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THE DEVELOPMENT AND APPLICATION OF BIOGAS TECHNOLOGY IN RURAL AREAS of EGYPT

Ninth progress report (PR/9)

Submitted to th JCC

by

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1- INTRODUCTION

This Summary progress report covers the period from April to september 1983. Its basic objectives are to outline recent achievements, compare them with the previously set plans, and propose the future course of action. In addition, the U.S. Panel report is annexed.

2- PLANS vs. ACHIEVEMENTS OVER THE PAST SIX MONTHS

In the previous report (PR/8) plans for the period were set in the section entitled 'future course of action'. They constituted five major anticipated activities. In general, accomplishments were slightly short of plans. However, additional activities, not included in the plans, were undertaken.

2.1 Completion of the Shubra Kass Unit

As outlined in the previous report, a large scale demonstration digester was installed at Shubra Kass village mear Tanta. Its size is 50 cubic meter and is attached to a poultry rearing aperation. Funds were provided by VITA (Volunteers In Technical Assistance). At the time of preparing the last report, the unit was under preliminary test conditions.

Over the past six months, the unit was successfully started up. Additional technical features and ancillary equipment were introduced. These principally encompassed creating a green-house effect oround the unit, and converting a petrol engine-generator to operate on biogas. The first feature will reduce the heating requirements, thus makes more gas available for use. The second will improve the economics by providing alternative use for the biogas

When it is not being fully utilized for warming up the chicks. Furthermore, electricity can be generated at will on site, thus safeguarding the farm against the frequent power failures. The unit is presently approaching steady-state conditions.

2.2- Follow-up of operating Demonstration Digesters

Performance of all other demonstration digesters at Manawat, Omar Makram and NRC was monitored on a regular basis. The status of each individual field digester is outlined in the following:

A- Field Demonstration Units at Manawat

A.1- The Modified Indian Family Unit attached to the Khamis Family House.

This unit continued manifesting its technical as well as socio-economic success. It established itself as an integral component within both the household and farming systems.

A new mixer of an improved design and strength has been installed in the feed tank of the unit. The gas-holder has also been replaced by a new one. Though the old gas-holder was still functioning satisfactorily after two years of operation, its original low quality workmanship coupled with the development of excessive rusting on the outside, called for the replacement decision to avoid future hazards.

A.2- The Modified Chinese Plant at the Village Collective Unit

Despite the extremely well technical performance of this unit, it failed to fulfill its mandates. In

contrast with the Khamis family unit, this unit suffered from neglect by the governoment employees who feel no special attachment to or need for the unit. It is considered as a public exhibit and ownership. Thus feeding is quite irregular, and mostly done by the NRC Project team in order to keep the unit in a very low operating condition.

In order to simplify its running requirements, the outlet has been connected to a septic tank. This would alleviate the need formandling the effluent on a daily basis. Every few months, the septic tank will be evacuated mechanically and the resulting sludge will be applied in the Collective unit farm as an organic fertilizer. In addition, the digester holding time will be prolonged considerably by reducing the daily feed load to the minimum.

B- Omar Makram Demonstration Units

B.1- The Chinese-type Unit attached to the Sharkawy family House.

This also typifies another all rounded successful demonstration. The performance has always been outstanding and the family takes very good care of the unit. The unit covers the household energy needs. In addition, Mr. Sharkawy reported that the use of the digester effluent instead of the farm-yard-manure has effectively increased the agricultural cash income by some 30%. This is attributed to both increased yield and improved quality.

As in all project demonstration digesters, a new mixer has been installed in the unit feed tank. It is of the same previous design in this case, but much more rugged.

It was also noted that the gas produced in this unit exceeds the requirements of the family cooking and water heating using two simple gas stoves. The family requested the addition of a gas oven. In response to this request, and as a reward

for the much care and diligence taken by the family in running and maintaining the unit, a new modern gas range (with oven) has been supplied to them (actually it is a standard butagas range modified by the Engineering Group to operate on biogas). A greenhouse has been also installed around the unit to increase its productivity, particularly during winter.

B.2- The Diab Family Indian-Type Unit

This unit was also running fairly well. The family, However, was uneasy with two things. First, is the nasty job of handling the slurry, since in this particular case they chose to have the compost heap right outside the house. Thus, they have to carry manually many loads of the slurry from its tank to the compost heap. This has been resolved by building a slurry tank outside (next to the compost heap) and connecting the tank to the unit by a brick-laid channel. Flow is maintained by adjusting the levels from the unit exit to the outside slurry tank.

The second issue was that the gas produced is short of the family heat requirements. This aggravates very much during the winter season. Two reasons are behind this gas insufficiency (aside from the low ambient temperatures during winter). The first is that the unit size is relatively small (only around six cubic meters). The second is the small number of animals (three). To cope with this situation, a greenhouse has been installed around the .unit to effectively increase the digestion temperature and hence the gas productivity. In addition, the family promised to increase their cattle ownership to the previous level (5 animals) when the unit was originally installed. Furthermore, we plan to provide the family with an extra stove burning agricultural stalks of the type being currently developed in the Pilot Plant Laboratory of the NRC.

B.3- The Indian-type unit shared by the two Families

Despite the technical success, as manifested by the performance of the unit during the first few months of regular operation (and even till now under no feeding conditions), both families stopped operating the unit on account of social differences. Actually, this has always been anticipated by the project

leaders on account of the well known, deeply-rooted possessive nature of the Egyptian peasant (a common rural proverb says " a chicken of your own rather than a jointly-owned buffallo ".

Many attempts have been made to remedy the situation. None has succeeded so far. However, we are still continuing with further ideas. The objective is not to keep the unit running under forced conditions, but rather to exhaust the list of options for the purpose of learning more about possible socio-economic manifest ations and possible regulatory actions.

The Joint U.S. Panel Report attached in the Annex elaborates further details on the status of the demonstration units. It is based on the short-term sociological evaluation conducted jointly by Dr. H. Capener, the Project Principal Investigator and key members of the Engineering Group.

B.4- The NRC Plug-Flow/Indian Unit

As was mentioned in the previous reports, a new site in the NRC extension area was allocated to the Project. All activities have to be transferred there. However, since the new project which is going to be established in our old site has not started in the site yet, one of the three units is kept running for research purposes. The plug flow/Indian-type unit is still operating. For the past six months it has been exclusively run on poultry droppings. The purpose is to investigate aspects relevant to the large-scale Shubra Kass unit.

2.3- Preparation of the New NRC Biogas/Biomass Site

A new site, in the NRC extension area, is being developed to accomodate the development activities relating to the biogas project as well as biomass and bioenergy-related type of R&D work. The development of this site is planned in such way as to

provide the basic requirements for a core of multidisciplinary endeavors.

As to the biogas technology related activities in specific, the site will provide sufficient ground space to build around 5 types of prototype digesters, three of the already demonstrated designs, and two new designs under development to cope with certain dominant constraints in rural Egypt. The construction period of these digesters will provide a unique chance for training as well as educational material through video tape recordings. These digesters will be furnished with as much as possible measurement devices in order to provide for thorough performance assessment under equal conditions.

A fair Portion of the site preparation tasks has been accomplished. A ready-made cabin (35 m^2) has been installed to house the personnel working on site. Electricity and water have also been connected to the site. All these achievements only constitute around 60% of the planned site preparation work.

2.4- Supporting Research Activities

These continued along the same lines presented in the last report. The highlights of these works may be summarized in the follwing:

A- The Fertilizer Evaluation Group:

A.1- The Omar Makram field experiment indicated that the yield of crop (potatoes) as a result of biogas manure application increased by around 50% and 20% over the chemical fertilizer and farm-yard-manure treatments respectively.

A.2- The prolonged greenhouse investigations aimed at following up the fertilizer accumulative residual effect will continue for another year. So far, the results tend to indicate that the air-dried slurry gives the highest increases in wheat yield. Meanwhile, the application of fresh biogas slurry, though induced the lowest increases in wheat yield, manifested the highest increase in the soil water holding capacity. Other results are generally in line with previous findings.

B- Pollution Control Group

Follow-up of operating field digesters in Manawat, Omar Makram and Shubra Kass was carried out to investigate the effect of anaerobic digestion and post composting on the bacterial viability. Tests included:
total bacterial counts; and enumeration of total coliform, faecal coliform, and faecal streptococci groups.

Results indicated that:

1- The anaerobic digestion process is very effective in reducing the numbers of both the total viable bacterial counts and the bacterial indicators of pollution examined. A removal up to 99% was recorded.

2- The difference in the design of the digesters exhibited no significant effect on the fate of bacteria during the digestion process.

3- Good operation and maintenance of the units, particularly that in Manawat, is prevailing.

4- On account of apparent inconsistencies, the effect of post composting on the viability of bacteria mandates further investigations.

C- Parasitology Group

C.1- Parasitological and bacteriological examinations of samples received from various field digesters indicated the persistence of some highly resistant pathogenic agents. These encompassed: ascarid eggs and Eimeria oocysts on the parasites side; and Salmonella spp., Clostridia spp. and Mycobacteria spp. on the pathogenic bacteria side. In some instances, however, certain conflicting findings with contradictory results, as the presence of certain pathogens in the outlet samples despite their absence in the inlet ones, were noted. These, in addition to the qualitative nature of the identifications, call for further study.

C.2- Additional laboratory-controlled investigations were continued to assess the effects of certain variables and treatments on the most predominant pathogens, particularly the Ascarid eggs and the oocysts of Eimeria spp. The treatments involved the influence of use of lime as well as certain biological treatments. Both were effective. The latter treatment, however, in which some fungi (helminthiophages isolated from the soil) manifested the ability of inhibiting either the development of Ascarid eggs or even destroying them, is of considerable promise.

D- Fundamental Microbiology Group

Work centered on scum formed during the anaerobic digestion of cattle dung. Results showed that:

1- Contrary to the general idea, scum formation resulted in an increase in the pH values within the scum (pH values 7.5-8.5 within scum vs. 6.9-7.3 in the subscum layer).

2- The formed scum can be dispersed by adding anti-bloat agents which are composed mainly of polymethylsiloxane and silica. This appears to have good prospects in combating the undesired phenomenon of scum formation. Thus, the group will concentrate on this direction by using antifoaming agents; and at the same time assessing their effect on the different biochemical activities of the different microbial groups (i.e. cellulose decomposers and methanogens).

E- Central Services Laboratory

This group has increased its support services to such an extent that it is undertaking almost all chemical and instrumental analysis work required for follwing up the performance of operating digesters, including the evaluation of the digested effluent as fertilizer. For instance, spectrophotometric determinations of elements such as Na,K, Fe, Ni, Cu, Zn, Mn, amd Mo covered around 250 samples.

Training of the members of this group is continuing both abroad and on job. One of the laboratory supervisors, Dr. Samy ElAfifi, was trained at Perkin Elmer facilities as well as at the specialized laboratories of the Metropolitan Sanitary District of Greater Chicago. He conveyed the experience thus gained to his colleagues and assistants through intensive lectures and practical demonstrations.

2.5- Additional Activities

Two more activities that took place during the report period are worthy of mention.

The first pertains to contacts established with two industrial complexes in upper Egypt: Aluminium Company of Egypt and the Egyptian Chemical Industries Co. in Aswan. This constitutes a new element of an important dimension in the Project lifecycle. Both companies are undertaking, as a side activity, large scale cattle raising as well as land reclamation and cultivation. A visit has been made to the Aluminium Co. in Najaa Hamady to explore the possibilities of biogas technology additions and prospects of joint cooperation. Consequently, and upon the company's request, the Engineering Group has prepared a prefeasibility study which will be soon submitted to the company. Results of this preliminary study are encouraging. A 225 m^3 biogas unit has been proposed.

The second notable activity relates to the International Biogas conference planned to be held in Cairo next year. The conference is intitled " state of the Art on Biogas Technology, Transfer and Diffusion ". It will be held November 17-24,1984. The first annoucement and call for papers has been issued in August 1983.

3- FUTURE PLANS

Future work will continue very much along the same lines outlined in this report. More emphasis, however, will be put on the following:

1- Completion of the new biogas project demonstration site at the NRC extension area.

2- In-depth evaluation of the techno-socio-economic viability of the prospective biogas technologies under the prevailing conditions in the rural areas of Egypt.

3- Arrangements for the November 1984 International biogas conference to be held in cairo.

ANNEX

Rhe U.S. Panel Report

REPORT ON THE ANNUAL EVALUATION OF THE SOCIAL, ECONOMIC, CULTURAL AND POLITICAL IMPLICATIONS OF BIOGAS TECHNOLOGY DEVELOPMENT, TRANSFER AND DIFFUSION

General Appraisal

Now proceeding into the fifth year of its design, implementation and feasibility testing, the biogas project has reached a stage of maturity from which meaningful village application assessment can be made. Overall, there are clear examples of both successful and failed systems of biogas development. From a technical analysis, all six of the digesters in the three separate villages can be said to be performing very satisfactorily. From social and cultural evaluation criteria, two of the digesters must be described as troubled systems.

Why Are Two of the Six Biogas Units Failing as Demonstration Projects?

It should be emphasized again that from a technological standpoint the two digesters are performing very satisfactorily. The problems lie in the areas of social adaptation and accommodation. The first of the ailing systems is a Chinese model which, interestingly, has shown the best technical performance. The failure of the unit lies primarily on grounds of social and system use feasibility. The biogas unit is installed in a government institutional setting where there is a combined social center and elementary school facility. A fairly large number (50-100 head) of water buffalo calves are being fattened and sold as veal to the market as a money-making project. The biogas unit is designed to use some of the waste products from the animals as a source of digester material.

The present constraint on the success of the digester is the fact that the social center and school personnel are only present during the

official working hours of the day. This means continuing personnel are not present to care for the digester nor to make effective use of the products of the digester such as the gas and fertilizer.

This situation is one where more time and attention to creative social engineering are required to systematically address the opportunities being lost. A few suggestions are offered which may stimulate a needed group-level problem-solving approach:

1. A visit of suitable outside dignitaries might be arranged to get the attention of the social center and school officials and teachers. Such dignitaries might come from the National Research Center, the Governate, the Ministries of Education, Agriculture, Health, and Energy, ORDEV, or any combinations of the above.
2. Social center and school officials and teachers might be asked to respond in helpful ways to questions such as the following:
   a. What relationship, if any, does the biogas demonstration project have to the programs of the social center or the subject matter being taught by each of the teachers? Obviously, the relationship may be greater to the health or homemaking services of the center or to the physical and natural science subjects in the school. Still, there is much to be learned if the social service center and the school personnel could be persuaded to become totally aware of and to adopt the biogas demonstration project as a constituent part of the social center program and the school facility and curriculum.
   b. In what ways could the biogas project be used as a village demonstration of home and health improvements or as a labor-saving mechanism for both men and women? To what extent could

student practicals be built around experiments with biogas relating to subjects like science, chemistry, mathematics, economics, biology, home economics, social studies, and health services?

c. In what ways might the social center or school utilize the total biogas demonstration system as an educational and teaching facility for residents of the village or for parents of students and/or for particular groups of the village? For example, could a set of demonstration vegetable gardens be established along the lines of the Grow More and Better Food program? Could fertilizer demonstration trials be carried out? Could the calculations of costs and benefits of the biogas system be assessed and used as case study material in math and social studies courses? Could the questions of what appropriate technology is and what would have to happen at the individual family household level for the biogas technology to be accepted and adopted be addressed in various parts of the school curriculum or by staff at the social center?

d. Could a school parents' day, an older youth day, or a village field day be planned to demonstrate to relevant audiences the farming system, household system, and village system level benefits that projects like biogas, Grow More and Better Food, and Integrated Rural Development can provide.

3. In a real sense, approaches within a social center or a school system can be likened to the 4-H extension approach, wherein it is recognized that participative education through youth, both boys and girls, is an effective way of intervening in the cycle of age-

old, tradition-bound patterns within the farming and household systems of village life.

4. Considerable advantage could be gained by using an analysis comparing the two biogas demonstration units within the village of Al-Manawat, one of which is the ailing Chinese model already described, with its location within the social center and school setting. The second is a totally successful unit which has been installed at the nexus between the private farming and household systems of the Khamis family. The latter is a fairly typical farm family consisting of a husband and wife, a daughter, and a married son and his wife. The family owns three acres of land and rents two acres. They have six cows and a donkey. The biogas unit is connected to the barn to receive the animal waste and is also connected to the family latrine. The family-size digester provides an excellent demonstration of the practicability and feasibility of the biogas unit so far as its cost effectiveness, labor saving, and sanitation are concerned and as an alternative energy source and a labor-efficient source of desirable fertilizer.

5. In terms of comparative analysis, the two units potentially offer a useful contrast and therefore a rich set of educational and appropriate technological resources, if ways could be found to take advantage of the opportunities, particularly as a theme of Integrated Rural Development begins to characterize the thinking and planning of those leaders inside and outside rural villages.

The second troubled system, again failing on social and cultural criteria but succeeding technologically, is in the new village of Omar Makram. The design of this biogas unit is a modified Indian model.

The challenge of the installation has been a calculated risk to place it in a position to serve two separate unrelated family household units. These two familiies have barns that are side by side. The digester is placed just outside the two barns in a courtyard that separates the two houses.

At the beginning the two families had a history of amicable relationships and of being good friends over a period of some fifteen years. However, the digester could have been predicted to put the best of relationships to a very severe set of tests as its requirements for mutual trust and willing cooperation placed such demands as:

1. Agreements about how much animal waste each family would put in the digester on a daily basis.
2. Agreements on how much of the biogas each family can or should use on a daily basis.
3. Agreements on how much of the digested effluent each family is entitled to use for fertilizer on a weekly or monthly basis.
4. Agreements on a regularized time schedule on a daily basis for feeding the digester and for using a share of the biogas.
5. Agreements on who should be observing the relative height of the cover of the digester to monitor the general availability of biogas for use.
6. Agreements on by whom and how remedial measures will be taken to feed more materials into the digester when the level is too low.
7. Agreements on by whom and how remedial measures will be taken in the event of any malfunction of the digester.
8. Agreements on who will act as spokesperson for each family in the event of questions, differences of opinion, or any disputes.

9. Agreements and understandings about who owns the digester, the auspices under which it came, the understandings by which it can remain, and who has final jurisdiction about its long-term future.
10. Agreements on the placement of the digester, keeping in mind the importance of land and property in the minds of each family.
11. Agreements on who can serve as an acceptable arbitrator in the event disagreements occur and/or trouble arises beyond the two families' abilities to settle or resolve.

It is a well-known fact that in rural villages relationships between and among families are historically, traditionally and culturally bounded. The antecedent roots of values, beliefs and attitudes run deep; therefore the management of relationships between unrelated families is difficult, if not improbable.

It is not at all surprising that serious difficulties for the biogas project have arisen. In fact, they have arisen on nearly all of the points listed. At the latest visit to the site on June 2, 1983, the amount of biogas built up in the digester was very high. Neither family was allowing the other to use the gas. Neither family had any trust or confidence in fairness or cooperation, and the wives and children had become active antagonists over all of the management, maintenance and use functions of the digester.

An important principle in social-science-related development can and should be pointed up here. It lies in sharp contrast to much of development in the natural and physical sciences. In the latter case, normally experiments carried out in the laboratory or even in the field are concerned with testing inanimate objects, materials or things. If the experiment fails, the test is looked upon as having a measure of

success because one learns what does not work, and the experiment goes on for trial after trial normally enjoying financial and administrative support because the promised success only comes after continuous trial and error.

In social science development, the principle can be referred to as the "one strike" phenomenon. It means that when a new program or project is placed in an institution, community or village, its experimental subjects are individuals who have sensitive feelings related to their roles and positions and status. Therefore, if the experiment succeeds, all goes well. If the experiment fails, the one-strike principle holds; one cannot come back with second, third and fourth new trials because the experimental environment has been prejudiced.

How does the one-strike principle apply then to the two troubled biogas units in each of the two villages? The worst end result would be that the units would eventually be dismantled and counted as valuable lessons learned about conditions which do not or cannot lead to success. The time has not yet arrived in either case when the experimentation has yielded all of the important and necessary information. The reality may be, however, that the two troubled units will need to be carried on perhaps more in the framework of a null hypothesis - that is, using a wide variety of alternative solutions as a means of exploring the full parameters of what may or may not or what will or will not work in such social and institutional settings. It may very well be that at the end a longer list of creative options can be suggested for the social center and school locations. It may be that a list of 50 severe tests of a social relational nature can be identified as guides to future decision making in strategies of successful technology transfer.

Why Are Four of the Six Biogas Units Highly Successful

The high degree of success of the four biogas units measured on all criteria, both technological and sociocultural, is attributable to many interrelated variables. These can best be described as system level variables, and the goodness of fit of biogas within and between systems is what contributes to its success.

The Design and Engineering System

Very careful creative design work went into the processes of making suitable adaptations to both the Indian and Chinese models. Experimental units were built and tested before any installations were made at the village level. When the village units were installed, the best-trained, highest-paid professional engineers went to the villages, where they lived and worked continuously. This created a means whereby the quality of the installation could be personally supervised and where an acquaintance and friendship-instructional relationship could be established with each family so they would thoroughly know and understand all parts of the biogas system operation.

The Farming System: Pre-Biogas-Installation

The Egyptian village farming system contains numerous features supportive of the biogas technology. A listing of these supportive features will serve to confirm this point:

1. The typical village farm is small in size, 3 to 7 acres, and is basically organized around animals in three important respects. The first is the dependence on and use of animal power for plowing and preparing seed beds. The second is the use of animals for transport of supplies, materials, equipment and fertilizer to the farm and the

hauling of harvested crops and materials from the farm to the household and barn area. The third, and perhaps the most important, is the generation and use of animal waste as fertilizer for the farm crops.

2. The cropping system is largely oriented around the pivotal importance of the animal culture. In the two principal seasons, a winter season and a summer season, the allocation of land to crops is about half to animal feeds and half to crops for family use or market. For example, in the April to October summer season peanuts, millet, tomatoes, peppers, and eggplants would be grown. In the November to March winter season the emphasis would be on potatoes, horse beans, cucumbers, wheat and berseem.

3. The animals of the farm are at all times confined (tied), to accomplish two things: to insure that they do not get loose and destroy crops in the fields or injure someone and also to contain all of the animal waste so it can be collected and used for fertilizer or fuel.

4. The types of animals owned by farm families tend to be cows, water buffalo, donkeys and camels, in that order

5. As a means of generating an extender component to the fertilizer, the farm animals are all brought to the house in the evening and tied inside the barn attached to the house. The animals are often taken to the farm in the daytime and tied under a shade tree.

While they are confined in the barn, the common practice is to spend the equivalent of about 20 man days and about 40 donkey days a month hauling some 1,700 lbs. per day of soil from the farm to put under the animals in the barn. The objective is to soak up all of the urine and animal waste for application back on the farm. The

practice is to build the layering of this fertilizer material under the cows until it becomes so deep they can no longer wade around in it. Then the process is reversed. All of the wet mucky material is loaded into double bags on the donkeys' backs and hauled back to the fields. It is there placed in a compost pile until it can be spread on the appropriate crop in its cycle or season.

The common estimate of man and donkey gross labor expenditure per day for hauling the soil in and out of the barn is about 15 Egyptian pounds in the winter months and about 8 Egyptian pounds in the summer months.

6. Farming tends to be very labor-intensive, and the time invested in fertilizer production by available farm labor and the donkeys takes them away from other productive tasks, so that labor often has to be hired at extra cost from outside the farm.

7. Even if a portion of the animal power function of the livestock is replaced by custom tractor plowing, the more important functions of transporting, meat, milk and fertilizer will be maintained with strong emphasis.

The Farming System: Post-Biogas-Installation

1. There is no longer the necessity to allocate 20 man-days and 40 donkey-days per month to hauling enormous amounts of soil to the barn and from the farm to the fields. This saving of labor on the part of human and animal power is calculated to have an Egyptian pound value of LE 200-300 per month. Furthermore, the human and animal power can now be allocated to other productive tasks on the farm.

2. The effluent coming out of the digester after about 30 or 40 days emerges odor free and has no attraction for flies.

3. The amount of effluent pushed out of the digester on a gravity basis is comparable to that loaded into it from the opposite side. The emerging digested material is still in a slurry form and runs into a series of shallow collecting pits. As the material dries it can be crumbled into small cake-like pieces for hauling out to the field.

4. The digested material still retains virtually all of its nutrient components in its dry and transportable form. When it is hauled out to the field, it can be mixed with other animal or agricultural residues in the compost pile, or it can be applied directly to the fields or plant materials.

5. The early reports from farm use indicate that while the digested material equals perhaps only one-third of the previous volume of muck-type fertilizer, the richer nutrient value produces an equal amount of crop yield with a higher quality of product, especially for market outlets.

30% [illegible] volume

6. The dried and crumbled effluent can be plowed under in the seedbed preparation, or it can be used conveniently as a side dressing for growing plants.

7. The men point to the dramatic change from the very heavy and highly disagreeable soil and manure hauling practice as the greatest benefit of the biogas system.

8. The men say that the extra amount of free time gained from doing away with the old practice of soil and manure hauling has almost made them feel lazy. In other words, they come close to feeling guilty now that they do not have to work so hard to obtain good fertilizer materials.

9. The men are beginning to think about more productive ways the time being saved can be applied for better, more intensive farming operations. The effluent material from the digester is now being taken to the field each morning as the animals normally go there for the day's farming activity. This eliminates any extra hauling trips for the fertilizer materials.

0. The men seem to appreciate very much how the tasks of the women have been made easier by the biogas system. Still, they generally feel that on balance they have been the greatest beneficiaries in their management of the farming system.

The Household System: Pre-Biogas Installation

The Egyptian village household system comprises many features supportive of the biogas technology, as follows:

1. When the animals arrive at the household, they become the responsibility and concern of the women of the household.
2. The women do almost all of the feeding, milking, cleaning, and caring for the animals as long as they are at the household and attached barn location.
3. The cows are milked in the morning and at night. The milk is used for drinking, cooking, butter and cheese, and the extra is sold in the village market.
4. The women have to contend with the basic process of building up the fertilizer extender in the barn. This is the process in which a large amount of soil is brought to the barn nearly every day to soak up all of the animal waste for fertilizer. The soil becomes soft and mucky for both the cows and the women to wade in inside the

barn. Only when the fertilizer muck becomes too deep for the cows or the women is the fertilizer removed to a compost pile in the field and the process started over again.

5. The high value of the fertilizer for farm use places special burdens on the household system. Examples are the unsanitary and disagreeable tasks of caring for, feeding, cleaning and milking the cows twice a day; living with the pervasive odors of the cows the manure and the barn; being exposed to an unlimited fly population; having the whole household permeated with the environmental presence of the animals; and having the task of washing clothes, cleaning milking equipment, and trying to maintain a reasonably clean household.

6. A young wife would almost surely have an overload of responsibilities in terms of caring for the animals; washing; cooking; cleaning; collecting and storing fuel in the form of cow dung cakes or cotton or corn stalks; marketing and processing farm produce; and raising children. Typically, however, this total load of responsibilities is deferred for a time, since a new wife goes to live with her husband in his family's household and farming situation. The mother-in-law is in charge of the household. If she has daughters, then a division of labor is worked out to distribute the tasks to be performed.

7. All of the cooking is done on single-burner stoves fueled by purchased bottled gas called Butagas or in an outside earthen oven heated by cow dung cakes and/or cotton or corn stalks.

8. Washing of clothes is done by hand. Sometimes a family can afford a simple washing machine run by electricity, but the rinsing is done by hand and the drying by sun heat. The wash water is heated on

either of the cooking arrangements. A certain amount of washing is done nearly every day to keep up with the requirements.

9. The length of the work day tends to be very long for the farm household. Usually the women are up early, between 5 and 6 a.m. After prayers, their first tasks are to care for the animals. The fresh cow dung is collected from the muck and saved to make cow dung cakes. Then an attempt is made to clean the animals so they can be milked. The animals are fed and the milk is cared for or marketed. Breakfast is then prepared and served, and the men are sent off to the fields to work. Cleaning, washing, child care, and preparation of lunch follow. After lunch a little siesta or rest is enjoyed, followed by more cleaning, produce handling and cooking. Then it is time to milk and feed the animals again for the evening.

The Household System: Post-Biogas-Installation

1. Upon rising an hour or so later in the morning, the women approach the barn and the cows in a whole new frame of reference.
   a. There is no more wading in muck up to one's knees to get from cow to cow to milk. This change comes from the installation of a brick andconcrete floor in the barn. The floor is slanted behind the cows, and a trough is provided to wash and sweep the cow dung along the trough and into the digester, using a limited amount of water. If a small amount of cow dung needs to be saved for cow dung cakes to bake the bread in the earthen ovens, this can easily be accomplished.
   b. The cows are infinitely cleaner, since they stand or lie on a firm floor. The milking can be carried out with minimum prepa-

ration of each cow. The total time of milking and cleanup has been reduced by about two-thirds.

c. The quality and cleanliness of the milk has been significantly improved. It is more healthful for family consumption and is better appreciated in the market.

d. The extra cleaning and washing of clothes worn in the animal care and milking operation has been virtually eliminated.

2. The total cleaning of the barn on a daily basis has done much to eliminate the heavy stench of the previous bulk of barn muck that was always present.

3. The greater cleanliness of the barn and the animals has resulted in greater pride and cleanliness in the house, particularly that portion that connects to the barn.

4. The cleanliness of the barn and animals has done much to reduce the fly population.

5. The methane gas from the digester has made it unnecessary to purchase or use any Butagas from the market.

6. The ample availability of the biogas has made it possible to remodel the kitchen to install a stove of more than one burner and to add a biogas-heated oven so that all of the cooking needs are met with this source of fuel except bread baking, for which the outdoor earthen oven is preferred.

7. All of the hot water required for dishes, clothes washing and bathing is now available to the family.

8. A new indoor latrine has been installed and hooked up to the digester. This alone as a qualitative feature of an improved life style is of inestimable value.

9. When questioned about the worth and perceived value of the digester as a new feature of their household systems, all of the women have unanimously agreed that if they had to give up conveniences such as a televison set, a washing machine, or their digester, all would willingly forgo everything but their digesters.

10. In terms of overall benefits, including labor saving, convenience, sanitation, improved health conditions, more comfortable life style, general pride, and special social status, the women basically feel the household has benefited the most from the biogas system.

Principal Constraints and Principal Incentives Concerning the Development of the Biogas Resource in Rural Areas of Egypt

Summary Listing of Constraints

1. The initial cost of between 500 and 700 Egyptian pounds is too high for an individual farm family to pay in a lump sum for installation. A payment schedule against a government loan over a period of five years could provide a very feasible development plan.

2. Since the household lot size is very limited in the compact village setting, the actual space for installation of a biogas system may not be available, feasible, or allocable, considering the numerous pressures for alternative space utilization such as expanded housing, animal shelter, and storage.

3. The minimum number of livestock (cows) to assure a satisfactory biogas digester operation is four adult animals. Several rural family households may not meet this criterion in the relationship between their farming system and household system.

4. Dr. Mohamed El Halwagi, Principal Investigator of the biogas project and Head of the Pilot Plant Laboratory of the National Research Center, offers a rough estimate of the number of eligible rural households. He says, "All things considered, perhaps a quarter million rural Egyptian households out of the some five million total would suit the optimum conditions for single household biogas installations."

5. The basic objectives of the biogas demonstration project have been successfully completed. These are to demonstrate that biogas at the household level in the Egyptian village is technically feasible, economically viable, and socially acceptable. Constraining problems at the next level now arise, namely, how to move the proven biogas technology from the research environment of the National Research Center to the applied operations environment of the Ministries of Agriculture, Health, or Energy and/or the governates. Such a process entails obtaining administrators' attention, interest, and conviction, followed by incorporation into sectoral and national planning supported by necessary budgetary provisions in the national plan.

6. The U.S. Agency for International Development must assume a major level of responsibility in assisting with the transition of technology from the basic research institution to the applied program administrative institutions. In the future there may be significant advantage in creating these linking processes from the initiation of such projects.

7. The National Research Center can never assume the responsibility for implementing a national program of biogas development in Egyptian

villages. This would compromise its principal purpose. It can, however, provide the technical advice, guidance, and training necessary to assist other appropriate governmental agencies or institutions in the transfer and application of the biogas technology.

There are a logical set of training tasks which the National Research Center could and should undertake in the technology transfer process. These have to do with training the trainers of biogas development personnel in the following areas: the technical phases of engineering design and installation; the biological conversion of digester materials; the management and day-to-day operation of digesters; and the ecological, economic, social, and cultural factors essential to accord full credibility in achieving a formula for success.

8. The government policy of heavy subsidization of petroleum-based fuels will act as a strong deterrent to biogas investment. Currently many rural families are using propane gas called Butagas in their households for some cooking. This gas is available at a low subsidized cost, so the incentive to replace Butagas with methane gas is in and of itself very low. The government development policy will have to consider providing equivalent subsidies for methane gas development, which is a renewable source of energy.

9. While the logistics and cost of installing biogas digesters in individual households (generally defined as kinship family units) will be more of a problem than they would be for multifamily installations, the social fabric of the village prohibits the latter. Traditional patterns of envy, possessiveness, jealousy, and interfamily factionalism systematically undermine any well-meaning

efforts at cooperative sharing of biogas systems between unrelated kinship family systems.

10. While the temperature variation between the winter season and the summer season is not extreme--ranging between 10° and 40° centigrade or 50° and 104° Fahrenheit—there is a difference in the yield of methane gas from the digester. Generally the digester functions more efficiently in the warmer weather, but this is a time when the animals spend more time in the fields and the manure is less available for the digester. In the winter the animals then to be confined more in the barn, the green feed from berseem clover is more abundant, and the yield of manure for the digester is greater. The demand for the methane gas for cooking, lighting, heating, etc., is greater, but the efficiency of the digester is somewhat reduced.

    A planned correction for this constraint is being designed in the form of a plastic canopy over the digester to catch the sun's heat in the daytime and keep the digester more insulated against the cooler night temperatures of the winter season.

Summary Listing of Incentives

1. The demonstration project carried out at the National Research Center under the project leadership of Dr. Mohamed El Halwagi has proven that the adaptive design changes made on the Indian and Chinese digester models have achieved their desired specifications of performance. The successful results fall into numerous areas of investigation, as follows:

    a. The adaptive engineering design work concerned with availability and use of local materials such as bricks, cement, metal parts,

plastic tubing, pressure and temperature gauges, and adaptable cooking, heating, and lighting units.

b. The adaptive engineering work concerned with distance, depth, size and type of digester, type of barn arrangement, and location of digester in relation to the nature and composition of different households.

c. The biological conversion of animal waste as a principal source of material for the digester. This includes separate demonstration units for cow dung and for poultry waste.

d. The analysis, value, and demonstration results of using the spent slurry coming out of the digester for fertilizer on field crops.

e. The health benefits from the method of receiving, storing, and handling the spent slurry from the digester, which is rendered odorless, relatively pathogen-free, unattractive to flies, and light and crumbly in texture for transport to the field.

f. The flexibility and liberating utility of having abundant free biogas to use in almost any room of the house for a variety of purposes through the means of adaptable plastic tubing.

g. The careful bench scale modeling, laboratory testing, and pre-trials simulating village conditions all yielding successive and progressive information leading to the actual field trials at the village level.

h. Early in the project design, a group of social science team members selected four representative villages for conducting a detailed examination of the economic, social, cultural, and traditional issues that could be associated with introducing a

biogas demonstration. The result was greater sensitivity on the part of the project staff relative to the powerful constraints and facilitators to be accounted for in the successful introduction of the biogas experimental project.

2. As a result of the well-organized and efficiently managed demonstration project phases referred to in item 1 above, the biogas experiment has proven itself to be technically feasible, economically viable, and socially acceptable.

3. The proof of the technical feasibility of the biogas digesters is the fact that all six of the demonstration units in the three different village settings are performing very well.

4. The viability of the claim of economic efficiency is the fact that on total labor saving alone, the cost of the digester can be justified. However, since labor income is not traditionally counted by subsistence-level farmers, the new opportunity to reallocate this saved labor to direct crop production activities does command the attention and interest of farmers. Further, the better quality of fertilizer coming out of the digester is infinitely easier to handle and is bringing about a higher yielding, better quality of field crop for the market.

For the women, labor-saving efficiency in handling the animals and their products of fertilizer, fuel, meat, and milk is accorded almost equal merit as for the men. Cleaner milk for the market, cleaner clothes, a cleaner house and kitchen, and saved time for other productive household and field-related tasks were identified as economic and esthetic gains of significant value.

5. The apparent social and cultural incentive for the biogas unit is its goodness of fit as a valuable facilitating mechanism between the farming system and the household system. The biogas digester is relatively cheap to install, it is easy to operate, it is highly labor saving on the most undesirable of farm and household chores (handling the animal wastes), and the products coming out of the digester in the form of methane gas and easy-to-handle fertilizer are perceived as long-term, renewable, virtually free benefits.

   Once the conditions are in place of appropriately selected households, proper number of animals, adequate space considerations, and agreeable divisions of labor for operation and management, the positive support features for biogas in the individual village household far outweigh other considerations.

6. Administrative agencies of government such as the Ministries of Agriculture, Health, and Energy should be able to compile a realistic package of rationale, incentives, and procedural means by which the biogas developmental program could be properly phased and expanded.

7. The larger commercial-scale biogas digester, such as the one designed for the combination poultry and citrus orchard operation, has attractive private sector development potential. The growing number of poultry feeding and beef feeding enterprises can take maximum advantage of the way the biogas digester contributes beneficially between the cropping system and the animal enterprise. Biogas power derived from the digester is used to pump water to irrigate the orchards and fields. The slurry from the digester can be used to chop green feed and grains for the animals.

matic watering systems, lighting systems, and temperature control systems can be developed for poultry flocks from the biogas source of energy. The above are illustrations of the potential commercial attractions that may serve as incentives to private sector entrepreneurs and investors.

8. The concerned development agencies and organizations of national and international origin must more directly address the issues of appropriate technology transfer. The bureaucracies involved in the organizational networks may inadvertently become the major constraint to utilizing appropriate technology once it is demonstrated and proven—of they can mobilize and facilitate the incentives in ways to cause their true goals of service and development to be more fully recognized. The biogas project now brings the administrative and development organizations into the central focus. Let us hope their wisdom and skill will be equal to the challenge at hand.