apex institution, is mandated to providing assistance and means to address poverty related issues and constraints. It presents an innovative model of public private partnership. Through a network of 74 partner organizations (POs) across the country, PPAF provides support to disadvantaged through its four instruments of intervention: i) lines of credit to poor communities that cannot readily access financial institutions; ii) developing and upgrading rural areas through provision of grant based small scale infrastructure projects; iii) providing trainings for human development to existing communities benefiting from PPAF's

1– In Pakistan only about 5% of total land is forested and indigenous resources suffice just 21% of fossil oil demands.

financial and nonfinancial services; and iv) providing access to basic health care and primary education to deprived and poor communities. PPAF has disbursed over Rs. 40 billion in 120 districts of the country since its inception in year 2000.

By virtue of available resource base and network of POs, PPAF is well positioned, especially with respect to rural areas, to promote in providing viable alternative energy sources. Optimum adaption and conservation of existing domestic resources are the single most important imperative in this regard. PPAF strives to explore and disseminate alternative energy sources for addressing power deficiency at micro level. For this purpose, it has already tested and deployed various innovative interventions exploiting hydel, solar and wind energy. As an initiative for diversification in this area, this report focuses on findings of a pilot project initiated in southern region of Punjab province (Rahim Yar Khan) introducing biogas as fuel at household level. The study assesses adoption, utility and effectiveness of the pilot project.

Technological Process

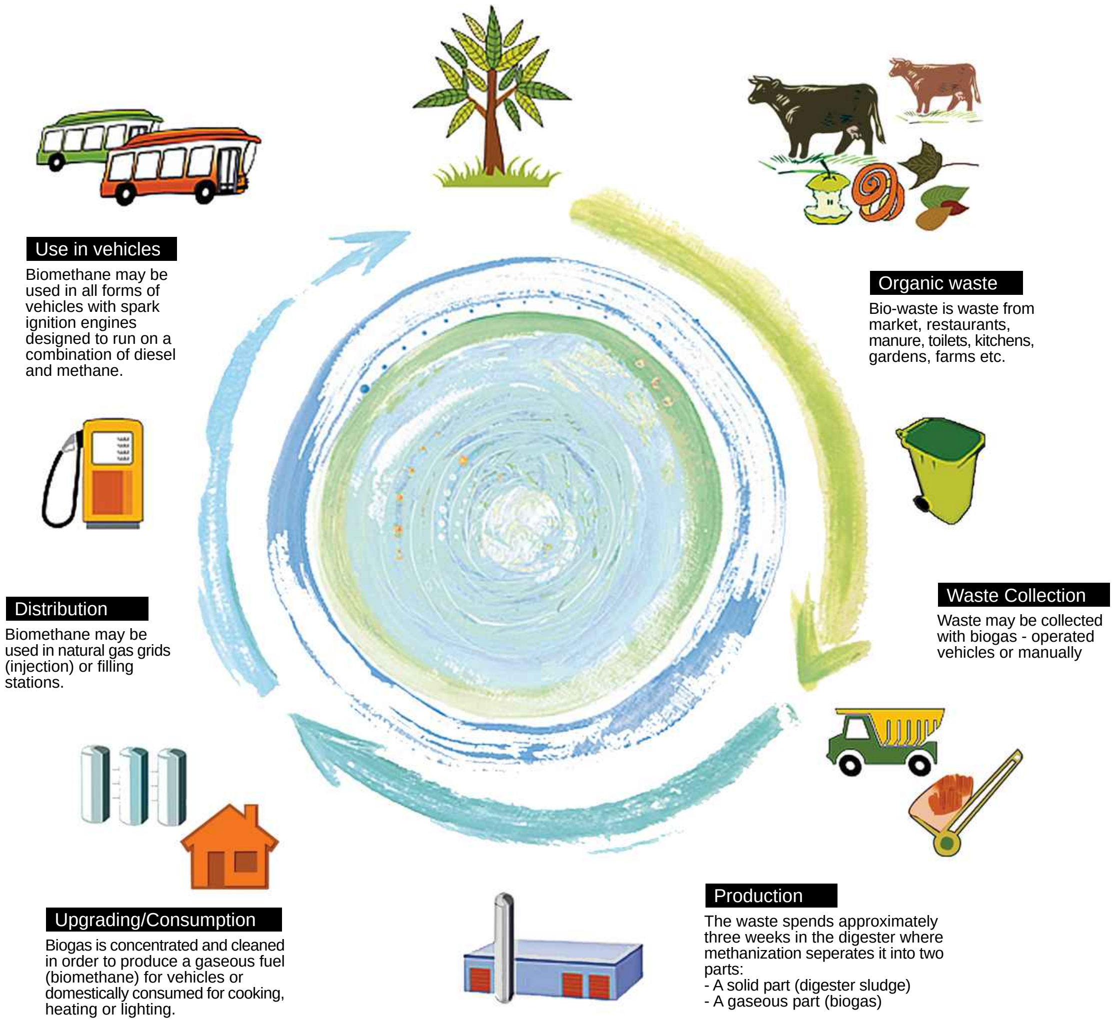
Biogas is methane-rich fuel potentially produced by manure, agricultural waste or aquatic weeds. The production process is carried out by fermentation of biodegradable material in absence of oxygen (anaerobic process). The gas thus produced accumulates in an airtight chamber (a biogas plant or biogas digester) specifically designed to serve as biogas reservoir. Biogas burns with an odorless, soot less and intense flame with appreciable thermal efficiency.

The essential input required for producing biogas is abundant in rural areas. According to research, subject to effective and efficient use, annual production of biomass globally is four times greater than required to meet energy needs over the same period (Majid 2002). This demonstrates the immense potential and viability of employing this huge source of energy at both household and industrial level.

Figure 1.1

Biogas Lifecycle

Range of potential applications



Benefits & Advantages

Health and Hygiene

Women in rural households generally carry the responsibility of collecting manure and preparing dung cakes, manually. Manure gets deposited in nails and palm troughs results in spreading germs and bacteria during other household work such as, cooking and serving, looking after the children. This is perceived to predispose users/handlers to infection and diseases in rural areas; children are especially vulnerable.

The downside of burning raw dung or other traditional cooking fuels (i.e. firewood, straw, coal etc) is pollution (and carbon emission) caused by their smoke. Traditional cooking fuels not only pollute the air but also degrade the quality of food being cooked. Women are at high risk of developing a range of diseases including, chronic obstructive pulmonary diseases, respiratory illnesses, eye diseases and tuberculosis. Children on the other hand, particularly those under 5 years of age are at high risk of contracting acute respiratory illnesses such as pneumonia or chest infections.

By-products

An additional benefit of a biogas plant is effectiveness of its by-product (called sludge or slurry) as high-grade organic compost that is far more effective and safer than raw manure or synthetic fertilizers. Since disease-causing germs are killed due to anaerobic condition in biogas digester, slurry does not emit odor or attract flies and other carrier insects. Generally, it is diluted with irrigation water for utilizing as fertilizer. Sludge can be filled in pits and left to dry in the sun for storage purposes. On drying, cakes are dug out and stored in piles for future use. However, drying and storing may cause some loss in its fertilizing value.

Ancillary Benefits

Other scientifically proven benefits of biogas (Majid, 2002) are enumerated below:

- It is absolutely non-poisonous.
- It has no offensive odor.

- It burns with clean, blue, soot less flame.
- Its caloric value is High (4,700 – 6,000 kcal/m3)
- Its thermal efficiency in a standard burner is 60 per cent which is graded as ‘high’.
- It is cheap and environment friendly.
- It reduces deforestation and consequently land erosion and flooding.
- Unlike smoky fuels, it is not harmful to health and leaves utensils clean.
- It is simple and convenient to use.
- A well managed biogas plant does not have any unpleasant odor around it.

Constraints & Issues

In spite of its numerous benefits described in the preceding section, there are constraining factors related to employing biogas technology. A review of relevant literature suggests that these problems can broadly be classified in three categories.

Technical

- Where water table is high, ground water can exert hydraulic pressure on the plant causing damage to its various components.
- Corrosion due to chemical nature of gas and fermentation process leads to decay and leakage in the gas holder.
- Pipes connecting the plant to stove can potentially produce catastrophic results (in case of damage or leakage) if not handled or taken care of properly.
- Variation in weather (cold or hot) significantly affects the plant’s technical efficiencies.
- Its storage and transportation is not easy and economical when produced at household level.
- Appropriate training for maintaining the plant and using biogas stove carefully.
- Problems may arise when users either neglect instructions for handling or try to experiment with the system.

Social

- Beliefs, behavior, norms and customs need to change when dealing with new ways of doing things.
- Rural areas where fossil fuel source (natural gas) is available, better-off households give manure of their cattle to poorer ones. Installation of biogas plants in better off houses in such areas would shift them to the new source hence poor households would have the disadvantage of having to compete for scarce fuel and energy sources.

Economic

- A significant impediment to extending this technology to poor households is its high capital cost. Poor households may or may not be able to pay the total upfront cost.
- Scarcity of input material due to insufficient number of livestock by beneficiary household may compel them to buy dung from external sources which will increase maintenance/running cost hence distorting expected outcomes.
- Another problem which is cited in literature is toxicity of slurry due to vaccination and antibiotics given to animals for treatment purposes. This could potentially make crops fertilized by such slurry, poisonous.

Product Utility & Efficacy

International Evidence

International experience whether at small or large scale suggests significant common practice. Some evidence from developing and more developed countries is cited below:

- Grameen Shakti in Bangladesh has initiated biogas programme, with a successful pilot project. It envisions a potential market of 4 million biogas plants in five years through financial means and mechanisms based on credit, thereby making biogas plants affordable and sustainable.
- In India small scale digestion

facilities are catering to over 2 million households. Under the Deenabandhu[2] Model, Ministry of Non-conventional Energy Sources of Government of India is providing subsidies to communities as well as masons constructing these plants.

- Biogas is extensively used throughout rural China and an estimated 18 million households were benefiting from this source by the end of year 2005.
- In Nepal, 150,000 biogas plants have been installed in rural areas under Biogas Support Programme. This programme has won the Ashden Award for excellent work.
- Vietnam's Biogas Programme for animal husbandry has led to installation of over 20,000 plants throughout the country.
- In Colombia experiments with diesel engine generators partially fuelled by biogas demonstrated that biogas could be used for power generation, reducing electricity cost by 40 per cent compared with purchase from regional utility.
- In Rawanda, the Kigali Institute of Science and Technology has developed and installed large scale biogas plants at prisons to treat sewage and provide gas for cooking.
- Sri Lankan Government has recognized usefulness of this technology in 1970. Since then people are reaping its benefits at both household and commercial levels. It has significantly supplemented the dairy sector as herd owners are producing biogas on industrial basis and also getting economic benefit from the slurry by selling it as fertilizer.
- Biogas can effectively replace fuels used in combustion engines, generators and boilers at industrial level. As evidence, compressed biogas is widely used in Sweden, Switzerland and Germany for the same purpose. A biogas powered train has been in service in Sweden since 2005.
- South Africa has recently initiated a Household Biogas Program in 2008 with a vision of providing biogas digesters to 12,000 households in two provinces

2– Hindi for "helpful to the poor".

(Eastern Cape and Kwa-Zulu Natal) by targeting households and community groups that can afford to pay 10 per cent of their monthly income during five years and a 10 per cent upfront payment.

National Perspective

IIn line with international trends, introduction of Biogas technology is not a novel phenomenon in Pakistan; rather, it has a history of over 35 years. In 1974, Government of Pakistan initiated a comprehensive biogas programme at the national level and 4,550 such plants were commissioned by 1990. The project was undertaken in three phases: i) One hundred demonstration plants with grants from Government. ii) Biogas plants installed with some community share. iii) Biogas plants installed solely by communities' own efforts. Unfortunately, the third phase flopped due to absence of Government funds and, in turn, lack of interest from the communities (Khurshid 2001). However, this shows that the idea of biogas technology is well-worn in the country with a potential of large scale adoption. However, some backstopping in the form of financial and technical assistance by either Government or civil society is a requisite.

In Pakistan, approximately 70 per cent population subsists in rural areas where 62 per cent of cooking fuel needs are currently being met by gobar (dung/animal waste) and the rest by wood, kerosene and/or other fossil fuels (Ilyas 2006). Livestock is an essential commodity possessed by nearly every rural household no matter rich or poor. Over the years rapid structural transformation in agriculture has taken place which is both inter-sectoral and intra-sectoral. Population of large ruminants has increased to 60 per cent over the last 20 years, to stand at almost 56 million (Pakistan Livestock Census, 1986, 1996, 2006). In the province of Punjab alone, where agriculture is a predominant activity, share of crops subsector in agriculture value added has declined from 64.1 per cent in 2000 to 59.9 per cent in 2007; correspondingly livestock subsector has increased from 34.8 per cent to 39.9 per cent over the same period. This phenomenal growth in the livestock subsector indicates the potential of exploiting products and byproducts obtained from these animals. As an estimate, only 50 per cent manure obtained from these livestock can suffice the cooking needs of 30 per cent of rural population if processed for producing biogas. (Majid, 2002).

Adoptability Prospects

As people in rural areas are culturally accustomed to handling manure/dung therefore intensive efforts on persuading them for adopting biogas technology is not required. Introduction of biogas plants will change modality not means; therefore it is a matter of developing systematic policy and implementation design and provision of some technical assistance. Moreover, maintenance of a biogas plant is much easier than traditional process of making dung cakes. Therefore, acquisition of biogas technology is not only envisioned to significantly saving time but also helping women to divest of a highly labour intensive and menial work activity.

2
Study Design & Parameters

Background

National Rural Support Programme (NRSP) is a PPAF partner organization operating at the national level with dedicated focus on rural areas. NRSP, in collaboration with Jamal Din Wali (JDW) Sugar Mills under Corporate Social Responsibility (CSR) initiative, promoted renewable energy sources on pilot basis in the region of Rahim Yar Khan (Punjab). Under this project, one hundred biogas digesters were planned to be installed at household level out of which 40 have been installed and fully operational since February 2009. The rest are under construction and expected to become fully functional by June 2009. Biogas digesters are being installed with 80 per cent share from JDW sugar mills and 20 per cent from the household getting the facility[3]. NRSP provided data and information as background use for cost benefit analysis and evidence of impact.

A biogas digester has an inherent limitation of not performing optimally during winter season. Although winters last only for three months in Rahim Yar Khan, yet the shortcomings are reflected in survey results as this study was carried out during winters. In summers (rest of the nine months), two fold increase in production of the plants is estimated. This will also be supported by our survey findings imparted in preceding sections. Therefore, results of this study reflect the “minimum base”.

The pilot project was taken under meticulous consideration and a study was commissioned to discern the efficacy and viability prospects of the technology. A team was formed comprising of Evaluation, Research and Development (ERD) and Community Physical Infrastructure (CPI) units. The survey team comprised of three members from CPI unit tasked with examining physical design and assuring optimum functioning of the plants, and one member from ERD unit with responsibility to carrying out a survey and focus group discussions with beneficiaries and gauge social and economic outcomes of the intervention.

Methodology

A random sample of 50 per cent plants, installed and functional till the date of survey, was selected. According to the sample drawn, 21 (out of 41) biogas plants were visited. Efficiency was examined through physical inspection of the plants and recording the duration for which a stove attached to the digester would burn continuously. This exercise was done for each selected plant twice a day (at dawn and dusk). Beneficiaries were asked not to use the gas during

3– An eight cubic feet biogas digester costs Rs. 40,000 including all the accessories like valves, pipes and a stove.

other timings throughout the day. Social and economic benefits were quantified and views of beneficiaries and time variant data were collected through administering a questionnaire specifically designed for this purpose. Moreover, focus group discussions with users and beneficiaries were carried out in order to elicit subjective and qualitative information regarding effectiveness and/or inefficiency of the technology.

The survey provided significant insight into different aspects of development of this project. Major results and findings of the survey are imparted in the preceding sections.

3 Survey Results & Findings

Survey Results & Findings

Demographic Profile

The surveyed households had fairly large average household size of 10.5 with 54 per cent men and 46 per cent women.

Social Mobilization

In development interventions at grassroots it is very important that the end users have complete awareness and ownership of the project. Therefore, sufficient time period is imperative between identification, introduction and provision of facility. To that end, time period between introduction of technology and physical installation of the plant was recorded.

Figure 3.1 shows that about 50 per cent of beneficiaries were provided the facility within one month of introduction. Another 33 per cent were given a period of two to three months while 19 per cent were left for four months or more for further appraisal and consideration of compatibility of the project with their domestic needs and constraints.

Monthly savings ascribed to acquisition of biogas plants (as reported by the respondent) are compared to the period allowed for awareness and social mobilization is depicted in Table 3.1.

Figure 3.1
Time lag between introduction and installation of plant

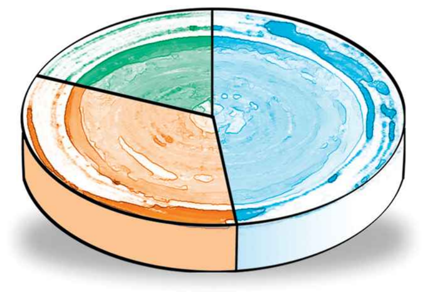


Table 3.1
Financial Benefits (% households)

Amount saved (Rs.)/month						
Rs.	<=1,000	1,001 - 1,500	1,501 - 2,000	2,001 - 25,00	> 2,500	Total
1 month	23.8%	19.0%	4.8%	-	-	47.6%
2 – 3 months	19.0%	4.8%	-	4.8%	4.8%	33.3%
> = 4 months	-	-	-	14.3%	4.8%	19.0%
Total	42.9%	23.8%	4.8%	19.0%	9.5%	100.0%

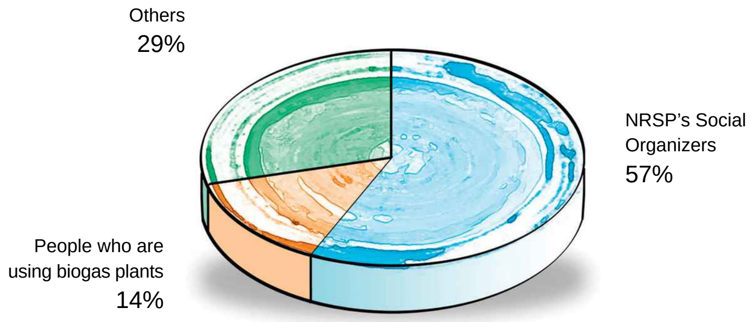
The cross tabulation between social mobilization and financial benefit accrual by virtue of biogas digester, reveals an interesting phenomenon. Households getting larger period (four months or more) enjoy considerably more financial benefit from the intervention compared to those getting the facility sooner after introduction. This shows the importance of awareness and social mobilization in development interventions.

Sources of Information

The source(s) of information (and relative credibility) significantly influence communities' technology adoption decision or behavior. Figure 3.2 shows that more than half (57 per cent) of households surveyed named NRSP's social organizers as the primary source of information about the technology. Among other sources 14 per cent were households already using this facility. Another 29 per cent were introduced to the bio gas technology from other sources like friends, relatives, books or brochures.

A high percentage of respondents getting knowhow of the project from NRSP shows the active role and acceptability of the NGO in the area. On the other hand, another significant percentage of households (43 per cent) acquiring knowledge about the

Figure 3.2
Sources of information



facility from other local sources indicates the social cohesion and potential of people in the area to influence each other. A relatively smaller proportion (14 per cent) of people influenced by successful users is also a good sign and this share is expected to increase with further dissemination and information.

All surveyed beneficiary households reported that they were well informed about the pros and cons of the project prior to its physical installation and that they have opted to adopt this technology voluntarily.

Trainings

In innovative technology projects extensive trainings guarantee success of the intervention. All the surveyed households informed that after installation they were trained on usage and maintenance at least twice. Apart from comprehensive trainings, several monitoring visits by NRSP staff were also conducted on regular basis to examine and ensure the correct use of biogas plants.

An overwhelming proportion (around 87 per cent) of households was of the view that trainings were effective and have provided complete understanding of the technology. The other 13 per cent reported that they were not quite sure about the use of the plants however with passage of time and subsequent monitoring visits the knowhow of technology increased.

Raw Material

Most important factor in maintenance of biogas digesters is adequate availability of input material (manure). In this respect, household getting the technology must ‘possess’ sufficient number of animals for producing required amount of dung. According to the survey data, households getting the facility on average own six large and three small[4] animals as source of dung for the digesters. However, this number must be interpreted in relevance with number of household members in order to estimate the sufficiency of input material.

As indicated by the data collected during the survey, about 80 per cent of beneficiary households mentioned that they have sufficient amount of

4– Large animals refer to buffalos, bullocks or cows while small animals imply calves, goats or sheep.

manure to produce enough gas. Other 20 per cent said that are at present dung produced by their livestock own does not suffice for producing enough biogas. The deficit was reported to be met by collecting manure from neighbors or relatives. However, this is not a long term solution and unavailability of dung from external sources in future may cause the plants to be abandoned.

Perceived Benefits

Feedback of the end-user regarding utility (or otherwise) of any project/interventions is vital.

According to Figure 3.3, 53 per cent of beneficiary households classified this intervention as “highly beneficial” and useful in fulfilling their needs. Other 33 per cent rated the technology as “beneficial” while 14 per cent were not sure enough to say anything about the project. The latter category of households is mostly those who do not have enough dung to optimally benefit from this facility and/or are not maintaining plants properly.

The success or failure of a project depends upon perceived requirements for which the plants are installed. Figure 3.4 shows that one third of beneficiaries claimed that the

Figure 3.3
Perceived benefit of intervention

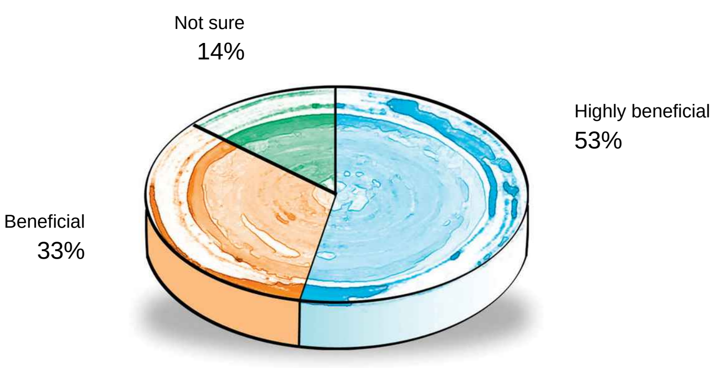
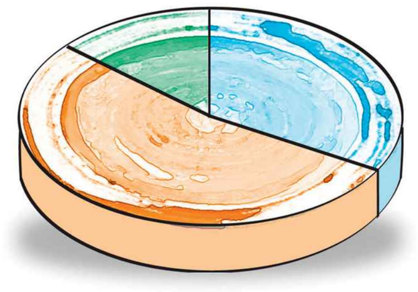


Figure 3.4
Level of satisfaction (needs fulfilment)



plant is effectively catering to their cooking needs. However, another 53 per cent reported the intervention moderately meeting the requirements while 14 per cent rate the output as insufficient to their needs.

Efficiency Dimension

Primary rationale for this project was that it would provide alternative energy source for cooking at household level. Therefore, a pilot project must show positive trends in order to provide a benchmark for its future dissemination. The effectiveness and how well the project is lending itself to achieving desired outcomes can be obtained through analysis of the before and after situation.

According to survey data, about half of the visited biogas plants were functional since last summer. Therefore, we can get an idea of their effectiveness in both summer and winter seasons.

Summer Season

The data show s 54 per cent replacement of firewood and 90 to 100 per cent replacement of dung-cakes with biogas during summers. Dung-cakes account for 60 per cent of cooking fuel consumed in rural households (Illyas 2006), which is effectively being supplanted by biogas. Therefore, an overall replacement of approximately 80 per cent of traditional cooking fuel is evident according to the survey data.

Winter Season

Replacement of firewood with biogas falls from 50 to 25 per cent in households having biogas plants functional since summer. This decline can be ascribed to decreased efficiency of biogas digesters in winter and extra use of firewood during cold weather. However, in case of dung cakes, biogas is an ultimate replacement irrespective of seasonality. Therefore, availability of biogas in winters may be pronounced as capable of catering to 65 per cent of household needs.

Notwithstanding, when projects are included that have started functioning in winters, the results were surprisingly better than expected. Some of the newly installed biogas digesters had as high efficiency in winter season as obtained from some plants in summer season. This improvement may be attributed to better design evolving over time and increased awareness of operating and managing digesters.

4 Conclusions

Energy deficit in poor households results in practical constraints such as inadequate lighting, inadequate space heating, inadequate cooking fuel and thus fewer hot, cooked meals, and a short supply of hot water. The setbacks caused by the energy poverty in turn have consequences in the standard of living of the poor through illness on a more frequent basis (with consequences on income), deprivation in well being and vulnerability to economic shocks. Access to clean and convenient energy services are therefore vital to alleviation of poverty.

Biogas experience at the international level reveals viability of this technology in urban as well as rural areas. It is being quite extensively used at household, industrial and commercial level with great success. Its economic benefits are well proven as it effectively supplements the household economy through providing cheap and viable source of energy within means and resources. The use of its byproduct as valuable natural fertilizer is also cited as one of its economic benefits. Positive effects of biogas digesters on health have also been reported from all over the globe and are well recognized. It not only helps improving individual health but also develops cleaner and safer environment leading to a more pollution free atmosphere. It is expected to significantly improve female health and hygiene at household level, which, in turn, will definitely improve children's health while reducing infant mortalities.

At the national level although the idea of exploiting biogas as energy fuel is not new, yet its sustainable public policy success in the long run is still to be established. Previous national experience shows that support/assistance is imperative for promoting the technology. Moreover, the experience of implementing this project at community level has not seen success in the past. Therefore, more emphasis should be laid upon targeting individual households.[5]

Availability of sufficient amount of dung is a major concern that limits utility of biogas to only those areas/households that possess sufficient livestock. According to the survey results, a household optimally benefiting from the biogas digester has 1:1 ratio between adult household members and livestock possessed. Another major impediment in providing this facility to poorest of the poor is its high upfront cost. Poor households may not have the capacity to bear capital cost fully or even partly. A plan may be worked out to bring the down upfront cost without compromising the quality. This would help extending this facility to the poorest of the poor as well.

5– The plants may be installed in clusters comprising of at least 15 eligible households .

Extensive trainings on the use of the digesters are essential to ensure the success of the project. Current study shows that beneficiaries should be trained and mobilized before physical provision of the facility as the period given for social mobilization positively correlates with accrual of benefits. Exposure visits in this regards can prove handy to get the beneficiaries familiarized with pros and cons of the technology.

There is sufficient evidence to suggest that on average a biogas plant can fulfill the household requirements of cooking fuel to up to 80 per cent in summers and 60 to 65 per cent in winters. However, the efficiency peaks at 100 per cent in summers and 80 per cent in winters in well managed biogas plants.

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Annexure 1
Output time measurement of surveyed Biogas plants (Feb 2009)

HHs Head Name	HHs Size	Village	Start Time	End Time	Output Time	Total Time
Fayyaz Ahmed	11	Kot Faqira	5:35 PM	7:30 PM	1:55	4:15
			9:05 AM	11:25 AM	2:20	
Niaz Ahmed	12		5:49 PM	8:00 PM	2:11	4:04
			9:07 AM	11:00 AM	1:53	
Saeed Ahmed	14		5:52 PM	6:40 PM	0:48	2:25
			9:08 AM	10:45 AM	1:37	
Amjad Raza	17	Gulshan Imam Din	5:10 PM	6:30 PM	1:20	3:35
			9:10 AM	11:25 AM	2:15	
Asif Mehmood	7		5:15 PM	6:45 PM	1:30	3:07
			9:13 AM	10:50 AM	1:37	
Shahid Iqbal	18		5:22 PM	6:30 PM	1:08	2:57
			9:11 AM	11:00 AM	1:49	
Shaukat Ali	9		5:25 PM	6:50 PM	1:25	2:28
			9:15 AM	10:18 AM	1:03	
Waqar Ahmad	8	Malik Mehram	5:36 PM	6:06 PM	0:30	1:05
			8:43 AM	9:18 AM	0:35	
Dr. Ayaz	17		5:46 PM	5:58 PM	0:12	0:30
			9:55 AM	10:13 AM	0:18	
Nawab	7	Raees Allah Dad	6:13 PM	7:00 PM	0:47	1:17
			9:05 AM	9:35 AM	0:30	
Shamas u Din	11	Sathi Khan	6:57 PM	7:04 PM	0:07	0:15
			11:00 AM	11:08 AM	0:08	
Haq Nawaz	8	Kotla Hayat	4:45 PM	5:25 PM	0:40	1:35
			7:45 AM	8:40 AM	0:55	
Bashir Ahmad	12		4:52 PM	5:00 PM	0:08	0:14
			7:53 AM	7:59 AM	0:06	
Lal Bakhsh	11		5:07 PM	5:36 PM	0:29	1:11
			7:38 AM	8:20 AM	0:42	
M.Naseem	8		5:45 PM	6:05 PM	0:20	0:30
			7:40 AM	7:50 AM	0:10	
M.Iqbal	7	Basti Khambra	5:43 PM	6:39 PM	0:56	2:04
			9:22 AM	10:30 AM	1:08	
Sajid Ali	7		5:50 PM	7:30 PM	1:40	3:33
			9:27 AM	11:20 AM	1:53	
Shaukat Ali	8		7:19 PM	8:05 PM	0:46	1:41
			8:51 AM	9:46 AM	0:55	
M.Abbas	7	Fatehwal	4:22 PM	6:13 PM	1:51	3:05
			6:56 AM	8:10 AM	1:14	
Shabir Ahmad	12	Raees Allah Jawaya	4:53 PM	5:53 PM	1:00	1:50
			7:05 AM	7:55 AM	0:50	
Karim Bakhsh	11	Raees Allah Jawaya	5:17 PM	6:30 PM	1:13	2:07
			7:11 AM	8:05 AM	0:54	

Annexure 2

Output time measurement of surveyed Biogas plants (Sep 2008)

S.No	Beneficiary Name	Mouza	Village	Average Time	Dung Kg/ Day
1	Jam Mureed	Dera Dehran	Jam Shahroo	2:15	35
2	Manzoor Ahmed	Dera Dehran	Jam Shahroo	4:58	70
3	Niaz Ahmed	Makhan Bela	Malik Mehram	4:29	55
4	Muhammad Sharif	Makhan Bela	Malik Mehram	4:22	55
5	Muhammad Nawab	Makhan Bela	Rais Allah Dad	3:45	50
6	Muhammad Hashim	Dera Dehran	Jam Shahroo	2:23	45
7	Siraj Ahmed	Dera Dehran	Jam Shahroo	5:18	75
8	Ashiq Hussain	Dera Dehran	Jam Shahroo	1:55	55
9	Sadique Ahmed	Makhan Bela	Rais Allah Dad	1:51	50
10	Waqar Ahmed	Makhan Bela	Malik Mehram	4:43	65
11	Razi Ahmed	47/NP	Jam Haleem	5:01	70
12	Muhammad Haneef	47/NP	Malik Jara	4:30	65
13	Muhammad Murad	Makhan Bela	Sathi Khan	1:19	55
14	Shamas Din	Makhan Bela	Sathi Khan	3:59	60

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