

BIOGAS TECHNOLOGY TRANSFER TO RURAL COMMUNITIES IN EGYPT

SAMIR EL-SHIMI AND SALAH ARAFA

Biogas Unit, soils and water Res. inst. Agric. Res. Center, Giza, and
Science Department, The American University in Cairo, Egypt.

Abstract -Recent studies revealed that 76.4% of gross energy consumed in Egypt's rural areas originated from building crop residues and dung cakes, while 23.6% of the needs are met by conventional energy sources. The efficiency of releasing energy from biomass by direct burning in traditional primitive stoves is very low (5-10%). Also the organic matter content in the Egyptian agricultural soil is low (about 2%), a level which is considered very poor and needs annual amendment. Besides, the projects for expanding the cultivated area by reclamation of desert sandy soils presents and additional increasing demand for organic manures. The process of biogas generation from crop residues, animal droppings, municipal solid wastes and sewage sludge could positively affect the process of rural development because of the numerous benefits realized from it. Through the cooperation between the Basaisa Community Development Association (Basaisa-IRTECTAP), the Agricultural Research Center (ARC) and the Technology Transfer Component of the National Agricultural Research Project (NARP-TTC) it was possible to plan and implement a realistic promotional program to assist the process of transfer the biogas technology to the villages of Egypt. Over 5000 rural people were reached during the promotion campaign, 40 persons got practical training on the technology, and 18 family size units and 2 farm size units were built to-date. The paper discusses the factors affecting the biogas technology transfer program and reports on the field experience with emphasis on how the problems of promoting biogas at the village level are dealt with. Guidelines for successful transfer of the technology to rural areas are given.

1. INTRODUCTION

Recent studies on the use of energy in rural Egypt (Alaa El Din et al, 1984) have shown that 76.4% of the gross energy consumed originated from burning crop residues and dung cakes, while 23.6% of the needs were met by conventional sources, e.g. kerosene, butagas and electricity. The efficiency of releasing energy from biomass by direct burning in primitive stoves is very low (5-10%). The contribution of crop residues and animal dung to net energy used in rural areas represented only one-third of total energy consumption, while conventional sources met about two-thirds.

The organic matter content in Egyptian soils is 2%, a level which is considered very poor and needs annual addition. Besides, the projects for expanding the cultivated area by reclamation of sandy soils presents an additional demand for organic manures. The available crop residues after harvest are estimated at about 22.6 million tons, out of which about 13.7 million tons or 61% are used for direct burning. Animal droppings, principally of cows and buffaloes, are used as organic manure ("Balady manure") or as fuel for rural cooking. Removal of these nutrient-rich resources from the fields deprives the farmer of much needed

fertilizer and their replacement often means the use of chemical fertilizers at a severe financial and energy cost. The annual biomass resources in Egypt are presented in Table 1. Biogas technology has become therefore interesting as a way to improve the energy release from agricultural residues, save plant nutrients, and improve health conditions and quality of life in the villages.

Table 1. Annual BioMass Resources in
Egypt, 1984

Resources	Quantity on dry Basis in Ton	Potential Utilized as Energy (1)	Energy Content 10^{15} J	Conversion Efficiency %	Net Energy Output 10^{15} J (3)
Agricultural			(2)		
Residues	22.6×10^6	13.7×10^6	200	8	16
Animal Excreta	4×10^6	1.5×10^6	17	8	1.4
Animal Power			96	10	10
Municipal Refuse	4.5×10^6		27		
Sewage Sludge	250×10^6		29		

(1) The rest is used as animal fodder and organic fertilizer

(2) Supply

(3) End Use

Source: Egyptian Renewable Energy Field Test Project, Cairo, Egypt, Sept. 1985

The process of biogas generation from crop residues, animal droppings and human wastes has attracted the interest of Egyptian scientists because of the numerous benefits

realized from it. Biogas technology provides a clean and convenient fuel for cooking, lighting, generation of electricity, and running of water nitrogen content and more free from pathogens and parasites as compared with the traditionally prepared manures. Besides, crop stalks like straw which are otherwise burned as fuel are saved for use as fodder and for silage making.

Biogas as a fuel contains an efficiency of 60 - 70% with a heating value of 5513 Kcal/m³. The estimated quantity of biogas needed to cover the daily demand in rural Egypt had been reported to be 0.6 - 0.7 m³/capita/day for cooking and lighting (El-Shimi, 1994).

The digested material obtained after fermentation and releasing the gas is a natural organic manure called "Biogas Manure" which contains high concentrations of plant nutrients and organic matter. Biogas manure is richer in essential nutrients, suitable amounts of micro-nutrients, growth regulators, vitamins and plant hormone. The manure is free from pathogens, parasites and grass seeds as compared with traditionally prepared from the other organic manures. The mean values of chemical analysis for air dried biogas manure which prepared from cattle dung are presented in Table (2).

Table 2. Characteristics of Dried Biogas Manure Produced from Biogas Digester Fed With Cattle Dung

Parameter	Unit	Ranges
Moisture	%	20.85-26.35
Organic Matter	%	48.82-56.57
Organic Carbon	%	28.02-32.47
Total Nitrogen	%	1.39-1.45
Carbon: Nitrogen, (C/N ratio)	%	20.15-22.35 :1
Total Phosphors	P ₂ O ₅ %	1.20-1.45
Potassium	K ₂ O%	0.48-0.95
Zinc	ppm	3-4
Iron	' '	5-10
Manganese	' '	7-13
Copper	' '	0.2-0.4
E.C.	M mohs/cm ³	1.08-1.17
Sodium Chloride, (NaCl)	%	0.22-0.25
Salinity	ppm	691-748
Density (weight of m ³)	kg/m ³	280-285
Water Holding Capacity	%	300-390
Odor	-----	None

The direct and residual effects of biogas manure as a complete substitute for NPK and micro-nutrients on growth and yields of principle crops were evaluated during the years 1982-1983 through filed experiments in the old Egyptian lands. The application of biogas manure at the rate equivalent to

traditional chemical fertilizer increased the yield of maize 35.7%, wheat 12.5%, rice 5.9%, broad bean 6.6%, cotton 27.5%, carrots 14.4%, and spinach 20.6%.

2. INTRODUCTION OF BIOGAS TECHNOLOGY TO EGYPT.

Biogas technology attracted the interest of Egyptian scientists and rural developers because of the numerous benefits realized from it. In 1980, Agricultural Research Center (ARC), Ministry of Agriculture (MOA), National Research Center (NRC), Egyptian Academy of Scientific Research and Technology (EASRT) and Faculty of Agriculture at Fayoum; Cairo University started research programs to introduce the biogas technologies in rural Egypt.

Soils and Water Research Institute (SWRI) ARC started since 1980 a research and demonstration program to promote the biogas technology in rural communities and new reclaimed lands. Biogas Training Center at Mushtohour in the Delta Region was constructed by SWRI ARC to help the biogas users in construction, maintenance, and utilization of biogas technology. More than 900 biogas digesters were constructed, operating in various governorates so far, with different capacity, gas utilization, and environmental impacts.(El-Shimi, 1994)

Three types of biogas digesters are applicable in rural Egypt; the first is the Indian type which is fed with animal droppings. This digester is provided with gravel basin to produce air dried biogas manure. The second type is the Chinese biogas digester which is fed with crop residues and vegetable wastes. The major constraints in rural areas are scarcity of animal droppings and large amount of crop residues. So, the ARC modified the design of the traditional biogas digesters to suit the Egyptian farms. The new system is a two-stage fermentation system fed with both animal droppings and crop residues to cover the energy consumption for household.

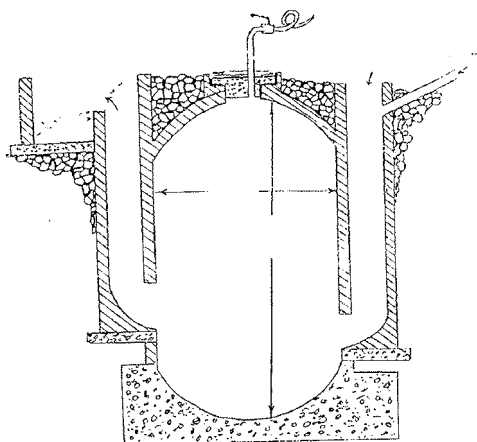


Fig. 1.A. Chinese Type Digester

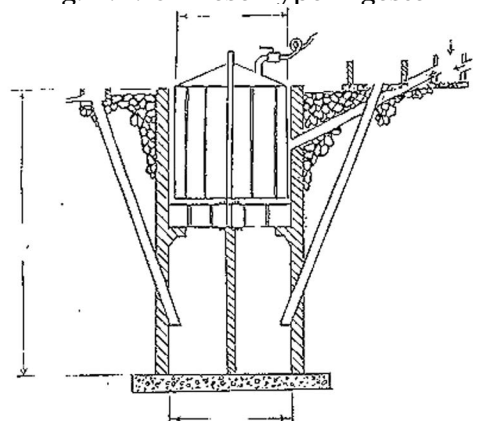


Fig. 1.B. Indian Type Digester

3. INTRODUCTION OF BIOGAS TECHNOLOGY TO THE BASAISA VILLAGE.

The first concepts about biogas were introduced to the people of the Basaisa village by the AUC, NSF-Basaisa Integrated Field Project. (Arafa et al, 1978) During group discussions in the initial stages of the project as early as summer of 1978.

In May 1982, Prof. Arafa approached the Scientists of the Agricultural Research Center (ARC), Ministry of Agriculture, with a view to collaborating with them in a biogas program for the Basaisa area.

The first phase of activity in the program of Basaisa was a visit to the Biogas training center at Mushtohour by six people from Basaisa in May 1982.

The ARC team were there to receive the Basaisa group and explained to them the technical and socioeconomic aspects of biogas plants in operation at the center. The villagers were very impressed and expressed interest to start constructing biogas plants

soon in Basaisa. Two weeks after the visit to Mushtohour, a scientist and technician from ARC visited Basaisa Village and a seminar on "Biogas for Rural Households" was given at the village community center. The seminar was supported by a slide show and posters and was attended by a large group of village inhabitants of all ages, males as well as females. As a result of the visit and the seminar, 10 households expressed an interest to build such units. A final plan for construction, based on this survey, had two household units and one collective unit.

It was decided that one person from Basaisa should receive some technical training at the ARC the following week. However, two appointments given to him were canceled. The first time, the ARC technician was not available, being busy elsewhere, and the second time, due to some labor problems construction at another site required attention. Ramadan started on 22 June and since it was unlikely that any construction would take place during this time other paper formalities were initiated and undertaken during this month.

Knowing that the farmers would require financial incentives to opt for a new energy source such as biogas, the project decided that the money given to each household for construction would be regarded as a soft loan from the cooperative repayable over a period of 10 years. The project philosophy was not to give anything to any individual completely free. The cement was obtained from zagazig and certain paper formalities were completed before the cement was released. Sand, gravel, etc., were bought from the local market and stored systematically in the technical center. During this procurement, One person from Basaisa was actively involved at each stage.

The project team usually visit Basaisa on Fridays, and being a holiday, the ARC team was not keen to visit Basaisa on that day. The people of Basaisa would leave their other agricultural chores to receive and make necessary arrangements for the scientists and the technician who would fail to turn up at the appointed hour. The village enthusiasm, resources and manpower were thus all available but the work was delayed. Thus we come to the question of who is to be educated? Are they the patient farmers in the villages or bureaucrats in the cities? If

appointments are not honored, will villagers not lose faith in our concern for their development? The constant delays (be they unintentional) and wasting of their time is very unfair to them. We were anxious not to spoil the reputation of the project itself (with the village people). After several meetings with the ARC team, by the end of February 1983, the three biogas plants were completed. The ARC also organized a training course for extension, civil engineers, masons and plumbers. This multi-purpose program was attended by two people from Basaisa.

The three plants were formally inaugurated on April 1, 1983 by the officials from the Al-Sharqiya governorate and visited by many people from nearby villages in the area.



Fig 2: The construction of the first Biogas plant in Basaisa.

The actual cost of construction of biogas plant was estimated as L.E.1000 according to 1982/83 prices. No one will risk up such amount in a venture whose outcome is not apparent at the beginning. Thus the project considered an amount of LE 400 as a subsidy to each plant of 10m³ Indian type and L.E. 300 each plant of 10m³ Chinese type. The remaining cost was given as a loan for the end-user from the Basiasa community cooperative. The smoothness and efficiency of the operation of the plants determined the spreading of biogas technology to other end-users in Basaisa and to other villages in the area. Short-term training courses were conducted in Basaisa (rather than in Cairo) to maximize the benefits from this experience. Now, villagers from neighboring-communities easily visit Basaisa to inspect the biogas in operation and to seek technical and financial consultations.

The preliminary results indicated that the initial cost is very high and is a potential barrier to the spreading of the technology.

The question of subsidizing biogas was thoroughly discussed and a more attractive scheme for implementation was recommended based on experience and discussions with

As already stated, the success of the units built in Basaisa will reflect on the spreading of biogas use in the area. Work on promoting biogas plants began in October 1992 in collaboration with ARC, and with financial support from the technology Transfer Component of the National agriculture Research project (TTC-NARP). Different types of training courses were organized at the newly constructed Basaisa Integrated Rural Technology Center for Training and Production (Basaisa-IRTECTAP).

4. TRANSFER OF BIOGAS TECHNOLOGY TO RURAL COMMUNITIES

Basaisa-IRTECTAP has designed an awareness training program for biogas technology transfer in Rural Egypt. (El-Shimi & Arafa, 1995 and El-Shimi et al, 1995). The activities of this program are as follows:

Table 3. Project Plan and Activities

1st. year	2nd Year		Year				
Quarter	1	2	3	4	5	6	7
1	2	3	4	5	6	7	
STC	—	—	—	—	—	—	—
GTC	GTC	GTC	—	GTC	—	—	—
2TS	3TS	3TS	3TS	3TS	3TS	3TS	3TS
ID	ID	ID	ID	ID	ID	ID	ID
10PID	7PID	7PID	2PID	2PID	2PID	2PID	5PID
2TAV	5TAV	5TAV	4TAV	4TAV	4TAV	4TAV	4TAV
—	SF	SF	SF	SF	SF	SF	SF
CON	CON	CON	CON	CON	CON	CON	CON
—	MO	MO	MO	MO	MO	MO	MO
—	—	—	EV	—	—	—	EV

STC Special Training Courses

These are technical courses for:

- i) Project staff
- ii) Board members
- iii) Potential local cadre

GTC General Training Courses

These are designed as public education awareness campaign for:

- i) Farmers
- ii) Agriculture extension officers
- iii) Members of NGDO's
- iv) Youth graduates
- v) Public figures
- vi) Financing Agents
- vii) Policy and decision makers
- viii) Agriculture/Technical schools
- ix) Agriculture/Technical universities
- x) Mass media



Fig 3: Training Class of Rural Communities

- TS Training Sessions for
- i) End users
 - ii) Local cadre
 - iii) Local craftsmen
 - iv) Public
- ID Information Dissemination sessions in the field with demonstrations
- PID Promotion and Information Dissemination visits
- TAV Technical Assistance and field visits
- SF Supervision and Follow up visits
- CON Construction of biogas plants
- MO Monitoring: Periodic visits by the local technicians to plant's sites for monitoring, maintenance and repairs
- EV Evaluation: This is done by the project team with the local technicians.



Fig. 4: Household Biogas Unit



Fig 5: Biogas Digester Under Construction

5. ECONOMIC RETURNS FROM HOUSEHOLD BIOGAS DIGESTERS

Following is a pre-feasibility study for the Household Biogas Digester (Indian type 10m³). Technical assistance and supervision is not included.

5.1 Total Cost

L.E. 2700.0 L.E. = 850\$

Civil constructions: 1890.0 L.E. (70% of cost), 50 years life span

Gas holder: 756.0 L.E. (28% of cost), 15 years life span

Accessories: 54.0 L.E. (2% of cost), 5 years life span

The cost of constructions and the other equipment are calculated based on 1991 price without government subsidy.

5.2 Capital Consumption Rate

Civil constructions: 38.0 L.E./year (2% yearly)

Gas holder: 50.0 L.E./year (7% yearly)

Gas equipment: 12.0 L.E./year (20% yearly)

Total Capital Consumption: 100 L.E./year (3.6% of total cost).

5.3 Daily Loading Rate

75.0-90.0 kg fresh cattle dung/day. This is equivalent to the cattle dung produced from 4-6 big animal/day.

5.4 Biogas Production(energy)

Biogas production rate:

1.0m³/5.26 kg dry cattle dung equivalent to 31.0 kg fresh cattle dung.

Daily biogas production: 2.4-3.0m³/day.

1.0m³ of Biogas equivalent to the following conventional energy

sources: 0.40 kg Butagas, or 0.60L Kerosene, or 0.79L Natural gas, or 7.45 kg dung cakes, or 6.84 kg crop residues, or 7.90 kg water hyacinth, or 2 kwh electricity.

Value of Yearly biogas production as equivalent to the value of Kerosene is 154-194 L.E./year.

5.5 Biogas Manure (Natural Organic Manure)

0.15-0.18m³/day equivalent to 54-56m³/year as a liquid form contains 5-7% of total solids.

15.0-16m³/year as an air dried form

Price of the air dried biogas manure: 30 L.E./m³ on basis; 0.15, 1.07, 1.17 and 0.77 L.E./kg of organic matter, nitrogen, p205 and k20 respectively.

Value of biogas manure production: 480-600 L.E./year.

5.6 Operation Cost:

0.30 L.E./day as a price of fresh cattle dung and cost of daily operation. 108.0 L.E./year.

5.7 Economic Return:

Energy return	(+) 174.0 L.E./year.
Manure return	(+) 540.0 L.E./year.
Capital Consumption	(-) 100.0 L.E./year.
Operation cost	(-) 108.0 L.E./year.
Net Return	L.E. 508/year

The household biogas could therefore cover its total cost in five years. The household biogas digester (10m³) will cover the domestic energy needs for rural family consists of 5-8 persons. Also producing the natural organic manure, with high quality is enough for completely fertilizing two feddans during the agriculture rotation period.

6. OUTPUTS AND ACHIEVEMENTS

Over 5000 people were reached during the promotion campaign and over 400 people got first hand information about the technology. The project has established credibility among local inhabitants through active field visits, field days and demonstrations.

Over 40 persons got practical training in biogas technology. The trainees have become catalysts for change and active players in promoting the technology.

The design of an acceptable financing system attracted farmers to purchase biogas units. The system is as follows:-

The farmer will pay the amount of 100 L.E. at the starting time of the construction process. The project personnel will offer the technical assistance free of charge. The farmer will contribute for most of the non-technical labor and some of the cost for building materials as much as he can afford at the time of construction. The remaining cost of the plant (estimated to be 2500 L.E.) will be taken from the Basaisa village

cooperative as a loan to be paid-back in installments for a period of maximum 4 years with no interest. After the 4 years period the farmer is going to pay an interest rate of 2.5% on the remaining amount for every month of delay. The loan scheme was discussed and approved by the majority of the trainees and the potential end-users.

* Brushures and manuals were written and circulated among interested people. The manual defines the biogas technology and describes the steps for the construction of plant and the procedure to apply for the loan system as well as other activities of the cooperative.

* A company for commercialization of biogas plants to be administered by young graduates who were trainees at Basaisa-IRTECTAP and who do believe in biogas as one of the important future energy resources for villages and desert communities have been formed.

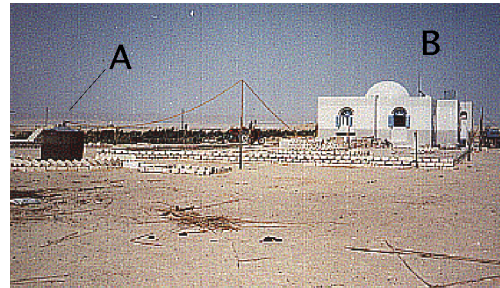


Fig 6: The communal house in the New land community at Ras Suder, Sinai with the biogas plant connected to the kitchen and the PV array on the roof to power the house.

* The project is seeking additional funds to continue its biogas program. The target is to build 5000 units by the end of this century.

7. ACKNOWLEDGMENTS

Thanks to Basaisa-CDA, IRTECTAP and AUC, NARP, ARC for support. Special thanks to Dr. Lakany, Ms Kaddah and Ms Abu Shadi for assisting in the preparation of the text.

8. REFERENCES

- Abdallah, H (1982) "The Energy situation in Egypt", Ministry of Petroleum, Egypt.
- Alaa El-Din, M.N., Rizk, I., El-Lakkni, H. Abdel-Nabey, M., El-Sabbah, M. and El-Shimi, S.A. (1984) "Rural energy in Egypt, A survey of resources and domestic needs",. Inter. Cong. state of the art on biogas technology, transfer and diffusion, NRC, Cairo, Egypt.
- Arafa,S. and Nelson,C., 1981 "Rural Energy: Energy Consuming Activities and Traditional Energy Resources in the Village of Basaisa", AUC-NSF-Basaisa Project Report No. 01127-11.
- Arafa,S., Nelson,C. and Lumsdaine,E (1978) "Utilization of solar energy and the development of an Egyptian Village: an Integrated Field Project", Project proposal approved and supported by the US National Science Foundation, Grant No. 78-01127 and sponsored by the American University in Cairo.
- El- Shimi, S.A.(1994) "Biogas Production and Utilization in Rural Egypt. Activities and Achievement of Agricultural Research Center",. Egyptian - French Seminar on Biological N-Fix Associated with Cereal Crops, Giza, Egypt, Sept. 26-28.
- El- Shimi, S.A., and Arafa, S.M. (1995) "Biogas Technology for Rural Egypt",. Conf. on Settling Technology for Industrial and Social Development. Alex. Scientific Committee of the Alexandria Syndicate of Engineers,Egypt, Jan. 24-26.
- El-Shimi, S.A., Arafa, S.A. and Badawi, M.A. (1995): "Environment and Economic Returns for Reuse Urban and Rural wastes",. Conf. on Environment and Economic. Cairo, Mansoura University, Egypt, April 17-19.