PD-AAX-663

National Research Centre

APPLIED SCIENCE AND TECHNOLOGY PROJECT
(PROJECT NO. 263-0016)

DEMONSTRATION SUB-PROJECT
(ACADEMY OF SCIENTIFIC RESEARCH AND TECHNOLOGY)

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

SEVENTH PROGRESS REPORT (PR/7)
SUBMITTED TO THE JCC

BY

PROF. DR. M.M.EL HALWAGI
PRINCIPAL INVESTIGATOR

OCTOBER 1982

1.0 Introduction

In this report, a summary of the Project status as of October 1982 is presented. Emphasis is laid on the highlights of work progress as well as anticipated future program plan.

1.1 Project Objective

The overall objective of the Project is to assess, on the basis of an integrated R & D, technology transfer and field demonstration program, the limits and conditions of technical feasibility, social acceptability and economic viability of Biogas Technology (BGT) in the rural setting of Egypt.

1.2 Program Goals

Major program goals encompass:

- Study and assessment of world-wide potentially prospective technologies.
- Survey the relevant socio-economic features of typical Egyptian villages.
- Transfer, adapt and develop appropriate village-type Biogas technologies and demonstrate them in two types of villages representing the traditional and the new-planned villages.
- Assess the technico-socio-economic feasibility under the local conditions as depicted by village demonstrations.
- Carry out, through an inter-disciplinary team, whatever supportive studies that are needed to accomplish the individual program goals and thus the Project objective.

1.3 Project Status as of October 1982

As outlined in previous reports, the fact-finding phase as well as a major portion of the R & D endeavors have already

been accomplished. Over the past year, more emphasis has been placed upon the central goal of the Project, i.e. village demonstrations.

Village demonstrations have started since early 1981. Two family-size units of about 10 cu.m. size have been installed and successfully operated at "Al-Manawat" (a traditional Egyptian village). The first is of an adapted Indian type attached to a farmer house, and the other is of a modified Chinese model installed in the village collective unit. By the end of May 1982 three more digesters were started up successfully in Omar Makram village (a new planned village). Two are of the Indian type and the third is of the popular Chinese version. All are connected to farmers' houses. Except for one which is installed for two families jointly, the other two are single family units. Socio-techno-economic assessments of all demonstration units are being continuously carried out.

By October 1982, all phase I equipment have arrived. The majority of these equipment have already been installed and put into operation.

2.0 Phase II Program Plan

In a previous progress report (PR/5), an annex entitled "Biogas Project Work Statement" was devoted to presenting the key features of planned phase II program together with its estimated budget and principal requirements. Though much effort was made to keep as close as possible to the plan, delays in the final approval of phase II in general, coupled with other changing factors have caused mandatory deviations and delays. It is estimated that a one-year project extension may be necessary to meet the originally planned objective.

2.1 Program Plans By Inputs

Major inputs include: training, equipment, panel and consultants, and local materials and supplies. Project total budgets and disbursements till the end of 1983 have already been approved, but after about one year delay. The totals allocated to the project are (in thousand dollars): equipment 400, training 82.3, Consultants 50.4 and local materials and supplies L.E.67,000.

2.11 Training plans through December 1983

The Project training plans till June 1983 have been outlined in a memorandum addressed to Dr. Nockrashy (Annex I). Program short and long-term requirements, as well as the interdisciplinary nature of the Project have been taken into account. Most of these training plans have been discussed with the U.S. Panel members and the major part of the arrangements have even been set with their direct assisstance in conjunction with the NAS. These include direct training, fact finding and professional meetings. Participants belong to: the central services Laboratory, fertilizer evaluation, pollution control and engineering groups of the project team.

2.12 Phase II Equipment needs

The list of Phase II equipment was sent to Dr. Nockrashy last year (June 20, 1981). We understand that these requirements have not as yet been processed by the concerned U.S. agencies. An updated modified list, is therefore attached in Annex II whereby the order is arranged according to priority. A list of spare parts for phase I, budgeted in phase II, is also enclosed in Annex III.

2.13 Panel and consultant visits through December 1983

The last joint U.S. Panel - Project Committee meeting was held in Cairo during the period April 3-6, 1982. The program of

the meeting together with the Panel report are attached in Annex IV. The next meeting is scheduled during April 1983 (pending U.S. Panel members approval).

In the previously submitted 'Project work Statement' an allowance for 6 man-month of consultants was requested. A 3.5 man-month consultant needs by specific objectives and length of times are outlined in Table 1. The remaining 2.5 man-month equivalent budget is requested for financially supporting a proposed 'Biogas Seminar' to be held in the NRC in Cairo early 1984 under the auspices of the ASRT and to which few leading international experts can be invited. If this request is approved, arrangements can be started in collaboration with the U.S. Panel members and NAS. This would allow an excellent chance to evaluate the prospects of Biogas in Egypt and possible future courses of action.

Table 1

List of Consultants needs (during 1983)

	Objective	Time	Possible Nationality
1.	Gas use devices particularly conversion of petrol or diesel engines for gas use.	2 weeks	India or U.S.
2.	Large-scale digestion systems with agitation, heating and controls; preferably with experience in integrated Biogas systems.	8 weeks	India or philippines
3.	Microbial technology with special emphasis on engineers requirements.	4 weeks	U.S.

2.2 Program Plans by Output (Expected Status December 1983)

In the original project Proposal a tentative master plan was given in which the envisaged key milestones of the Biogas

program over a 5-years period were presented. In the more recent 'Biogas Project Work Statement', Phase II tentative plan was proposed covering the period till the end of 1983. Inevitably because of the delays in approving phase II, deviations have to take place. It should be also noted that changes from planned courses of action have taken and will continue to take place in the future to accomodate unanticipated conditions or developments.

2.21 Village Studies

Though the Project plans were made for two demonstration villages, AlManawat and Omar Makram, studies could not be confined to these two. Requests coming from individuals, agencies and organizations mandated at times studying other localities as will be discussed in more detail in Section 4 of this report.

As to the two specific villages selected as the Project demonstration sites, more digesters will be built. It is anticipated that by the end of 1982, three more digesters will be installed at AlManawat; two will be of the family-size type, and the third will be a heated large scale unit attached to a cattle farm. In addition, the multidisciplinary follow-up work on the operating digesters, together with the social-technical-economic analysis and appraisal in the context of village demonstrations will continue on a regular basis.

Whether or not more digesters will be built in Omar Makram depends on the situation of the other requests under discussion from individuals and agencies who have approached the NRC recently. It is expected that by the beginning of 1983 the situation will be clear, and appropriate decisions can then be taken at that time.

2.22 Fertilizer Evaluation

Field experiments carried out for the purpose of demonstrating the handling, use and the beneficial role of the digested

materials as fertilizer will continue in conjunction with owners of operating biogas plants in AlManawat and Omar Makram villages that have been built by the NRC team. Results will be monitored over long enough periods (even extending beyond phase II if needed) to quantify the effects of continued use of the spent slurry as fertilizer.

Since the operation of the 3 demonstration digesters in Omar Makram, members of the fertilizer evaluation group have been regularly visiting the owners and advicing them on the various aspects relevant to handling, storage and use of digested slurry. During 1983, full-fledged field experiments similar to, but probably longer than, the one that has already been conducted at AlManawat (and described in detail in the technical report Nov. 1982) will be undertaken. In these field demonstration experiments the effects of using digested materials are evaluated and compared with other mineral, organic and biofertilizers.

2.23 Other Studies and Supportive Services

These encompass: the engineering development work at the NRC extension site, pollution control work, fundamental microbiological studies, and central services loboratory.

Though the field demonstrations are almost the exclusive responsibility of the engineering group, the group has also to undertake R & D work, development of the NRC Biogas extension site, and promotional activities so vital to the project future. During 1983, the group will complete the preparation of the NRC biogas site as a central location for development work, training and extension services. Development work will center on alleviating the major shortcomings of the digester designs thus far tested under local village conditions. For this purpose, two new digester models will be installed and tested. One with a solar heater, and the second is that normally known as "dry fermenter" which allows use of exceeding proportions of agricultural

wastes (rather than animal dung).

The pollution control work will be undertaken by two groups; one for work relating to pathogens, and the other to parasites. Both groups will continue to follow up the occurence and survival rates of some entric microorganisms and parasites in conjunction with the field demonstration digesters. Laboratory research will also be continued to identify the best practical treatments leading to minimization of possible pathogenic hazards.

The fundamental microbiological group will continue undertaking its stand-by trouble shooting role as well as the complementary work relating to the search for diagnostic techniques. In addition, the group will start work on possible promoters of methane productivity in anaerobic digesters. Due consideration will also be given to the U.S. Panel recommendations pertaining to the volatile acids aspect.

The 'Central Biogas Service Laboratory' group will continue the process of installation and operation of the analytical equipment that have arrived recently or will arrive in the future. The group will also under-take the exclusive responsibility of all instrumental analyses relating to the project (as well as others if the need arises).

3.0 Phase II Program Plan (bar chart)

Complementary to the previous narrative discussion given in section 2.0, the proposed key milestones of the plan for the remainder of phase II and till the anticipated end-of-project period is shown in Figure 1.

Activity	1982	1983				1984			
A. VILLAGE DEMONSTRATIONS									
A/1-AlManawat									
3 more digesters									
A/2-Omar Makram									
2 more digesters									
A/3-Other Sites									
Performance follow-up & Socio-econ.Eval.									
B. NRC Biogas Site									
Preparation									
Development work (2 digesters)									
Operation & tests & training									
C. Central Services Laboratory									
Rest of Phase I equipment installation									
Phase II equipment									
Analytical Services									
D. Supportive Studies and research									
E. Consultants									
F. U.S. Panel									
G. Reporting									

Figure 1-Key milestones of the proposed phase II Plan over the period October 1982 - Sept. 1984.
(Year division by quarters)

4.0 Suggested follow-on activites

What needs to be done to enhance the adaptation of biogas technology in Egyptian rural areas? and what after the end of the Project as supported by U.S. AID and ASRT? are two central questions and have always been recurrent among the Project management team. As a matter of fact, these two questions were foremost in the discussions taking place during the Joint U.S. Panel-Project Committee meetings, and substantial portions of the Panel reports were in some way or another touching upon them.

The first question was also raised in both the Egyptian Supreme Energy Council (resources Committee) and the Supreme Council for New and Renewable Energy, both in which the biogas project principal investigator, Dr. ElHalwagi, is a member. The minister of electricity and energy asked Dr. Halwagi, within the context of endeavors to formulate the National Renewable Energy Strategy, to undertake the responsibility to areas relating to biomass in general and biogas in particular. A complete report (ElHalwagi, "Towards a national strategy for optimum biomass energy utilization", Dec. 1981-in Arabic) was devoted to these aspects and was approved by the Minister as a basic document. In this strategy, it is estimated that 400000 biogas units can be built till year 2000 in both the traditional rural areas and new planned villages. This takes into account the various constraints relating particularly to the availability of both the substrate and space (for more details refer to publications no.5 and 7 in Annex V entitled 'Project Major Publications').

As a short-term plan of action, the proposed strategy recommends construction of 1000 demonstration units over a period of 3 to 5 years.

The NRC (through Dr. Halwagi, Dayem and Hamad) is presently negotiating with ORDEV (the Organization for Reconstruction and Development of Egyptian villages) a 3-year plan of action to construct 1000 demonstration units in 15 governorates with partial funding from the USAID basic village infrastructure services. The basic elements of this programme may be summarized as follows:

1. Establish a biogas training centre at the NRC to train in the first year 100 persons from the governorates (including engineers, technicians and skilled labour) to form the nuclei of biogas services core in the respective governorates. These trained task forces will build during the first year 50 demonstration units under the supervision of the NRC. During the following two years, they will construct, operate and follow-up 950 family size units on their own and with minimum NRC involvement.

2. 1000 rural house-holds will be chosen on the basis of suitability criteria, and each should pay 25% of their digester cost. The remaining 75% of the cost will be given as grant.

Such a programme is believed to be effective in the long-term propagation of the technology, particulatly since local capabilities will be gradually built up and spread throughout the villages. Moreover, the first 1000 units will provide a strong demonstration base to satisfy the social awareness and acceptability criteria.

In addition to the previous endeavors, the biogas project team, particularly the principal investigator and the engineering group leaders have exerted substatial promotional efforts. About 50% of the time of Drs. Halwagi, Dayem and Hamad over the past year was spent along this line. Originally, these efforts were aimed at giving the Biogas Technology in general and the Project in particular selected and directed publicity through mass communication media. These included three radio talks, five television programs and 6 newspaper articles. Furthermore, around 30 visits were paid

to the NRC biogas demonstration sites at the NRC, AlManawat and Omar Makram; some of these were made by Egyptian and foreign dignitaries. A highly favorable response ensued. Many inquiries were received and several requests were made for building digesters. Aside from individuals and village requests, the following relate to important agencies:

1. VITA (Volunteers In Technical Assistance) request for constructing two large scale digesters in conjunction with poultry rearing operations in a village near Tanta. The NRC has very recently sent a proposal including a prefeasibility study offering a joint project whereby VITA provides actual costs and the NRC biogas team provides the technical know-how and supervision. This proposal is attached in Annex VI.

2. The Egyptian Ministry of Defence in conjunction with the armed forces large cattle raising operations. Two studies (in Arabic) relating to two specific locations have been made by the engineering group and are currently under study in the Ministry of Defence.

3. ORDEV inquiries. In addition to the proposal made to them and referred to earlier, two more studies (in Arabic) were made for them. One relating to the prospects and options of biogas technology in rural areas of Egypt and the other on the feasibility of establishing a 100 cu.m. biogas unit to be attached to a cattle raising farm.

4. Mariut International Centre for Rural Development requested the NRC to assist them with know-how and expertise in implementing a biogas project supported by the Italian Government. Drs. Halwagi, Dayem and Hamad provided the earlier assistance. Presently, Dr. Dayem is a member of the follow-up committee.

The biogas Project team is always keen to attend meetings,

seminars and conferences held in Egypt basically for the purpose of exchanging information with other teams involved in the field of biogas technology and in an attempt to coordinate to some extent the activities of the various teams. During the past year, the biogas teams of the NRC, the Agricultural Research Centre and the Faculty of Agriculture at Fayoum met three times (in addition to more informal meetings and demonstration sites visits). The first was during a one-day biogas seminar held at the Fayoum campus; the second at the African Conference on Biofertilizers; and the third in a seminar held at the NRC on renewable energies during the celebration of the NRC silver jubilee. The NRC seminar was arranged and chaired by this project principal investigator. The proceedings of this seminar were published by the NRC (in Arabic) and were widely distributed to the various persons and agencies related to the field of renewable sources of energy. Excellent recommendations that have bearing on our topic of discussion here, i.e. measures needed to enhance adaptation of biogas technology, were adopted in the seminar.

We may conclude from the previous narrative discussion relating to the first question that the biogas Project team has been well aware of its importance and has taken preliminary measures for increasing the public awareness of the technology and for convincing the decision makers of its potentialities. Nevertheless, the team tries to refrain from intensifying promotional activities aiming at widespread implementation on the national scale until the socio-economic feasibility is demonstrated over long enough periods and to a high degree of certainity.

Now we turn to the second question relating to what after the end of the Project. This has been studied among the Project team leaders and with the President of the NRC. It was concluded that the biogas project has developed valuable resources within the NRC and the Country as well. These include: good management techniques and capabilities, R & D and field demonstration expertise that can

work and interact together in an interdisciplinary manner, up-to-date valuable instruments and equipment and well known authoritative persons in the field of renewable energy and biogas technology (who have represented Egypt in U.N. and international conferences and provided as well consultancy work for international agencies and local authorities). To keep all these resources intact, the following measures and plans were or are being taken:

a) Equipment relating to instrumental analysis are installed in a central laboratory and operated by specially trained, mostly full-time, personnel. This allows efficient service to the project, other projects, the NRC and its clients at large. For instance, the pharmaceutical chemicals project (one of the newer ones in the Science and Technology Project) modified its equipment needs on the premise that some of the biogas instrumental analysis equipment (particularly the gas cromatograph) will be available for their use. As a matter of fact, and in due time, the biogas well-equipped instrumental analysis laboratory will constitute a valuable addition to the pool of NRC service laboratories that are used by internal NRC projects or outside clients.

b) Plans are made to expand the activities in the NRC biogas extension site to include R & D work on biomass energy around a strong core of biogas activities. Figure 2 shows the layout of the proposed plan which has been approved in principle by the President of the NRC. Preparation of the site and the building of a 2-storey laboratory will allow the housing of most of Phase II and a part of Phase I equipment there and thus the establishment of a central R & D laboratory for multidisciplinary work relating to anaerobic digestion and gas use devices and engines. Such well developed site will ensure extended utilization and cooperation of the core of interdisciplinary biogas technology group as well as its future expansion. The role of such group will encompass development of new and improved designs, transfer of appropriate technologies, extension services and training (as put by the U.S. Panel 'assume the role of trainer of trainees

rather than trainers of the masses').

To conclude, the biogas Project was relatively successful and produced good outcome. The sound foundation that was laid through this project is hoped to effectively provide future results that will benefit the rural people of Egypt.

ANNEX I

August 17,1982

MEMORANDUM

TO : Prof. Dr. A.S. El- Nockrashy

FROM : Prof. Dr. M.M. El-Halwagi

SUBJECT : Biogas Project plans for training till June 1,1983.

The attached table outlines plans, requirements and other relevant information regarding the training component of the project during the next 10 months ending June 1,1983. It should be noted, however, that these are plans set to the best of our judgement at present and may be subject in the course of time to some slight variations. Thus, a certain degree of flexibility is required.

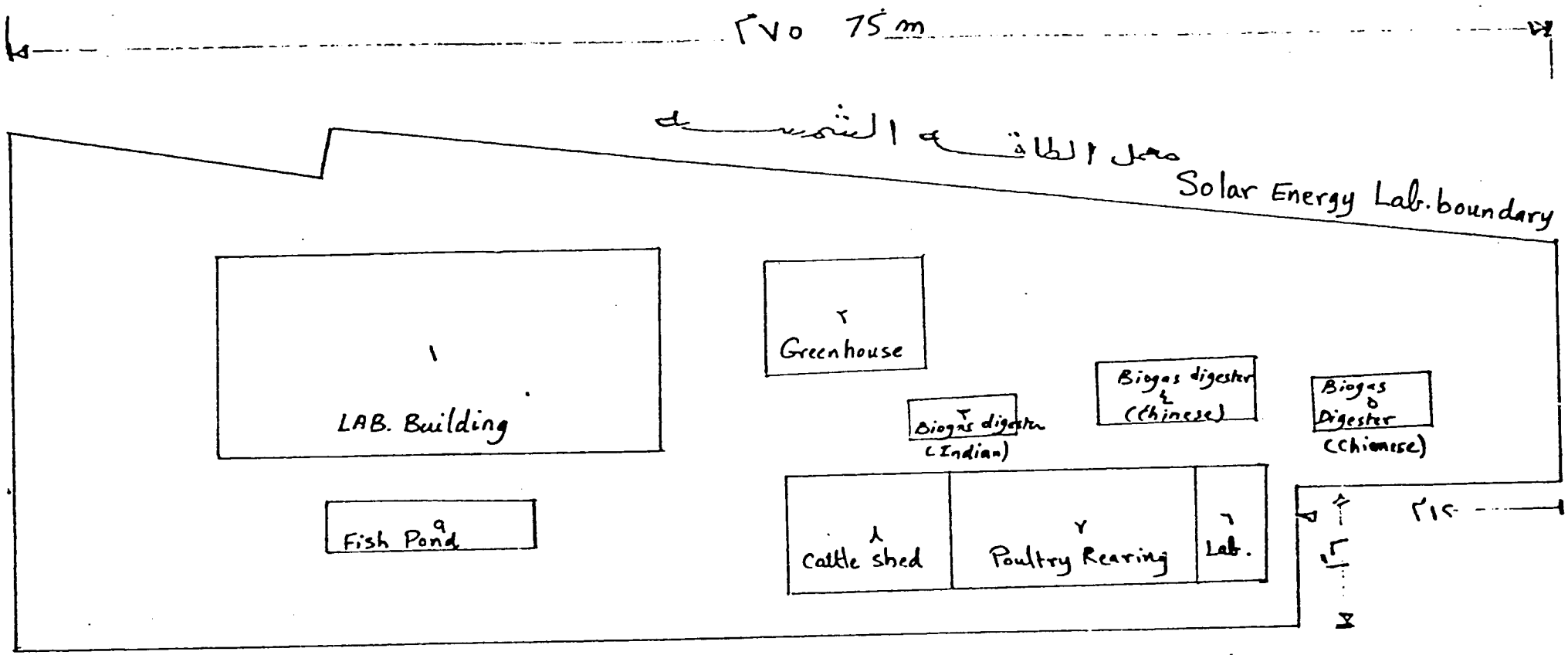
Copies of C.V.'s of the cadidates that did not have previous ones sent are as well attached.

It may be noted also that a large portion of these training requirements has been sent to Dr. Nockrashy and handed informally to Mr. Nasmith and U.S. Panel members to enquire for possible training opportunities. A recent reply (Memo from Nasmith "Future U.S. visits for members of Biogas Project" August 2,1982)has been received.

With best regards

MMH/ma

c.c. Dr. Osman Galal
Dr. Leo Packer



١- بئر المعمل
٢- صوبة
٣- الجهاز الهندى
٤- الجهاز الصينى الثانى
٥- الجهاز الصينى الأول
٦- معمل
٧- حظيرة دواجن
٨- حظيرة ماشية
٩- حوض اسماك

المساحة الكلية ١٦٠٠
Total Area 1600 m^2

FIG. 2- Plan of NRC BIOMASS EXTENSION SITE.
Based on the core of Biogas facilities.

Biogas Project Training an till June 1,1983

Name of Candidate (with title)	Relationship to Project	Training needs and Possible Opportunities
1) Dr. Samy El Afifi (Ass. Prof.)	Central Services Laboratory Supervisors	27 days - January 1983, Perkin-Elmer Advanced training on analytical methods and techniques used in G-L chromatography, atomic absorption and UV/VIS spectroph.
2) Dr. Shireen El Shawarby (Ass. Prof.)		15 days - March 1983, Perkin-Elmer IR Spectroph, liquid chromatog., Nitrogen Analyzer. 10 days Bench-scale & Pilot fermentors - New Brunswick Sci. Co. 25 days
3) Dr. Said Badr El Din	Fertilizer Evaluation Group	18 days - October 1982, Dept. of Soil Sci., U. of California/Davis + 3 days with Dr. Prakasam
4) Dr. Mohamed Khalafallah		15 days, April 1983 - Soil Sci. Dept. U. of Minnesota (Dr. E.L. Schmic
5) Dr. Shawky El Hawary	Pollution Control Group	20 days - October 1982, Metropolitan Sanitary District of Greater Chic (Dr. Prakasam) ; Dept. of Virology & epidemiology, Baylor Univ. Colleg Medicine ; EPA Health effects Research Laboratories.
6) Dr.Badawy Ismail (instead of Dr. Abagy)		15 days - 1983, Either of two options are proposed : 1) Training sessi "Pesticide Residue Analysis & Pesticide Metabolism (Dr. Robert Flying) Deputy Director for International Training, Room 3529, South Building, Office of International Co-operation & Development U.S Dept. of Agricu Washington D.C. 20250, U.S.A.)
7) Dr. M.M.El-Halwagi	Principal Investigator	One month, January 1983, Attend IGT Conference, visit some Biogas site U.S. & Europe + possible short-term management training session.
8) Dr. A. Abdel Dayem	Engineering Group	15 days, visit Biogas projects in U.S. & Latin America
9).Dr. M.Hamad		20 days, Visit large-scale & Commercial Biogas Units in Taiwan, Korea, Philippines, India, China.

ANNEX II

Biogas Equipment List - Phase II

(Listed in order of priority)

1. Salmonella Sets of Antisera; Antigens; chemicals and media. (These were ordered several times since the inception of the Project, i.e. during phase I, but were never supplied. The work of the pollution control group relies basically on their availability). For details, see previous orders.

2. Vegetation shredder (This a manual gadget selling at £70 in Lockstoke Developments Ltd., Easebourne Lane, Midhurst, West Sussex, GU 29 9AZ England, Telephone (073081) 3169 Telex 86736 SOTEXG).

3. Lockstoke Developments Rubber Biogas Plants, single unit of system II and system III, and two units of system I.

4. Red mud plastic methane generator, 2 units sizes 5 and 20 m^3 Union Industrial Research Laboratories, Industrial Technology Research Institute, 1021 KUANG FUROAD, HSINCHU (300), Taiwan.

5. Microbus, 9 passenger.

6. Crewcab pickup truck with trailer hitch.

7. TOTEM engine (FIAT or Brooklyn Union Gas) or other equivalent. It operates with biogas to produce 15 KW electrical energy. The engine is equipped with heat exchange system to produce hot water from the waste heat.

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* Request $ 10000 to cover extra spare parts for phase I equipment above and over that sum allocated in phase II as per Annex III.

8. Portable slurry pump,
   fitted with variable fuel engine(diesel and biogas if possible).
   discharge rate 5 cubic meters per hour
   discharge head 100 meters of water
   suction head 4 meters of water.

9. Gas meters, stainless steel construction
   5- Wet Test Gas Meter, 680 liter per hour
   3- " " " " , 50 cubic feet per hour
   2- " " " " , 100 cubic feet per hour
   1- " " " " , 6 cubic meter per hour
   1- Dry Gas Meter, 200 cubic meter per hour.
   Oil, technical. 50 SSU at 100 F.

10. Portable video recording and play back system.

11. English-Arabic electric typewriter.

12. Packed Columns for Liquid Chromatograph:
    Equivalent to: Perkin Elmer Part No.

- Autocontrol LC-75			
- PE RP-8/10	packed	column	0258-1484
- Silica-A	"	"	0087-0702
- HC-ODS SIL-X	"	"	0089-0716
- PE RP-8/10	"	"	0258-1484
- PE RP-2/10	"	"	0258-0684
- SIL-X-11	"	"	0087-3120
- Octadecyl SIL-X-11	"	"	0087-3121
- PARTISIL-10SCX	"	"	0087-0693
- PARTISIL-10SAX	"	"	0087-0694
- Shodex A 804/S	"	"	0258-8586
- Shodex S-804/S	"	"	0258-9186

13. Calorimeter, bomb type, for solid and liquid fuels with all necessary accessories.

14. Gas calorimeter set
    - Calorific value range 4000 - 35000 Kcal/m^3
    with different burners for propane, butane, mixture of both, and mixture of methane and carbon dioxide (60: 40 i.e. biogas).

15. Research fermentor assembly, three unit batch type
    1- 3 x 5 liter vessels
    1- 3 x 14 liter vessels

16. Bench top chemostat:
    fermentation control system, including:
    - stirrer speed controller (200-1000 rpm)
    - temperature controller & recorder (5-60 C)
    - automatic controller
    - turbidity controller
    - dissolved oxygen analyzer and controller
    (equivalent to New Brunswick Sci., BIOFLO: Model C32).

17. Colony counter, automated, 220 V, 50 Hz.
    (equivalent to model C113-Cat. No. M112-5001 New Brunswick Sci).

18. Peristalic pump
    3- Single channel
    2- Multi channel (20 channel)
    (Equivalent to New Brunswick Sc., Series PA, with extra silicon rubber tubing).

19. Dispersing pump, programmable
    (equivalent to New Brunswick Sc., Model DP-200).

20. pH meter, with recorder, 6 pH electrodes, connectors and detachable cables.

21. Combustion pot furnace (thermobalance)

22. Torsional viscometer, 2 units.

23. Hydrometer set for specific density, 2 units
    (from 0.5 to 2 gm/c.c.)

24. Desk-top computer 64 K (equivalent to 4052 TEK system with 4611 TEK Hard copier) and Soft ware as per attachment A.

25. Radiation pyrometer.

26. Chart recorder, 6 channel, 2 units
    - 1 unit equipped for temperature measurement

27. Freeze drying apparatus
    Equivalent to: New Brunswick Scientific Co., Inc.
    B63 (cat. 377)
    with accessories
    Trap temp.: -51 C, ⅓ hp., 5 lit cap.

28. Centrifuge, refrigerated
    Equivalent to: New Brunswick Scientific Co., Inc.
    Model LE (cat. 377)
    with accessories
    Process rate: 10-50 lit/hr., speed: 15000-40000 rpm

29. Variable compression engine
    - equipped to operate on a wide range of gaseous and liquid fuels. (either on spark ignition (otto) cycle or compression ignition (diesel) cycle)
    - compression ratio range 4 : 1 - 22 : 1 or more.
    - 20 hp output, 3000 r.p.m.
    - fully instrumented for measuring: injection pressure, torque, speed and fuel flow, detonation ..... etc.

30. Instrumentation systems, including:
    - liquid level, on/off control, 2 units (for digesters of D = 40 cm, h = 80 cm & temp. up to 200 C) st.st.
    - liquid flow meter, 4 units
    - pad-type thermocouple, 10 units: 0-200 C
    - Thermocouple, single action, 2 units (60-70 cm long-Temp 0-200 C)
    - Thermocouple, dual action, 2 units
    - Temperature controller, 0-200 C, 2 units (0-200 C)

- Pressure reducing regulators, 4 units (10 to 2 bar) I.D. of pipel".
- Wet and dry-bulb thermometry, 2 units (st.st.) for R.H. 0-100%.
- Process pH controller, mutiple points (0-14 pH).
- In-line pH meter
- In-line conductivity sensor (0-14 pH fer temp 0-200 C) Teflon coated.
- In-line fluid density meter (0.5-0.8 kg/m^3 gas & 1-3 kg/lit liq).
- Control valve, 2" O.D., 10 units (st.st. or teflon seat, temp 0-200 C)

Attachment A

Desktop Computer specifications

User Memory Workspace: 64 K (Extendable).

CRT Display 7.5 in x 5.5 in

Printer : 72 Character per line & 35 lines

Graphics and Alphanumeric

Magnetic top drive 300 K bytes

Graphic Resolution : about 1024 x 780 viewable points

Auto repeat equipped keyboard

Preferably Bilanguage (English/Arabic)

Optional

Word Processor

Hard Copier

Software

1. Capital Investment Analysis
2. Cash Flow Analysis
3. Compound Interest
4. Critical Path Analysis
5. Investment Return
6. Discounted Return on Investment and Payback
7. Extended Risk Analysis
8. Solution of Polynomial Equations
9. Fluid Flow Analysis
10. Equation of state
11. Dew point and Bubble point Calculations
12. Isothermal Flash Calculations
13. Adiabatic " "
14. Packed Column Analysis
15. McCabe - Thiele Analysis
16. Simultaneous Non-linear Equations
17. Multicomponent distillation
18. Area Under Curve
19. linear Equation Gaussian Reduction
20. Simultaneous linear Equations.
21. Statistical Analysis
22. Ordinary Differential Equation
23. Optimization
24. Seawater Salinity and Density
25. Latent Heat of Vaporization
26. Vopor Pressure Correlations
27. Membrane Separation Calculations
28. Graphics-Software Package.

ANNEX III

List of Spare Parts For Phase I
Budgeted in Phase II

1. Atomic Absorption Spectrophotometer

Manufacturer : Perkin-Elmer 2380

Model : 0060 - 0259

Spare Parts of :

Item	Specifications	Perkin-Elmer Part No.	No. of
1) Microliter Pipets (Eppendorf)	5 µl Volume	0290-2135	2
	10 " "	0290-2136	2
	25 " "	0290-2139	2
	50 " "	0290-2140	1
	100 " "	0290-2141	1
2) Pipet Tips	Yellow, Polypropylene for Eppendorf Microliter Pipets, 5 µl to 100 µl pakage of 1000	0290-2147	1
3) Graphite Tubes	Pyrolytically coated. Box of 50 For use with HGA 400	0290-1766	2
4) Autoclave 3	Consists of PTFE sampling vessel enclosed in a protective metal housing for 50 atm. & 160°c.	0290-2151	1
5) Aqueous standard Solutions	Metal / Compound / Matrix / Vol. ml.		
	Arsenic / K_2HAsO_4 / H_2SO_4 / 500	88051	1
	Barium / $BaCl_2$ / H_2O / "	88052	1
	Cadmium / $CdCl_2$ / HCl / "	88056	1

Item	Specifications				Perkin-Elmer aPart No.	No. of
	Metal	Compound	Matrix	Vol. ml.		
	Cobalt	$CoCl_2$	Hcl	500	88060	1
	Manganese	$MnCl_2$	Hcl	"	88078	1
	Phosphorus	$(NH_4)_2HPO_4$	H_2O	"	89887	1
	Lithium	LiCl	Hcl	"	88076	1
	Molybdenum	$(NH_4)_6Mo_7O_{24}$	NH_4OH	"	88080	1
	Titanium	$TiCl_4$	Hcl	"	88113	1
	Lanthanum	$LaCl_3$	Hcl	"	88074	1
	Antimony	$SbCl_3$	HNO_3/Hcl	"	88050	1
	Chromium	$(NH_4)_2CrO_4$	H_2O	"	88059	1
	Strontium	$Sr(NO_3)_2$	HNO_3	"	88098	1
	Tin	$SnCl_4$	Hcl	"	88112	1
	Selenium		H_2O	"	88094	1
	Copper	$Cu(NO_3)_2$	HNO_3	"	88061	1
	Iron	$FeCl_3$	Hcl		88073	1
6) Intensitron Hollow Cathode Lamp	Chromium				0303-6021	1
7) Standards (Soluble in heavy organics) (5 gm)	Alumin. cyclohexane butyrate, AAS; 7.0% A1,5 gm				87255	1
	Barium cyclohexane butyrate, AAS; 28.9% Ba, gm				87257	1
	Calcium 2- Ethylhexanoate, AAS; 12.3% Ca, gm				87258	1
	Cobalt(11)cyclohexanebutyrate, AAS; 14.8% Co, 5 gm				87260	1
	Copper(11) cyclohexanebutyrate,AAS; 15.8% Cu,gm				87262	1
	Potassium cyclohexanebutyrate,AAS; 18.8% K, gm				87265	1

Cont.

Item	Specifications	Perkin-Elmer a Part No.	No. of
	Magnesium cyclohexanebutyrate, AAS; 6.7% Mg, 5gm	87267	1
	Manganese (11) Cyclohexanebutyrate, AAS; 14% Mn, 5gm	87268	1
	Sodium cyclohexanebutyrate, AAS; 12% Pa, 5gm	87269	1
	Nickel cyclohexanebutyrate, AAS; 14.6% Ni, 5gm	87270	1
	Lead cyclohexanebutyrate, AAS; 38% Pb, 5gm	87272	1
	Zinc cyclohexanebutyrate, AAS; 14.8% Zn, 5 gm	87276	1
8) Replacement filter		0057-2471	6
9) Replacement for Air Filter		0303-0229	1
10) Parts for: Burner Model 0057-0988	Corrosion Resistent Nebulizer	0303-0404	1
	Nebulizer Capillary Assembly	0303-0402	1
	Flow Spoiler	0057-2561	5
	Impact Bead	0057-2615	5
	O-Ring	0990-2147	5
	Corkprene Gasket	0047-2014	5
	Burner End Cap	0057-2563	1
	O-Ring	0990-2038	5
	O-Ring	0990-2236	5
	O-Ring	0990-2240	5
	Drain Tube Assemby	0047-0391	1
11) Transducer	For gas box BC-2		1

2- UV/Visible Spectrophotemter

Manufacturer : Perkin Elmer

Model : 559 A

Item	Specifications	Part No.	No. of	
1) Wave legth Calibrating Solution	Holmium Chloride (20Z. bottle)	030-0400	1	
2) Sealed Cell	Benzene Vapour	005-0401	1	
" "	Sodium Nitrite	005-0402	1	
" "	" Iodide	005-0404	1	

3- Gas Chromatograph

Manufacturer : Perkin Elmer

Model : Sigma 2 B

Data Station : P.E. Sigma 10

Detectors : HWD & FID

Item	Specifications	Part.of	No.of	Expected Price $
Print head	for Sigma 10			
Print head drive belt	" " "			
Glass liner	for Sigma 2B injector	0330-2221	5	15.5 x 5
Pressure gauge	0-100 psi		1	125
" regulator	0-100 psi		1	205
" gauge	0- 60		1	125
Septa	for Sigma 2B, Vacuum backed	0009-0652	2x50	31 x 2
Septa	" " " ,for metal cap.col	0009-0655	2x50	45 x 2
Magnetic Tape Cartidge	for Sigma 10	0332-1920	12	16.5 x 12
Loops for different gas sample volumes	Sample volume 0.5 c.c.	0332-4902	1	35
	" " 1.0 "	0332-4903	1	47
	" " 5.0 "	0332-4904	1	47
ECD Add-on Kit	Consits of detector, Amplifier and all necessary hardware to ADD ECD capability to an existing instrument	0332-3400	1	2380
Crimper	Tool for sealing the sample vial and cap removal tool	B003-8134	1	195
				3586.5

Cont.

Item	Specifications	Part No.	No. of
Adapter	1/8"to ¼" st.st.	008-0100	1
	1/8" to 1/16" st.st.	990-3198	1
	1/8" to 1/16" "	270-0286	1
Column Union	1/16" st.st.	990-3807	1
Slotted Adapter Nuts	st.st.	009-0249	1
Female Slotted Nut	"	009-1592	1
Male Slotted Nut	"	009-1593	1
Column's Packing:for VFA	-GP 10% SP-1000/1%H_3PO_4 on 100/120 chrom WAW	1 -1841	40 gm
	-GP 15% SP-1220/1%H_3PO_4 on 100/120 chrom WAW	1 -2144	40 gm
Column Packing Materials	a) Stationary Phases :	CAT. NO.	
	Squalane	0496-0642	50
	Apizon L (Tabe)	0496-0640	50
	Diethylene glycol adipate LAC-IR-296	0496-0668	50
	Diethylene glycol succinate LAC-3R-728	0496-0639	50
	Hexamethyl phosphoramide HMPA	0496-0613	50
	7,8 Benzoquinoline	0496-0619	50
	Trimer acid (empol 1040)	0486-0665	50
	Carbowax 20M Polyethylene glycol	0496.0646	50
	Molecular sieve 5A		50
	Silicone OV1 (100% methyl)	0496-3863	5
	" oil (" ")		5
	" OV 101	0496-5491	5
	" " 17	0496-3869	10
	" " 210	0496-5549	5
	" " 225	0496-5488	5
	Carbowax 1540	0496-0637	50
	Silica gel		50
	Alumina		50
	Benton 34	0496-0686	50
	Carbowax 20M Terephthalic acid	0496-3838	25

Cont.

Item	Specifications	Part No.	No. of gms
	b) Support Materials		
	Chcomosorb W-NAW (80/100 mesh)	0490-1124	100
	" W-AW (100/120 ")	0490-1131	100
	" W-HP (100/120 ")	0490-1136	100
	Gas " P (100/120 ")	0490-1011	100
	Gas " Q " ")	0490-1063	100
	" 101/103 " "	0490-1065	100
	" 102 " "	0490-1069	100
	Teflon 6 (30/60 mesh)	0490-1126	100
Columns	Empty stainless steel		
	- O.D.1/8,I.D. 2.2mm, length 6m	0498-9026	3
	- " " " 2 m	0498-9032	3
	- O.D.¼, I.D. 4.6mm, length 6m	0498-9036	3
	- " " " 2 m		3
Calibrati. Gases	Composition	2-3437	2
	- CH_4,CO, CO_2,C_2H_2,C_2H_4&C_2H_6in N_2 1% each (Scotty II)		
	- CH_4,CO_1 CO_2,H_2& O_2 in N_2 1% each (Scotty II)	2-2561	2
Tool kit	Xcelite (Supelco)	2-0599	1

ANNEX IV

JOINT U.S. PANEL-PROJECT COMMITTEE MEETING
ON
"THE DEVELOPMENT AND APPLICATION OF BIOGAS
TECHNOLOGY IN RURAL AREAS OF EGYPT"

NRC, Cairo - April 3-6, 1982

Saturday April 3	10:00 - 12:30	Whole group will meet to review progress, discuss project status and future plans.
	12:30 - 2:00	Panel will visit some laboratories and discuss work in small group.
Sunday April 4	10:00	Visit biogas sites at Al-Manawat.
Monday April 5	8:00	Visit biogas sites at Omar Makram.
Tuesday April 6	9:00 - 11:00	Whole group - finalize report and complete evaluation.
	11:30 - 2:00	Enlarged biogas team gathering and or discussion Seminars by U.S. Panel members.

Note The report is not attached; it has been previously distributed to the members of the Joint Consultative Committee. Additional copies are available either from ASRT/Cairo, NAS-NRC/Cairo or NAS-NRC/Washington.

ANNEX V

Project Major Publications

1. M.M. El-Halwagi
   Development and application of Biogas Technology for rural areas of Egypt.
   Pub. in Proc. Bio-Energy'80, World Congress and exposition, April 21-24 1980, Atlanta, Georgia, U.S.A., 446-447.

2. M.M. El-Halwagi, A.M. Abdel Dayem.
   Biogas generation from animal and agricultural wastes in Africa.
   Paper prepared upon request of the Economic Commision of Africa, Energy Resources Unit, Panel of experts on Biomass. Oct. 1980.

3. A.M. Abdel Dayem and M.A. Hamad.
   Design and operation of small biogas plants.
   Proc. 3rd Miami Inter. Conf. on alternative energy sources, 15-17 Dec. 1980, Miami U.S.A.

4. M.M. El-Halwagi.
   Pilot Demonstration of biogas technology in rural areas of Egypt.
   Proc. of National seminar on biogas technology July 9-11 1981. India.

5. Prefeasibility study on biogas technology in rural areas of Egypt.
   Conf. on Energy Conservation and Utilization, Cairo, Nov. (1981) (IN ARABIC).

6. F. El-Gohary and F. Nasr,
   Bioconversion of organic wastes, 4th Inter. Conf. on alternative energy sources, Miami, Fl., 1981.

7. M.A. Hamad, M.M. El-Halwagi.
   The expected role of biogas technology in rural areas of Egypt. Energy considerations.
   4th Miami International Conference on alternative energy sources. 1981, Miami, U.S.A.

8. Biogas Technology in Rural Areas
Bioénergy Directory 1981.

9. M.M. El-Halwagi, A.M. Abdel Dayem, M.A. Hamad.
Biogas Technology for rural areas of Egypt.
Proc. of the First OAU/STRC Inter-African conf. on Bio-fertilizers, Cairo, March, 1982.

10. M.M. El-Halwagi, A.M. Abdel Dayem, M.A. Hamad.
Village Demonstration of biogas technology.
An Egyptian case study.
Proc. of IGT 6th meeting on Energy from Biomass and Wastes.
Jan. 1982.

11. M.A. Hamad, A.M. Abdel Dayem, M.M. El-Halwagi.
Rural biogas technology: Effect of digester pressure on gas rate and composition.
J. Eng. and applied science, 1982.

12. Performance evaluation of two rural biogas units of the Indian and Chinese Versions.
M.A. Hamad, A.M. Abdel Dayem, M.M. El Halwagi.
J. Energy in Agriculture, 1982.

13. Zohdy, L.I. and Badr El-Din, S.M.S. (1982).
Evaluation of digested slurry as a fertilizer.
I. Its microbial and chemical composition and its phytotoxicity features.
Egypt.J.Microbiol. (in press).

14. Zohdy. L.I., Badr El-Din, S.M.S. Khalafallah, M.A. and Abd El-Maksoud, H.K. (1982).
Evaluation of digested slurry as a fertilizer.
II. Effect on biological and chemical properties of a virgin sandy soil.
Egypt. J. Microbiol (in press).

15. Zohdy, L.I., Badr El-Din, S.M.S., Khalafallah, M.A., and Abd El-Maksoud, H.K. (1982).
Follow up the fermentation progress in the digested slurry of biogas digester from the standpoint of its fertilizing value.
Egypt.J.Microbiol. (in press).

16. Zohdy, L.I., Badr El-Din, S.M.S. and Khalafallah, M.A. (1982).
Handling and storage of digested slurry produced from the biogas digester.
Egypt. J.Microbiol. (in press).

17. Zohdy, L.I. and Badr El-Din, S.M.S. (1982).
Comparison of biogas slurry treatments.
I. On the biological and chemical properties of a virgin sandy soil cultivated with wheat.
Egypt. J. Microbiol. (in press).

18. Zohdy, L.I., and Badr El-Din, S.M.S. (1982).
Comparison of biogas slurry treatments.
II. On the wheat yield, nitrogen and phosphorus uptake and nitrogen balance in a virgin sandy soil.
Egypt. J. Microbiol (in press).

ANNEX VI

VITA Request and NRC Proposal

Dr. Mokhtar El Halwagi, Head
Pilot Plant Laboratory
National Research Center
Al Tahrir Street, Dokki, Cairo

Dear Dr. Halwagi:

You are aware from our previous conversations of VITAs interest in promoting the utilization of renewable energy sources in Egypt. At the present time we are considering financing the construction and testing of two bio-gas digesters in the village of Shubra Kass, Garbeya Governorate. These digesters would be utilized to heat large chicken houses which in turn would supply fuel for the process. The digesters would be constructed for the local Community Council of Shubra Kass and Mr Abd Meguid Selim, an independent farmer in the same village.

On behalf of VITA I would like to request that the National Research Centre submit a proposal for this work. The proposal should contain the following for each digester:

1. A Feasibility Study (including current and future cost efficiency)

2. Cost of Digester Construction - utilizing if possible village workshop(s) in the village of Shubra Kass or the surrounding area

3. Supervision, Technical Assistance, Training, and Follow-Up support (for one year) from the National Research Centre

4. Training for 4 - 6 persons in digester operation and maintenance

5. Blueprints for digester construction, including references to ground water levels and adjustments required to accomodate such

6. All designs and cost should include retro-fitting of existing constructions - including gas pipelines, heaters, light fixtures, needed insultation, etc.

7. Non-essential items suggested as ideal or proposed for testin should be noted with separate cost factors listed.

In the development of these proposals, work will be directly with Mr. Abd Meguid Selim and Mr. Abdullah, Head of the Local Council Executive Committee of Shubra Kass. Final proposals in English should be forwarded to me for review and forwarding to VI I would appreciate very much if we could have all proposals before September 20, 1982. Immediate consideration will then be given to funding.

Unfortunately no renumeration is available for those institutions submitting proposals other than actual expenses up to 400 U.S. Dollars. Itemized expenses should be submitted with the proposals.

We hope that you will be able to develop these proposals and we look forward to working with you in the future.

Sincerely,

Prof.Dr. M.M.El Halwagi
Head,Pilot Plant Laboratory
National Research Centre,
El Tahrir St., Dokki,Cairo

September 19,1982

Mr. Roger A.Hardister
Vita Representative,
14 Hussein Hegazi St., Flat 1
P.O.box 5 Maglis El Shaab
Cario, Egypt

Dear Mr. Hardister,

In response to our previous discussions, and in reply to your formal request as per your letter of August 15,1982, please find enclosed herewith a proposal for constructing a biogas digester (or two) to be associated with one (or two) of the typical 600 large chicken houses in the area.

In essence, the proposal is a prefeasibility study tailored for the case of interest. Key points are:

1. Digester: $50m^3$, internally heated. Tunnel type design with a separate gas holder. The design is specially made and should be considered confidential and not to be utilized by anybody other than the NRC biogas team.
2. Estimated construction cost (per digester) including civil construction, gas holder, heating facilities, retro-fitting of existing construction and engineering supervision costs is around 6000 Egyptian pounds. This does not include any incentives for the supervision team or overhead charges.
3. The actual costs for one year supervision, technical assisstance, training and follow-up are estimated at 1500 Egyptian pounds. This only allows for out-of-pocket expenses for about 6 man-days per month of specialized personnel.
4. The operation of the system under the prevailing subsidized energy prices would be at loss. However, using international energy prices-which are believed to come gradually into effect in the future-the system is profitable. A conservative estimate indicates 14% simple rate of return on the investment. Intangible benefits, such as security of fuel availability, convenience and pollution control, are not taken into account.
5. Though we are pretty confident that our joint endeaver will be a successful one, a minute element of risk should be acceptable since the proposed system will be implemented for the first time. This is the usual

cont'd

attitude when undertaking a demonstration experiment for the purpose of full-fledged evaluation. It is, thus, suggested to start with only one unit. The second can follow after the first has been successfully demonstrated.

We hope that our proposal will meet your requirements and we sure look forward to joint fruitful work.

Sincerely yours,

M.M.El Halwagi
NRC Biogas Project Principal
Investigator

NATIONAL RESEARCH CENTRE (N R C)
Biogas Project

Proposal
on
Implementing two Large Biogas Units
Attached To Poultry Rearing Operations
In the village of Shubra Kass-Garbeya Governorate

Submitted by:NRC Biogas Project Team
To :VITA

September 1982

National Research Center
Biogas Project

Proposal on : Implementing two large Biogas Units attached to poultry rearing operations in Shubra Kass village, Garbeya Governorate.

1- Introduction :

Since the early part of 1982, VITA (Volunteers In Technical Assistance) representative and experts in Egypt have contacted the Biogas Project team of the National Research Center (NRC). They visited some of the NRC demonstration units, discussed in depth and at frequent intervals the NRC ongoing and future planned work relating to Biogas for rural areas of Egypt.

During a meeting between Mr. Roger A. Hardister, VITA representative in Egypt, and Prof. Dr. M.M. El Halwagi, the Principal Investigator of the NRC Biogas Project, the former discussed the possibility of joint activity whereby funding a specific limited project would be supplied through VITA (originating from USAID Washington) and the technical know how and implementation provided by the NRC.

A visit to Shubra Kass (15 km. from Tanta), Garbeya Governorate was made on thursday 19/8/1982 by Prof. Dr. Adel Dayem (the Engineering team leader) and Dr. M.Hamad accompanied by Mr. Hardister. The purpose was to examine the possibility of implementing two large Biogas demonstration units in conjunction of two poultry rearing operations. The first belongs to the Local Community Council of Shubra Kass, and the second is owned by an independent farmer Mr. Abd El Meguid Selim.

Following this visit, Mr. Hardister made a formal request in his letter addressed to Dr, Halwagi dated August 15, 1982. This proposal is made in response to this request.

2- Brief Description of the Relevant Aspects of the Case (Shubra Kass Village)

Shubra Kass is about 15km. from Tanta. Together with two neighbouring villages : Shubra Beel and Kafr Salem, it forms a triangular population conglomerate that belongs to Santa Center, Garbeya Governorate. Pertinent information relating to population, area of agricultural land and cattle ownership are listed in Table 1.

Table 1

Relevant information on

Shubra Kass, Shubra Beel and Kafr Salem

Village	Population (thousand)	land Area (Feddan)	No.of Cattle (Cows & W.Buffalos)
Shubra Kass	10-12	1500	2500
Shubra Beel	6-7	950	1335
Kafr Salem	3-4	505	760

About 600 similar poultry rearing houses exist in the area. The capacity of each is around 5000 per cycle, the cycle being 60-70 days (out of which 20 days are for cleaning). There are two main problems in conjunction with the operation of these poultry-rearing farms. The first is the difficulty in securing the butagas bottles needed for heating the chicks (around 2-3, 12Kg. bottles/day for each farm). The actual cost of the bottles is consequently more than double the official price. Moreover, sometimes-particularly during winter-some farms may not be able to secure the butagas needed most of the chicks may thus die. It was also mentioned that the inevitable recycle of butagas bottles among the various chicken farms could lead to transfer of diseases.

The second is related to the accumulation of poultry droppings which represent a source of pollution and disease transfer. During each cycle 25-30 m^3 accumulate. Though it is sometimes difficult to dispose of these quantilties, they are usually sold to land reclamation areas for a price ranging between L.E.70 to 100 for the whole lot.

The two sites proposed by VITA for establishment of biogas digesters appear to be suitable, though there may exist the usual problem of high underground water table (which is reported to vary from 1.25-2m). The village is already well prepared to and receptive of the biogas technology particularly since there is a genuine need for it in view of the problems associated with poultry rearing operations. The presence of the "Integrated Social Services Centre" in the area is an additional asset in respect of promotion and propagation of the technology once successfully demonstrated.

The costs of the main building materials as well as the prevailing wage structure in the area are as follows:

Materials

Red Bricks	L.E.40 per 1000
Gravel	L.E.8 per m^3
Sand	L.E.4 per m^3
Cement	L.E.70 per ton (though Mr.Abdullah Abbas Hussein, the head of the Local Village Unit indicated that cement could be procured at official prices which are

about half the free - market prices.

Wages

Brick Layer	L.E. 9 per 1000 bricks
Plasterer	L.E. 0.4 per m2
Excavation	L.E. 1 per m3 or L.E. 3/day
Concrete work	L.E. 3 - 4 per m3

3- The Proposed Biogas System

The proposed system is specifically tailored for the two poultry rearing operations under study. Each consists of two stories, 250m2 each , and accomodate 5000 chicken every 65 days cycle. The heating requirements to warm up the chicks vary from 3 small butagas bottles (12 Kg. each) at the start of the incubation period, decreases gradually until completely disposed of with ~~by~~ the end of the cycle. Chicken droppings accumulating over one cycle amount to 25m3.

Since the heating requirements increase during the winter season, when ironically the biogas production is at its lowest rate, digester heating is mandatory to ensure a controllable regular supply. Heating would also beneficially help in killing most of the pathogens and parasites, resulting in an almost pathogen-free effluent.

Because of the anticipated high underground water table, a new design is proposed, which may be called the "tunnel" digester whose engineering details are shown in figure 1. The confidentiality of this design and its engineering details are stressed. None of it should be utilized in any manner outside the control or the explicit approval of the NRC.

On the basis of an operating temperature of about 35°C the volume of the digester is calculated to be around 50m3 with a net gas production of 35m3/day, which is equivalent to 1.25 small butagas bottle per day. These calculations are given in table 2.
Now, since the actual gas requirements vary from 3 butagas bottles during the early stage of incubation and go down to ½ bottle by the end of the fattening stage, as shown in table 3, two solutions are proposed. The first involves a 250m3 flexible balloon to store the excess gas during the later stages and use it to supplement the gas production during the early incubation stage where it is mostly needed. The second option-which we recommend adopting-is to vary the rate of digester feeding according to a present schedule is given in table 4. In this manner, a deficit will only exist during the first 7 days of the rearing cycle, equivalent to around 7 small butagas bottles. These are normally available in each poultry farm and can be refilled at leisure and kept as such before starting the cycle.

A third alternative may be also suggested. This involves the use of a solar heater to heat up the digester and thus save about 15m3/day of gas (equivalent to about ½ butagas bottle) that would otherwise be used for heating the digester. This alternative, however, would require much higher capital investment (about 25% more) as well as additional technical complications.

Table 2

Biogas Unit Operating Conditions And Sizing

Feed Material	= 25m3 or about 12.5 tonne over a whole rearing cycle
Average Daily Feed	= 12.5 t/60 days = 200 kg/day on dry basis
Digeston Temperature	= 35^0C.
Feed Concentration	= 10% solids
Retention Time	= 25 days
Daily Feed Volume	= 2 m3 / day
Digester Size	= 25 x 2 = 50 m3
Gas Production Rate	= 1 - 1.2 m3/m3 digester - day

Average daily gas production ≃ 50 m3 / day (conservative estimate)

Amount of gas used for heating digester = 10 - 15 m3 / day (depending on the ambient temperature and other envitonmental conditions).

Net Gas Produced	= 35 m3 / day
Equivalent to	35 x 0.43 = 15 kg/day butagas

Gas holder size (40% of daily gas production) = 0.4 x 50 =20m3

Table 3

Heating Requirements During The Rearing Cycle

	Stage No				
	First	Second	Third	Fourth	Fifth
Days	7	14	14	14	14 - 21
Function	Incubation		Fattenning		cleaning
Butagas needed (small bottles/day)	3	2	1	½	-
No of bottles needed (per stage)	21	28	14	7	0

Total No of bottles during the whole cycle = 70 small bottles.

Table 4

Proposed Digester Feeding Schedule

	Stage No				
	First	Second	Third	Fourth	Fifth
Feed rate, m3/day	4	4	2	0	0
Gas Production rate (m3/m3 digester-day)	1.6	1.6	1	½	½
Equivalence (small butagas bottles/day)	2	2	1.25	0.6	0.6
Requirements (small bottles/day)	3	2	1	0.5	0
Deficit/day	1				
Deficit/stage	7				

.../7

4- Estimated System Economics

4/1 - Investment Costs

	L.E.	
- Construction Costs*	1500	(For details, see Annex)
- Gas Holder	1700	(Actual Quotation)
- Digester heating facilities	1000	
- Retro-fitting of existing constructions (gas pipelines, heaters etc.)	400	
- Engineering supervision** costs (transportation & subsistence costs)	1400	(no profit element or overheads included)
Total	6000	

4/2 - Annual production costs (excluding land)

(a)	Depreciation	
	- Civil works (20 years)	75
	- Other (8 years)	563
(b)	- Additional Labor	120
(c)	- Maintenance	60
	Total	818

4/3 - Annual Income & Profitability

This is based here on the tangible benefit only accruing from the fuel gas produced. However, there are other equally important - if not more important- benefits such as :

(1) Securing a dependable heat source within the farm premises itself. This would safeguard the life of the chicks in case of difficulties in procuring butagas or closed roads during rainy days.

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* Most building materials, particularly cement, at official prices.

** [illegible] be reduced in the future if local authorities get

(2) Pollution control, a particularly advantageous consequence would be the minimization of the hazards contagious disease transfer.

On the other hand the treatment and handling of the digested slurry to render it into a readily usable form (dry form), may cost more than estimated in the anticipated operating costs outlined above.

Income from the produced fuel gas ''biogas'' is calculated here on the basis of butagas equivalence, and at two price levels. The first is the prevailing market price at Shubra Kass (which involves an extremely high subsidy-though it is higher than double the official price), and the second is the international market price, which is expected to prevail in the future if the government subsidies are gradually withdrawn.

4/3 -1 Profitability based on butagas sub-sidized prices

- Total usable gas during the cycle is equivalent to about 66 small butagas bottles.
- The prevailing butagas market price for Poultry Rearing Farms in Shubra Kass is more than L.E. 1.25 for a small butagas bottle.
- Estimated imcome per cycle = 66 x 1.25 = L.E. 82.5 assuming 5 cycles per year, then Annual income = 82.5 x 5 = L.E. 412.5
- Profit = Income - Production costs
  = 412.5 - 818 = -405.5
  or an annual <u>Loss</u> of about 405 Egyptian Pounds.

4/3 -2 Profitability Based on Butagas World Market Prices

- Current butagas international price is $ 500 per tonne. or $ o.5 per kg. Thus a small bottle, 12 kg, should cost $ 6.00 or about L.E. 5 (based on official exchange rate of 0.8)
- Annual Income = 66 x 5 x 5 = L.E. 1650
- Profit = 1650 - 818 = L.E. 832
- Simple rate of return on investment
  $$= \frac{832}{6000} \times 100 \cong 14\%$$

5- Concluding Remarks

1. The actual cost of supervision, technical assiatance, training and follow-up support (after digester start-up) is estimated at around L.E. 1500. This presumes that all normal work is undertaken by local people. Only about one to two - man-day a week on the average is to be provided by the NRC biogas team.

2. In all the estimates thus for provided, only actual costs are given. No profit incentives or overheed charges are included, it should be noted, however, that the normal NRC contracting regulations involve around 165% additional charges for team incentives and overheads.

3. The system proposed for the Shubra Kass case as outlined here is tailored to its requirements and thus the design is a rather specific one. The NRC biogas project team who designed this system, has not as yet implemented any similar system, whether type-wise or scale-wise. Therefore this joint endeavor between the NRC and VITA should be viewed in its true perspective, that is as a pilot demonstration where normal risk-bearing should be anticipated. Nevertheless, based on the background, knowledge and previous experience of the NRC biogas team in building and operating family - size digesters of various designs and under different conditions, it is felt that in all probability, the outcome of the proposed endeavor will be a successful one matching as close as possible the performance expected.

Annex

Detailed Estimats of a $50m^3$ Digester Construction Costs

(A) Brick Work:

1. Tunnel:

Surface area of:

Cylindrical roof	$= 2x \frac{\pi}{2} DL$	$= \pi \times 2.5 \times 6$	$=47.12m^2$
Vertical Wall	$= 4 \times H \times L$	$= 4 \times 0.8 \times 6$	$=19.20$
Side Walls	$= 4(\frac{1}{2} \frac{\pi}{4} D^2 + HD)$	$= 4(\frac{\pi}{8} x 2.5^2 + 0.8 x 2.5)$	$=17.82$
Man holes	$= 2 \times \pi\ dl$	$= 2\pi \times 0.7 \times 0.25$	$= 1.10$
		TOTAL	85.24

For wall thickness of 25 cm.

No. of bricks

$$= \frac{85.24 \times 10^4}{13x7} = 9,370$$

2. Gas holder compartment:

Surface area $= \pi\ HD = \pi\ x1.5x5.05 = 23.80m^2$

No of bricks $= \frac{23.8 \times 10^4}{13x7} = 2,615$

3. Feed chamber:

Surface area $= \pi\ DH = \pi\ x1.5x1 = 4.71m^2$

No of bricks $= \frac{4.71 \times 10^4}{13x7} = 518$

Total Bricks with 10% excess $=(9,730+2,615+518)x1.1$

$= 14,000$

(B) Concrete for foundations:

Base of Tunnel	$=6.25 \times 6.25 \times 0.1=3.906m^3$
Base of gas holder compartment	$= \frac{\pi}{4} \times 5.25^2 \times 0.1 = 2.165$ "
Base of central pipe	$= 0.5 \times 0.5 \times 0.5 = 0.125$ "
Man hole covers	$= \frac{\pi}{4} \times 0.6^2 x0.15x2 = 0.085$ "
Base of feed chamber	$= \frac{\pi}{4} \times 1.6^2 \times 0.1 = 0.201$ "
Total volume of concrete	$=6.482\ m^3$

..../2

(C) Building materials.

1. Mortar for brick laying:

(For each 1000 bricks requires $0.6m^3$ mortar)

Mortar needed = $14,000 \times \frac{0.6}{1000} = 8.4m^3$

Sand = $8.5m^3$

Cement = 51 bags

2. Mortar for plastering:

Total surface area to be plastered = $120\ m^2$

(each $100m^2$ requires $1m^3$ mortar)

mortar needed = $120 \times \frac{1}{100} = 1.2m^3$

Sand = $1.2m^3$

Cement = 20 bags

Lime = $0.1m^3$

Fe cl_3 = 10 kg.

3. Concrete:

Total volume $7m^3$

gravel = $7m^3$

sand = $3.5m^3$

Cement = 42 bags

Required construction materials and prices

Material	Amount	Unit price (L.E)
Bricks	14,000	40 per 1000
Cement	6 tons	35 per ton
gravel	$7\ m^3$	8 per m^3
sand	$14\ m^3$	3.5 per m^3
lime	$0.1\ m^3$	10 per m^3
Fe cl_3	10 Kg	3 per Kg
Conc.pipe 10"	3 m	5 per m
St. pipes 2"	3 m	3 per m
iron rods	15 Kg	0.4 per Kg

..../3

Construction costs:

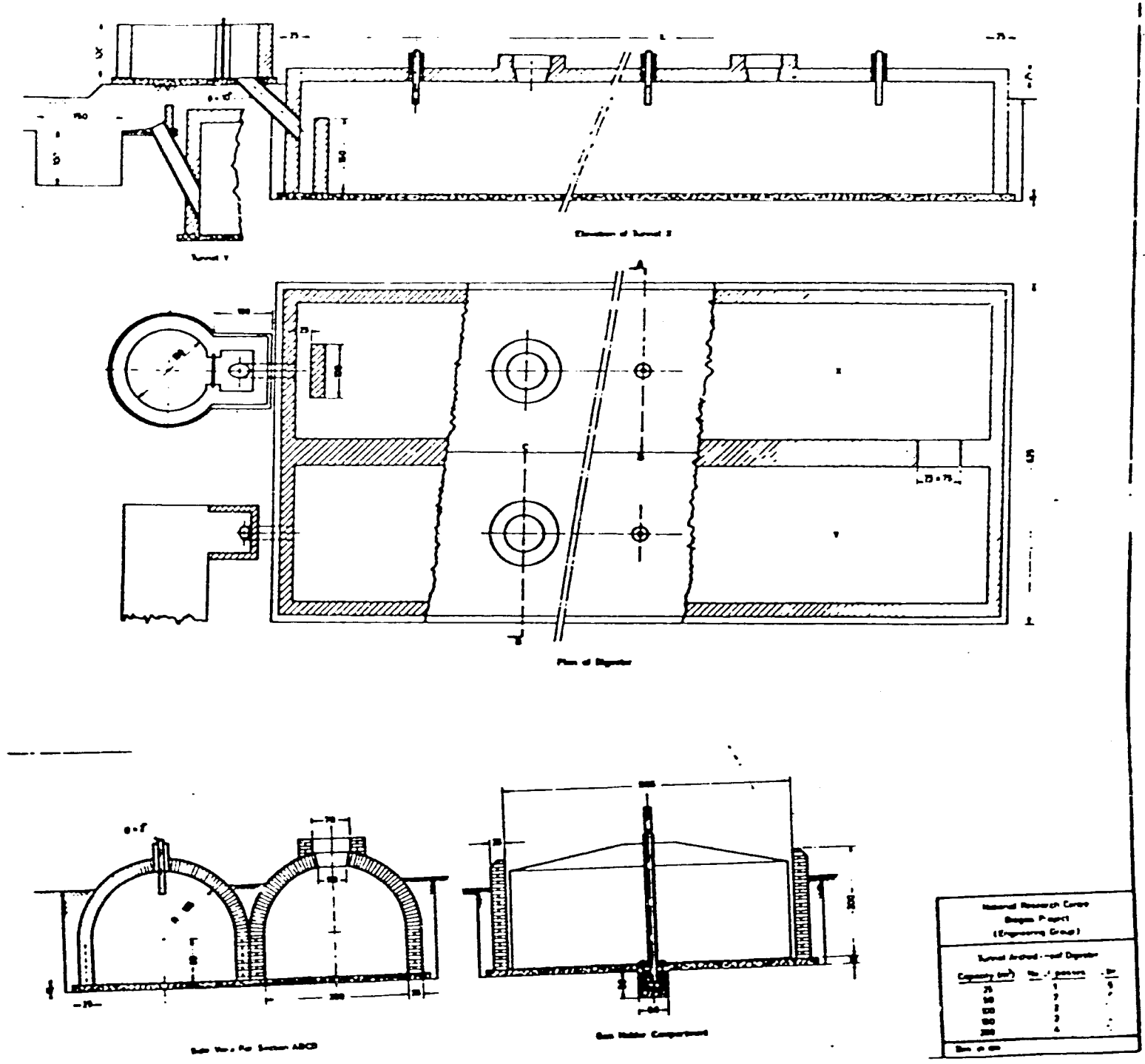
(A) Labour costs:

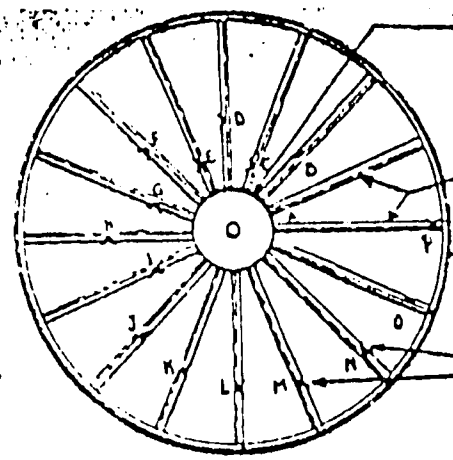
Excavation & Back filling	$= 120 \times \frac{3}{1.5}$	= 240 L.E
Brick laying	= 13 x 12	= 156 "
Plastering	$= 120 \times \frac{10}{30}$	= 40 "
Concrete work	= 7 x 3	= 21 "
	TOTAL	457 L.E.

(B) Building materials:

Bricks	= 14 x 40	= 560 L.E.
Cement	= 6 x 35	= 210 "
Gravel	= 7 x 8	= 56 "
Sand	= 14 x 3.5	= 49 "
Lime	= 0.1 x 10	= 1 "
Fe cl_3	= 10 x 3	= 30 "
Conc. pipe	= 3 x 5	= 15 "
St. pipes	= 3 x 3	= 9 "
Iron rods	= 15 x 0.4	= 6 "
Paints for gas holder		= 30 "
Mixers and ports		= 80 "
	TOTAL	1046

Total construction cost= 1500 L.E





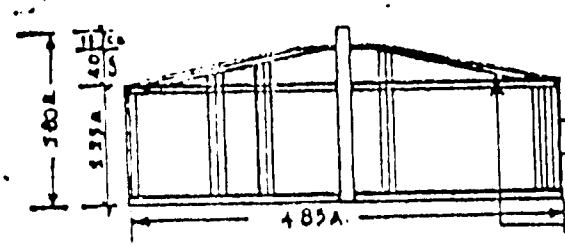
BOTTOM. PLAN

BOTTOM FLANGE WELDED TO CENTRAL PIP
BOTTOM HORIZONTAL BRACES KEEPING
OPEN FLANGE. DIA 900 AA x 10 AA THICK

BOTTOM HORIZONTAL BRACES 16 NOS. MADE
60x60x6 AA. ANGLE AND WELDED TO
RING FLANGE AND CENTRAL PIPE

BOTTOM RING MADE FROM 60x60x6 AA
WELDED TO VERTICAL AND BOTTOM HO
BRACES

16 ANGLES OF 60x60x6 AA EACH WELDED AT
SLOPING BRACES & AT BOTTOM TO HORIZON
BRACES AT A DISTANCE OF 45 CM AT A, 10
D, 60 CM AT C, 110 CM AT D, 70 CM AT E,
F, 80 CM AT G, 130 CM AT H, 90 CM
AT J, 150 CM AT K, 160 CM AT L, 17
185 CM AT M, 200 CM AT O AND 215 CM A
CENTRAL PIPE

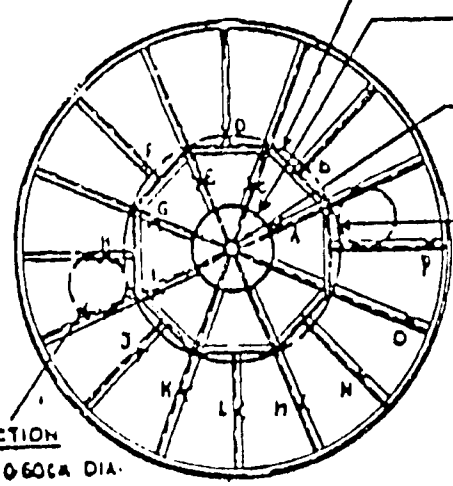


CROSS SECTIONAL ELEVATION

TO BE COVERED BY 10SWG (3.15 A TO) M.S.

VERTICAL SIDE BRACES MADE FROM 60x6
ANGLE WELDED AT TOP TO ROOF BRACE
RING AND AT BOTTOM TO RING.

ROOF RING MADE FROM 60x60x6 AA
TO VERTICAL AND ROOF BRACES



OCTAGON TO BE MADE FROM 60x60x6 AA ANGLE
TO BE WELDED WITH ROOF BRACES AS IN TOP

ROOF FLANGE WELDED TO CENTRAL PIPE
BRACES KEEPING PIPE OPEN. DIA 900x

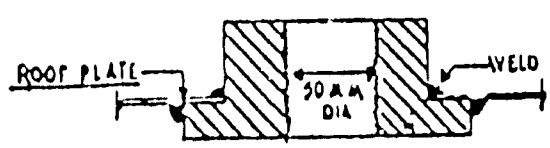
CENTRAL PIPE 150 AA. INTERNAL DIA 1.8C
WELDED TO UPPER & LOWER FLANGES
BOTTOM HORIZONTAL BRACES

2.4 A. DIA CIRCLE FOR GAS OUTLET FL
BE WELDED WITH ROOF PLATE ANYWH
CIRCUMFERANCE OF THE CIRCLE

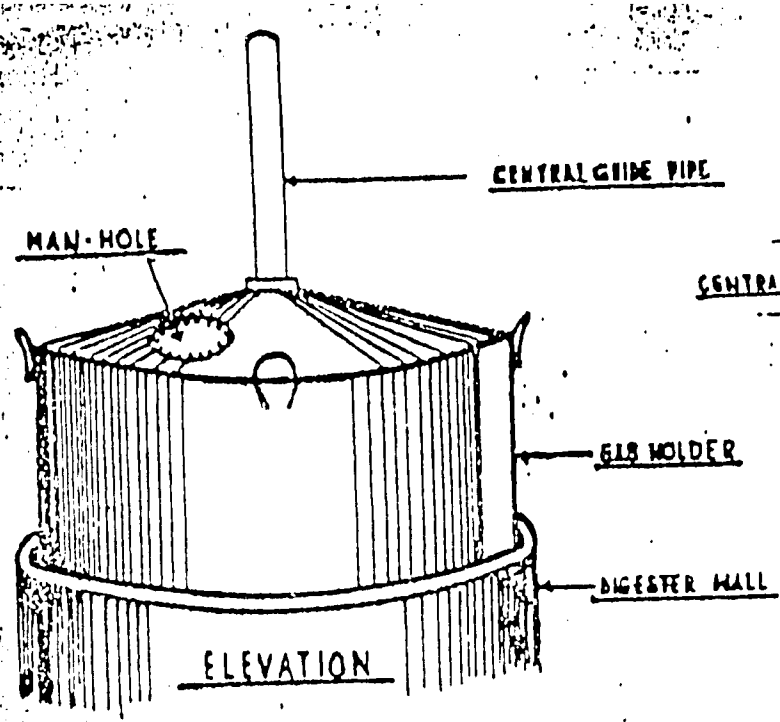
NOTE
4 RINGS TO BE FIXED ON TOP RING OF
(FOR HANDLES)

INSPECTION
CHAMBER 0.60CM DIA.
FOR DETAIL SEE ENCLOSURE

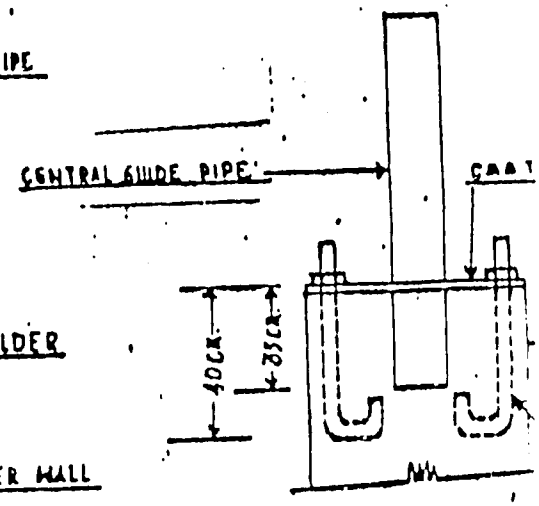
TOP PLAN



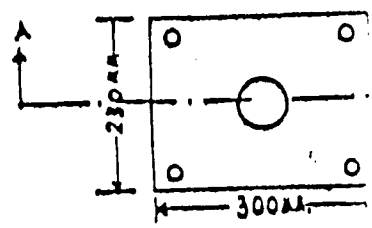
DETAIL OF GAS OUTLET
FLANGE
NOT TO SCALE



ELEVATION

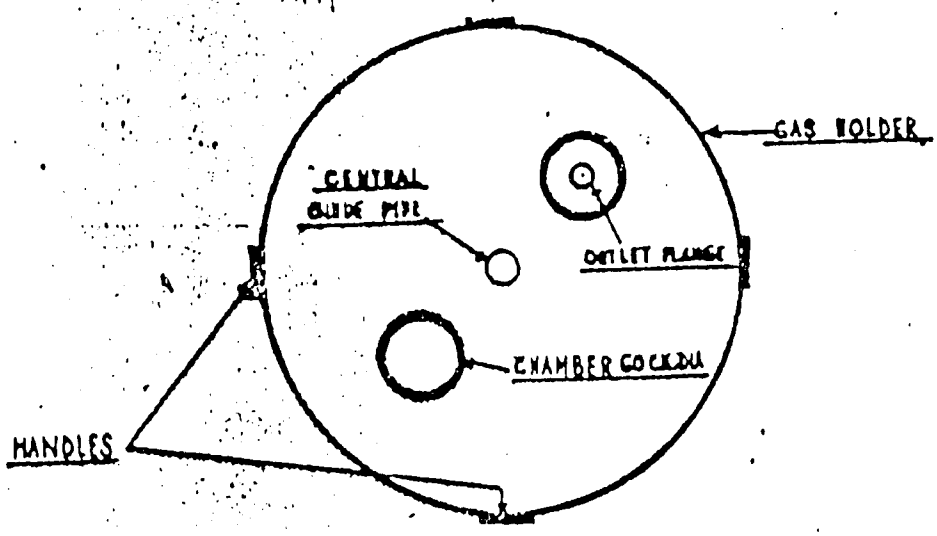


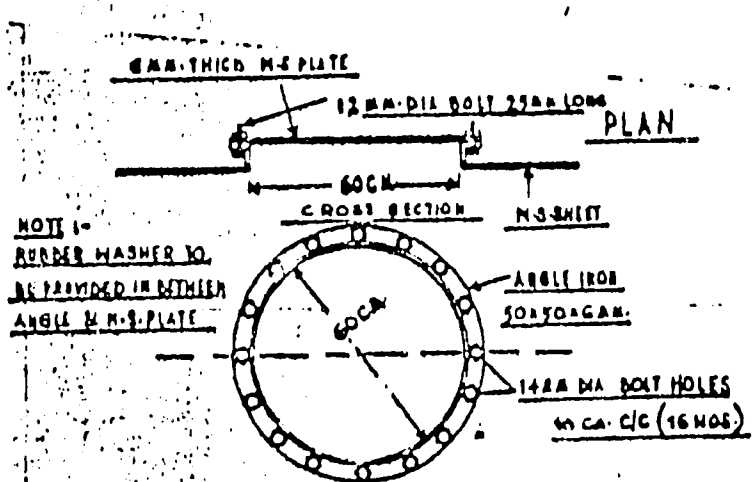
SECTION AT A-B



DETAILS FOR FIXING T

CENTRAL GUIDE PIPE IN THE COLUM





DETAILS OF MAN HOLE