PD-AAX-660

NATIONAL RESEARCH CENTER

APPLIED SCIENCE AND TECHNOLOGY PROJECT
(Project No. 263-0016)

Demonstration Subproject
(Academy of Scientific Research and Technology)

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

Third Progress Report (PR/3)

submitted to the JCC

by

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Principal Investigator

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PROJECT TITLE

The Development and Application of Biogas Technology in Rural Areas of Egypt.

BACKGROUND

The Biogas Project was a natural development of the National Research Center (NRC) keen interest in the field of renewable energy, particularly since 1975. Attempts were made to follow up developments in the field of biogas technology to assess its prospects in the context of rural development. This was complemented by two additional and concurrent actions. In the first, a multidisciplinary specialized group was organized under the NRC Appropriate Technology Committee to prepare for a national project. In addition, research on laboratory scale was initiated.

These endeavors culminated in a proposed national demonstration project for the development and application of biogas technology in rural areas of Egypt. The proposal was approved by the Academy of Scientific Research and Technology (ASRT), and thence was presented in the October 1978 JCC meeting. The JCC agreed that the project met criteria for demonstration projects, was feasible for implementation during Phase I, and recommended that a joint Egyptian-American Panel be formed to elaborate a project design.

Panel meetings were held during January 1979 and the discussions were centered around an updated draft proposal prepared by the NRC group. Visits were also made to several relevant laboratories in the NRC, and to two Egyptian villages as typical examples of a new planned village and a traditional one. As a result, a final project proposal was agreed upon, was submitted to the March 1979 JCC meeting and was approved.

PROBLEM

The application of village-scale biogas technology in various parts of the world exhibited various degrees of success. The Chinese and Indian programs in particular were relatively successful. For instance, more than 7 million biogas village units are now operating in the People's Republic of China. However, such success is no assurance of similar success in other countries particularly

where there are great differences in resources, socio-economic conditions, physical environment and living patterns. Previous experience in other developing countries that have started sizable biogas programs, has shown that success entails the development of viable conditions to ensure acceptance, adoption and propagation of the technology. Thus, the technology should be appropriate and compatible with the existing socio-economic conditions. Further, adequate scientific and technical infrastructure should be developed, and a sound national policy and plans on the technology promotion must be drawn up.

The project was thus proposed to provide such requirements and so as to ensure logical and appropriate sequence that can lay the foundation for subsequent viable implementation on the national scale.

OBJECTIVE

The overall objective of the project is to demonstrate that the application of biogas village scale technology is technically, socially and economically feasible in rural areas of Egypt. Major considerations include contributions of the biogas technology to village environment relating to supplies of energy and fertilizer, as well as to waste treatment, public health control and sanitation.

The major ends to be accomplished from the project are :

1. To carry through with a viable , creative and relatively successful village demonstration program,

2. To assess the biogas technology as a means for energy conservation, waste recycling, upgrading of soil fertility and pollution control, and

3. To come up on a sound basis embodying the results of a comprehensive technology transfer, research, development and demonstration program with concrete and practical recommendations on how to foster the implementation of village-scale biogas technology on the national level.

RATIONALE AND JUSTIFICATION

The rapid increase in the cost of fossil fuels, the scarcity of domestic fuel in rural areas, and the particular burden placed on developing countries has inspired research workers all over the world to look for alternatives to conventional energy sources with particular emphasis on the rational utilization of renewable resources. One of the feasible approaches which is consistent with environmental practices, is the bio-transformation of organic matter into methane. The process is widely referred to as bio-gas technology.

The recycling of animal, human excreta and agricultural wastes through bio-gas plants helps to improve the environment and also provides a source of clean fuel and fertilizer. The development and application of appropriate bio-gas technology would assist rural areas towards self sufficiency and self reliance with respect to their energy and fertilizer requirements. Countries like India and China demonstrated to various degrees of success how to adapt the bio-gas technology in their rural areas.

In rural areas of Egypt, crop residues, weeds, hydrophytes, together with human and animal excreta represent good feed stocks for bio-gas developments. At present, there are two major areas for the utilization of such residues. One, as a source of energy by direct burning (thus their fertilizer value is lost), and second, their use in making organic manures.

The major sources of energy available to most Egyptian villages are the non-commercial sources, which are estimated to have provided over one-third of the total energy consumed in Egypt in 1975. In addition, there is significant demand on commercial energy sources in rural areas and demand on petroleum products is increasing very rapidly, almost doubling by 1985. It is worthy to note that these petroleum products are very heavily subsidized by the Government.

A preliminary rough estimate was made of the bio-gas that sould be produced by utilization of crop residues already used as energy sources and animal and human wastes available in Egyptian villages. It was indicated that the bio-gas could provide almost all the residential rural energy requirements,

i.e. substituting for all the non-commercial sources as well as kerosene and butagas. Furthermore, an additional amount of organic fertilizer equivalent to about 20 million tons of farm yard manure would be produced, which would otherwise be lost through the direct burning of crop residues and dung cakes. This is also very improtant since it is estimated that the present deficit in farm-yard manure in Egypt is more than 80 million tons per year.

Thus, it appears that the implementation of bio-gas technology in rural areas of Egypt will be very useful as a suitable source of energy and soil fertilizer. Further, other intangible benefits such as the improvement of health and sanitation conditions would be quite significant.

ACCOMPLISHMENT TODATE

The initial project masterplan is shown in figure 1. The program is executed by an interdisciplinary team encompassing five functional groups. On the whole, the progress is fairly close to plan and two detailed progress reports (PR/1 and PR/2) covering the period from January till September 1979 have been submitted.

The fact-finding phase has been accomplished as scheduled. The literature search, the preliminary village surveys and the Asian study tour were all completed. A summary report on the Asian study mission is given in Annex 1, and a detailed documentary report is under preparation. A publicized one day seminar on the "Status and Recent Trends in the Development and Application of Village-scale Biogas Technology in India, China, and Thailand" was held in the NRC on January 1[illegible], 1980,. The program of this seminar is attached in Annex 2. The seminar and its discussions proved to be very fruitful media for coordination and exchange of views with those interested in the field of biogas technology. Representations from several universities (Cairo, Fayoum and American University), research organizations (NRC and Petroleum Institute) and government ministries (Ministry of Public Health and Ministry of Agriculture) attended and actively participated in the open discussion session.

The laboratory phase of the digestibility research work is in its final stage as scheduled. Bench-scale work is proceeding in its initial operating stage after completion of the experimental set up. The work on indicators of fecal pollution and pathogenic microorganisms is continuing parallel with the bench-scale work.

The engineering and development group built and started operation of the first prototype digester unit. Their work on gas-use devices is proceeding, though later than initially anticipated.

The fundamental microbiology group started work earlier than planned and completed a sizable portion of their work plan on the destruction of ova and embroys of Ascaris.

The fertilizer evaluation group carried out their planned laboratory and green house work on some digestion products of the laboratory-scale digesters. They are following with the products of the bench-scale and prototype digesters.

The sociological group concluded four village surveys and is proceeding with analysis of the results and report preparation.

EVALUATION OF PROJECT PROGRESS

The joint U.S.-Egyptian panel for the project held intensive meetings during the period from January 12-16, 1980 to review the project progress and draw up recommendations for future course of action. The agenda of the meetings is attached (annex 3). The U.S. panel evaluation report is also enclosed in annex 4.

FUTURE COURSE OF ACTION

It is anticipated that by October 1980, a major portion of the research and development endeavors will be completed. This will make it possible to carry out the village prefeasibility study preceding the demonstration phase.

The highlights of the various group plans may be summarized in the following :

... The laboratory and Bench scale research group shall investigate :

1. The optimum operating conditions for digesting a mixture of fresh cow dung, sewage and agricultural wastes (weeds, water hyacinth, cotton wastes and maize stalks).

2. The effect of precomposting on the rate of digestion and on the survival bacterial indicators and pathogens.

3. The possible contamination of agricultural wastes with pesticides and the effect of this contamination on the digestion process.

4. The effect of digestion and post-composting on the survival of bacterial indicators (Coli aerogenase group, fecal coliform and streptococci) and pathogens (Salmonellae group, Shigellae group and New Castle disease virus "NDV").

B. The Fertilizer Evaluation Group plans to :

1. Complete the evaluation of 18 laboratory digested samples.

2. Try several methods for handling and storage of both digested effluent and sludge. These methods include : air drying and enrichment with chemical fertilizers, absorption on materials possessing a high absorption capacity, composting with crushed agricultural wastes and precomposting fresh feed.

C. The Fundamental Microbiology Group shall carry out :

1. Isolation and identification of sulphate reducing and anaerobic sulphur bacteria from river bottom sediments and from the rumen.

2. Studies on some selective inhibitors of sulphate reducing bacteria and their effects on methanogenesis.

D. The engineering and Development group shall undertake :

1. Operation of the first constructed biogas prototype digester for testing its performance and optimizing the operating conditions, as well as determining the major elements for its management.

2. Continue work on test, development, design and construction of gas-use devices when sufficient biogas is produced from the digester.

3. Construction of a small biogas digester of the cylindrical wide and shallow type (2nd prototype) and test its performance.

4. Preparation of different mixes from local building materials and testing their mechanical properties and adequateness for use in digester construction.

E. The Sociological Aspects Group shall :

1. Finalize the remaining three reports on the villages surveyed in Guiza.

2. Conduct a fifth survey on a new village.

3. Select one village for first demonstration and start sociological pilot tests and orientation in this village to promote awareness, interest and mental thinking prior to the actual demonstration.

SECTORS INVOLVED

The project work-force includes members from the following sectors :

- National Research Center
- National Center for Social and Criminological Research
- Ministry of Public Health (Serum Laboratories)
- Ain Shams University

PROJECT DURATION

Starts : January 1979

Terminates : December 1983

STATUS OF EQUIPMENT PROCUREMENT

Equipment requirements have been submitted over a year ago. None has arrived as yet. Such a considerable delay in procuring core equipment and measuring devices will certainly have an increasingly negative impact on the progress of the project work.

PROJECT MASTER PLAN

(Tentative)

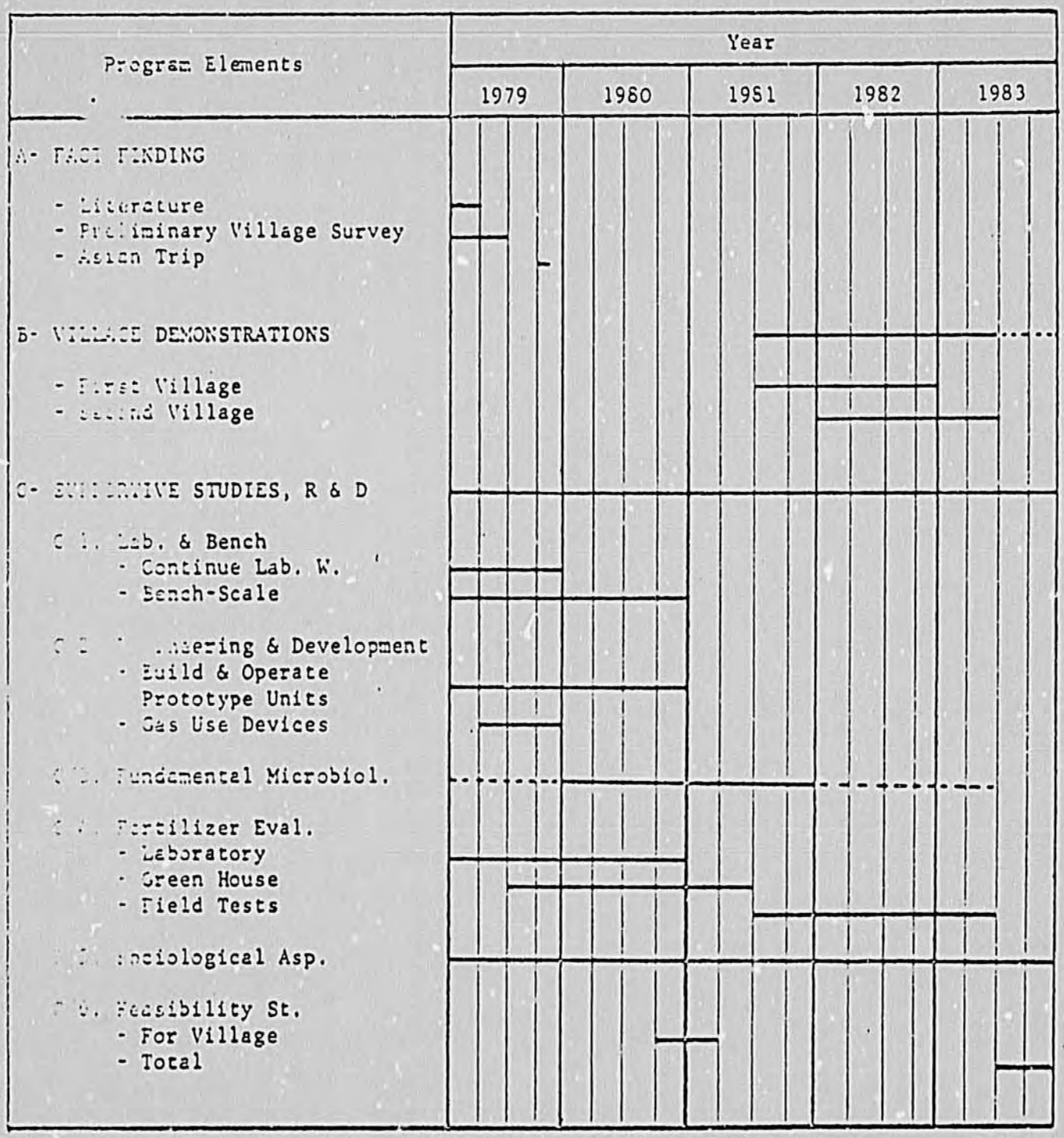

Figure 1. Key Milestones of the Proposed Bio-gas Program

Annex 1

NATIONAL RESEARCH CENTER
(NRC)

ACADEMY OF SCIENTIFIC RESEARCH
AND TECHNOLOGY

DEMONSTRATION SUBPROJECT : THE DEVELOPMENT AND
APPLICATION OF BIOGAS TECHNOLOGY IN RURAL AREAS OF EGYPT

Cordially Invite You to a Seminar on :
STATUS AND RECENT TRENDS IN THE DEVELOPMENT AND
APPLICATION OF VILLAGE-SCALE BIOGAS TECHNOLOGY
IN
INDIA - CHINA - AND THAILAND

To be held in the NRC main auditorium on Tuesday January 15, 1980 at 9:30 a.m.

PROGRAM

9:30	Introductory note	Dr. El-Halwagi
9:40	The Indian situation	Dr. Gohary
10:00	The Chinese experiment	Dr. Abdel Dayem
10:20	Thailand Status	Dr. Abdel Samie
10:40	Use of digester effluent as fertilizer	Dr. Badr El-Din
10:50	Sociological Aspects	Dr. Megahed
11:00	General Comments and slide presentation	Dr. Goodrich
11:10 - 11:30	Break and Refreshments	
11:30 - 11:50	Movie on the Indian Experiment	
11:50	General Discussion	

Annex 3

JOINT COMMITTEE MEETING ON THE
DEVELOPMENT AND APPLICATION OF BIOGAS TECHNOLOGY
IN RURAL AREAS OF EGYPT

NRC, Cairo - January 12 - 16, 1980

Saturday Jan. 12 -	9:30 - 11:30	Whole group will meet to review original project plans and to see if they need modification. We will discuss project status and set next 6 - 12 months plans.
	11:30 - 2:30	Panel will visit fertilizer group and the micro biology group. Will view the laboratory work and have time to discuss work in small group.
Sunday Jan. 13 -	9:30 - 11:00	Continue whole group meeting - start draft evaluation report.
	11:00 - 1:30	Visit to laboratories of Dr. El-Gohary and to the field demonstration work (Pilot digester) at N.R.C.
Monday Jan. 14 -	9:30 - 12:30	Seminars by Prakasam Capener Goodrich
	12:30 - 2:30	Panel will meet with Dr. Megahed and workers at Center for Social and Criminological Research.
Tuesday Jan. 15 -	9:45 - 12:00	Seminar on Asian Trip
	1:00 - 2:30	Work on Asian Report (6 persons)
Wednesday Jan. 16-	9:30 - 1:30	Whole group - finalize reports and complete evaluation.

Annex 4

Cairo, January 19, 1980

To : Dr. M. M. El-Halwagi

FROM : NAS Bio Gas Panel

Subject : Review of Bio-Gas Demonstration Project Status

An evaluation of the Bio Gas Technology Project is not difficult. The project personnel have worked hard to meet the objectives and the timetable for the completion of various tasks. There is a firm belief in biogas technology which is obvious as we talk to the members of the team.

The personnel are working well together. They are supportive of each others work and equipment, materials and samples are transferred between various groups as each has need.

The management of the project is being carried out in a very competent way. Meetings are held regularly to discuss progress and problems of the project and to keep personnel up to date. The importance of these meetings to the integrated project is clearly recognized. Every one is interested in knowing what is going on and how different activities affect the various stages of work. They also are serving to broaden the knowledge of the personnel.

The NAS panel found the written reports to be excellent. They are timely comprehensive, pointed, brief and yet they detail the progress of the work. These reports will no doubt become useful to others who can make use of the material.

Good communications exist between the principal investigator and the U.S. NAS panel members. Dr. El-Halwagi made it a point following his training at the Denver Research Institute to personally visit each panel member to discuss the status of the project and to seek out any additional inputs into the project.

The fact finding trip to China, Thailand and India was of tremendous value to the project. Not only was the six person group able to personally visit with researchers, technicians and users of biogas plants, but they were able to experience first hand the significance of the settings in which the projects were finding greater or lesser success and why. The three week period of continuous travel and work together provided a tremendous forum where they could discuss in depth what they were experiencing and how these matters relate to the Biogas Project in Egypt. This total sharing and learning experience gave a great boost to the project because of its extensive information input and its development of individual personnel. The oral report of the Asian trip was presented in Cairo on January 15, 1980. It was very well received by those who attended from various interested groups.

The panel is unable to understand how the persons who developed the AID budgeting for this project expected work to be done without funding for the local expenses. There is obvious need for local currency for supplies and for construction of the digesters on the NRC site. Also none of the expected instrumentation for the laboratories has arrived and in fact it is not known if it has ever been ordered from the manufacturers. It is very difficult to do a proper job with makeshift and inadequate instruments.

Overall we commend the research team and the principal investigator for excellent progress during this reporting period.

The panel would like to discuss some aspects of the project that it feels should be considered in the planning of the next years' program to increase the likelyhood of a successful demonstration project. These are addressed in two components: the Social Science Component and the Bench Scale Laboratory Component.

The Social Science Component

The four preliminary village surveys have been completed. These provide a good deal of useful factual information about physical conditions in each of the villages. They also provide an early partial insight about attitudinal predispositions about the acceptability of the biogas experimentation. It is understood that due caution will need to be exercised about assuming village-wide understanding, participation or acceptance of the experiment without a great deal more thorough and painstaking effort to understand the inner workings of the village life system and how a technology such as bio-gas will have an accepted and meaningful contribution.

The demonstration village is a social laboratory just as members of the research team will use the facilities of the National Research Center to carry out the bench scale testing of the fertilizer, microbiological engineering and laboratory components, so also should the social science component see the demonstration village as its laboratory. Several major areas of inquiry and exploration should properly begin as a means of preparing the "seedbed" of the demonstration village for subsequent implementation of the bio-gas technology. Among the areas to be explored and more completely formulated are the following :

1. Pushing up the time-table for selecting the demonstration villages.
2. Re-examining the criteria for village selection.
3. Using all feasible and available information to select the two villages for carrying out the demonstrations.
4. Work with the appropriate decision making and influence structure of each village to enlist their willing cooperation and coordination.
5. Develop a kind of committed social contract with each demonstration village to feel well connected and loyal to the bio-gas project. Each village might ideally and appropriately select and commission its own chosen persons to receive the training and expertise in bio-gas operation and management.

6. Examine the potential development of a series of infrastructure enterprises that would logically be related to the project such as pumping water, grinding grain, chopping fodder, turning woodworking lathes, etc.

7. Develop active linking ties with the residents of the village and the bio-gas research team at the NRC particularly in terms of how activities at each location are meaningfully related.

8. Identify the requisites of the organization, agency or program that should and can become actively involved in assuming responsibilities for spreading the benefits of the bio-gas project and its system level effects to other ready and willing villages.

9. Identify personnel who know and understand village life, its patterns, customs, influence structure, who is willing to become a pioneering worker on behalf of his/her own village betterment.

10. Perceive the process of thoroughly understanding and preparing the demonstration village to receive and manage the bio-gas project as a kind of "bench scale experiment" in the social science laboratory.

11. Employ needed social science research assistants or associates who are full-time residents in the demonstration villages, and who the village residents agree can best represent their interests.

12. Organize and arrange for project planning and progress review meetings in the village and for tours and training of village residents in the National Research Center.

13. Allocate high priority attention to specifying and spelling out the nature of the preparatory work to be done in the demonstration villages.

14. Review the budget for the first phase and second phase in terms of any adjustments for needed personnel or equipment to successfully implement the social science component.

The Bench Scale Component :

The progress made on the bench scale experiments on anaerobic digestion of various studies and on the studies of spent slurry as a fertilizer during this evaluation period is quite satisfactory. As a result of the discussions that the panel members had with the individual group leaders, it is felt that there are a few technical issues that need to be further investigated during the next six-month period. These are given below :

1. Evaluation of digestion of cotton stalks, aquatic weeds, etc. :
Cotton stalks and aquatic weeds comprise an important source of bio-mass in Egypt, which can be subjected to anaerobic digestion for the production of bio-gas. Hitherto, little work has been done either in Egypt or elsewhere on the bio-degradation of cotton wastes. Hence it is important to obtain information on the following :

   a. The feasibility of digesting these agricultural wastes.

   b. The amount or quantities of bio-gas to be expected.

   c. The fertilizer value of the slurry, and

d. The benefits of digesting the cotton wastes in reducing the perpetuation of the cotton plant pests, so that this information is available for application in the village demonstration phase.

2. Evaluation of pre-composting and post composting strategies :
The team leaders and the NAS panel members discussed the significance of pre-composting and post-composting of various waste materials and spent slurry respectively. The need to control pre-composting operations is emphasized because of the risk of losing energy in the form of heat in this operation. The strategy for pre-composting should be such that relatively complex substrata are broken down to simpler moieties which can then be subjected to anaerobic digestion to produce methane. The risks in post-composting of spent slurry are negligible. If sufficient degradable organic matter is left in the slurry, post-composting is advantageous in that it may kill any residual pathogens. If enough heat can be generated in post-composting, it may be advantageous to achieve this by composting the spent slurry in an annular chamber around the inlet feed mixing basin. By this means the feed to the digester can be preheated to some extent, which should be advantageous to the fermentation process.

3. Approaches to reduce the volatile acid concentration at high loading rates :
By increasing the organic loading rates, the digester volume can be progressively decreased for a unit volume of methane produced. But as the organic loading is increased beyond a certain limit higher and higher volatile acid concentrations result in the digester contents.
If ways are found to reduce these higher volatile acid concentrations, meth production can be sustained at higher loading rates, which means a further reduction in the digester volume requirement for the digester can be pre-heated to some extent, which should be advantageous to the fermentation process.

Precautions to reduce volatile combustion at high loading rates :
By increasing the organic loading rates, the digester volume can be progressive decreased for the production of a unit volume of bio-gas. But, as the organic loading is increased beyond a certain limit, the volatile acid concentration tends to build up and inhibit methanogemoration. If ways are bound to reduce these high volatile acids concentrations, methane production can be sustained at considerably higher loading rates, than are currently possible, which means a further reduction in digester size. Two approaches are suggested for further investigation :

1. Two stage digestion, and

2. Continuous adjustment of pH to alleviate the inhibitory effect of unionized volatile acids. These aspects may be studied as long range objectives.

Availability of relavent technical journals and books :
A site visit by two of the panel members to the Library and Documentation Center revealed that acquisition of a few journals and books, which are not available at this facility, would undoubtedly be beneficial to the project. A seperate list of suggested references will be sent by the panel members after their return to the USA.