UNITED NATIONS DEVELOPMENT PROGRAMME
PROJECT OF THE GOVERNMENT OF TANZANIA

PROJECT DOCUMENT

Number and title: URT/93/G31/A/1G/99

Electricity, Fuel, and Fertilizer from Municipal and Industrial Organic Waste in Tanzania: A Biogas Plant for Africa

December 1993

UNDP and cost sharing financing	
UNDP GEF	US$ 2,500,000
DANIDA (GEF)	US$ 1,491,000
Govt. or 3rd party cost sharing	
UNDP & cost sharing	US$ 3,991,000

Duration:	Three (3) years
Project site:	Tanzania
ACC/UNDP sector and subsector:	Renewable Energy, GHG Reduction
Govt. sector and subsector:	Renewable Energy, GHG Reduction, Waste
Govt. implementing agency:	Ministry for Energy, Water and Minerals
Executing Agency:	Government of Tanzania
Estimated starting date:	July 1994
Government inputs:	27,320,000 Tsh (in kind)
Local input when establishing the 5 identified replicable projects:	US$ 15 million

Brief description: The goal of the project is to reduce emissions of greenhouse gases in Tanzania by substituting bioenergy (methane gas and electricity), produced from anaerobic digestion of industrial and municipal waste in the Dar es Salaam area, for fossil fuels. Additional greenhouse gas reduction will be achieved by reducing the uncontrolled release of methane from improperly disposed organic waste and organic fertilizer will be produced. The project's main activities are to provide capital and technical know how for construction of a waste-treating biogas plant in Dar es Salaam. Through technological exchange and educational programs the required institutional, management, and social structure for sustaining the biogas plant will be developed. A prime activity of the upgraded institutions will be the capability for generation of replicable projects in Tanzania and other developing countries to demonstrate, first within the African context, the environmental and energy producing benefits from using municipal and industrial organic waste. The proposed plant will have the capacity for treatment of about 60 tons of organic waste per day, or about 3 percent of the daily waste generated in Dar es Salaam. The project combines methane emission reduction, for GHG remediation, with production of electricity, fuel for transport and fertilizer, thus helping to reduce Tanzania's dependency on oil (which amounts to more than 40 percent of the country's export earnings) and other imports and also helping alleviate the acute shortage of electricity currently faced in Tanzania.

On behalf of: (please type)	Signature	Date	Name/Title
The Government:	THE TREASURY P.O. BOX 9111 DAR ES SALAAM	17th March 1994	DEPUTY P. SECRETARY
UNDP Field Office:		18/3/94	R R a.i.
UNDP HQ GEF Unit:			

United Nations official exchange rate at date of last signature of project document:

$1.00 = _____

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A. CONTEXT

1. DESCRIPTION OF SUBSECTOR

While the development of renewable energy, such as biogas technology and the use of biogas energy, is emphasized in the 1992 Energy Policy of Tanzania, almost all of the country's more than 500 biogas units are small-scale plants designed for rural production of cooking or lighting gas from cow manure. Indeed, to date, large-scale biogas production facilities have not been established in any African country with the exception of South Africa.

Each day, the residents of Dar es Salaam generate about 1500 tons of organic waste, most of which is discarded into the city dump or burned. These methods of waste disposal contribute to environmental problems through leakage of toxic residues, contamination of ground water, pollution of the sea, water ways, etc. In addition, approximately 23,000 m^3 of methane (CH_4), a powerful greenhouse gas, is released daily as a result of the uncontrolled decomposition of this waste. In Dar es Salaam and other rapidly growing African cities, there is a great need to treat the organic fraction of municipal and industrial wastes in ways that protect the environment while also contributing to economic development and the quality of life.

Biogas technology is an efficient, well demonstrated and cost-effective method of disposing of organic wastes and producing electricity, fuels and fertilizers without releasing greenhouse gases (GHG) into the atmosphere. Using biogas technology, large quantities of organic waste can be almost totally converted to energy (for electricity production, heating, or truck and automobile methane fuel) and organic fertilizer.

This project, to construct and sustain a biogas plant in Dar es Salaam and create the educational, management and social structure for replicable projects in Tanzania and other developing countries, seeks to demonstrate, first within the African context, the environmental and energy-producing benefits from using municipal and industrial organic waste. The proposed plant will have capacity for treatment of about 60 tons of organic waste per day, or about 3 percent of the daily waste generated in the capital city. The project combines methane emission reduction, for GHG remediation, with new ways of producing electricity, fuel for transport and fertilizer for surrounding farms, thus helping to reduce Tanzania's dependency on oil imports, (which amounts to more than 40 percent of the country's export earnings), and also helping alleviate the acute shortage of electricity currently faced in Tanzania. The electricity generating potential of the portion of Tanzania's organic waste that was evaluated in a PRIF-study ("TAKAGAS, ENERGY FROM WASTE, TANZANIA, UNDP 1992") alone is equivalent to approximately 50 MW -- or 12.5% of Tanzania's total electricity generating capacity.

It is anticipated that this project will be the first in a series of similar biogas plants constructed throughout Tanzania and Africa. By demonstrating that it is not only technically feasible but economically viable, given initial donor capital investment, within the African context to use urban organic waste for biogas production, and by simultaneously cultivating the indigenous interest and capacity for creation of such a facility, this project can lead to the construction of additional plants with resulting energy and environmental benefits.

Once constructed, the biogas plant is designed to be economically viable, but also to generate profit by producing three products -- electricity, biogas to be used as fuel in cars, and fertilizer -- that have commercial value. Income from the sale of these products will be used to cover all operating costs of the plant and to promote the education and dissemination of biogas technology in Tanzania.

Tanzania's national power company, TANESCO, has already agreed to accept a connection of this biogas plant to the public grid, and to pay market rates for the biogas generated electricity. Many opportunities also exist to sell this electricity to private sector industry in the vicinity of the biogas plant. Cooperation with the University of Dar es Salaam has been a part of the project since the insemination of the proposal and educational programs at the University and the plant are included as an integrated aspect of the project.

The expected profit to be generated from the plant (after annual operating costs are subtracted from income from sale of electricity and fees from removing waste, and assuming GEF allocation of Total Capital Costs [without the GEF Funding the annual costs to repay the loan on capital would negate the projects profitability]) ranges from US$245,000 to US$305,000/year. Over the expected lifetime of the pilot biogas plant of 25-30 years, this income could easily be used to build many other equally profitable biogas plants.

The PRIF Report shows that sufficient quantities and qualities of readily available organic waste exists in Tanzania for at least 50 biogas plants which would be as financially viable as the pilot plant. These plants would cause each year a reduction in CH_4 emissions of 37 million m^3 and a substitution of 680,000 tons of CO_2 from fossil fuels. Added together these two sources of greenhouse gases are equivalent to a reduction of 1,2 million tons of CO_2 per year. In this case, assuming a 25 year life expectancy of the pilot plant (which cost a total of US$3.9 million - US$2.5 million for the plant and $1.4 million for the training and capacity building elements), the estimated cost of offsetting CO_2, by the first and the replicable plants, would be US$0.128/ton. A more conservative estimation, in which the profits of the pilot plant are used to construct only four additional plants, then the cost of avoiding CO_2 emission would still be only US$1.28/ton.

Ultimately, in Dar es Salaam alone it is envisioned that as much as 1400 tons of daily organic waste (about 90% of daily waste production) could be treated in biogas plants. Were this the case, and using the calculations above, the annual reduction in CH_4 emissions to the atmosphere would be 7.4 million m^3, and the annual reduction in CO_2 emissions by the displacement of 41,900 tons of diesel oil would be approximately 154,000 tons.

In spite of the anticipated financial viability of such a biogas plant, it is clear that multi-national, regional and national banks are not likely to make loans for such an enterprise until its feasibility is fully demonstrated in Africa, for example in a GEF project such as this. Such a project has not been demonstrated in the African context but the technology is no more complex than existing and operating commercial establishments in Tanzania and the technology is well established in Denmark and many other developed countries.

This project will also result in a better system of organized waste handling and management for Dar es Salaam. The extensive educational component aims at training the biogas plant staff, public sector members, University students and staff, the general public, interested

industrial parties, as well as others from communities and countries who seek to learn about this technology for use in their own areas.

There is a huge potential for expansion of this technology beyond Dar es Salaam, as several agricultural industries within Tanzania produce large volumes of organic waste. Two of the country's key industries -- coffee and sisal processing -- produce waste which has been analyzed at the Danish Technological Institute and found to yield high methane production through anaerobic digestion. Other significant sources of solid organic waste from industry and agriculture which are feasible for anaerobic digestion and biogas production include sugar processing waste and starch waste from the textile industry. On a national basis, it is estimated that biogas plants can reduce Tanzania's methane emissions by 10 percent -- in a profitable manner that generates income and improves the quality of life for the people of Tanzania.

While biogas production on a large scale is highly innovative within Africa, well-running medium-size industrial projects -- such as breweries and cement plants -- have been constructed and are operating well in Tanzania. Construction and operation of a large-scale biogas plant is no more complicated. Further, the technology has been successfully demonstrated over the past decade in northern Europe, particularly in Denmark's biogas plants, which treat municipal and industrial organic waste. More than fifteen biogas plants are functioning in Denmark currently, producing between 2,000 and 15,000 m^3 biogas per day. An additional 100 new biogas facilities are being planned and constructed in Denmark at this time. Danish experts in biogas technologies will play a key advisory role in this project throughout all of its phases, both within Tanzania and, most importantly, by training Tanzanian nationals on-site at the Tanzania facility and at technical institutions and biogas plants within Denmark.

2. HOST COUNTRY STRATEGY

In addition to signing the Global Convention on Climate Change, Tanzania is currently developing a comprehensive environmental policy which is putting high priority on global environmental issues such as global warming. The development of biogas technology and the use of biogas energy is emphasized in the 1992 Energy Policy of Tanzania. The Ministry of Energy, through its Renewable Energy group, is supporting all measures that can lead to utilization of organic wastes through biogas technology. However, currently the technological experience does not exist in Tanzania for the type of large-scale action required for significant national environmental mitigation via bioenergy processes.

Many connections and junctions link this project to goals of the UNDP COUNTRY PROGRAMME and the government's policy framework, as described below.

UNDP's Fifth Country Programme for Tanzania specifies, under section (e), "Environment and Natural Resources Management", several primary National Development Objectives (paragraph 56) which relate to the goals of this project:

1) Increase in capacity for natural resources management and policy development - inclusion of biogas as a nationally available energy source and form of waste

disposal increases the potential options for policy and management of other existing natural resources.

2) Increased availability of clean water - worldwide, municipal, industrial and other wastes are major sources of water pollution (*e.g.* leachate from landfills); disposal of waste in biogas facilities prevents this problem.

3) Improved urban environment - treatment and disposal of waste and production of CO_2-neutral electric energy, as proposed in by this project, will have direct impacts on the quality of urban life.

4) Negative impacts of urban planning - biogas facilities process waste in a period of days rather than storing it for years as in a landfill, reducing the need for such land intensive disposal methods, and, thus permitting improved urban planning

5) Desertification - biogas is a CO_2-neutral environmentally friendly energy source and wherever available can replace wood, collected from the surrounding land, or coal produced from wood as a heating and lighting source, either by burning directly or via electricity generation.

Under the section "Proposed UNDP cooperation" (paragraph 57) in the Country Programme, the government requests UNDP support for programmes addressing the connection between environmental degradation, rapid population growth and low agricultural productivity. The proposed project responds to this request by assembling all of these aspects in a waste treatment system which decreases environmental degradation, mitigates waste problems associated with rapid urban population increases, and, as a nearly cost free side benefit, produces quality fertilizers and soil conditioners improving agricultural yields.

The Country Programme makes special mention of education of women in environmental areas (paragraph 59). The extensive training program included in this project in all aspects involves coeducational institutions where opportunities for female education is stressed. In addition, grass-roots aspects involving women in agriculture will benefit. Better fulfilment of the energy needs of agricultural peoples for cooking and lighting will result: the environmental impact of especially women's activities in agriculture, for example wood collection for cooking fuel, can be reduced following implementation of this project.

"Employment creation through private-sector development" is a major theme of the Country Programme and this project's activities are well covered by this umbrella. The Tanzanian and African potential for replicable projects will stimulate employment in not only the management and operation of the suggested biogas plants, but will stimulate many other industries including the construction sector, refuse handling, and agricultural activities. Thousands of workplaces could be involved.

3. PRIOR OR ONGOING ASSISTANCE

Although medium and large scale biogas plants do not exist in East Africa, there is a relatively high density of small biogas plants in that part of the African continent. Tanzania and Ethiopia have more than 500 small-scale rural units each; Kenya about 200. Tanzania's efforts to promote biogas technology began in the 1970s. The Department of Small-Scale Industries (SIDO) of the Ministry of Industries, and the Center for Agricultural Mechanization and Rural Technology (CAMARTEC) are among the institutions which have been involved in promoting biogas technology.

4. INSTITUTIONAL FRAMEWORK FOR SUBSECTOR

The development of renewable energy, biogas technology and the use of biogas energy resources is strongly emphasized in the 1992 Energy Policy of Tanzania. President Mwinyi has recently stated the importance of utilizing the nation's biogas/biomass potential, and the Ministry of Energy, through their Renewable Energy Unit, is supporting all measures that can lead to utilization of these vast waste resources. However, all the biogas plants now in use are small-scale, rural units for the production of cooking and lighting gas, which, even in the largest versions, are designed for use at the village level only. Meaningful use of the countries bioenergy potential will require industrial scale utilization of biomass for electricity production, as proposed by the Ministry in this policy document.

Tanzania's national electricity utility, "Tanzania Electrical Supply Company" (TANESCO), operates under the Ministry of Water Energy and Minerals. TANESCO is headed by a Managing Director, appointed by the President of Tanzania, who is accountable to a Board of Directors appointed by the Government. Line ministerial responsibility remains at the Ministry of Water, Energy and Minerals.

B. PROJECT JUSTIFICATION

1. PROBLEM TO BE ADDRESSED; THE PRESENT SITUATION

In developing countries about 70% of the people have no access to electricity. Demand is increasing and in meeting the increased requirements, greenhouse gas emissions will also increase. Predictions for the next 20 years indicate that the greatest growth in emissions will be in developing countries.

The per capita income of Tanzania is US$ 180 and is thus among the lowest in the world. There is an acute need for electricity all over Tanzania. At present the electricity supply is limited and restricted, resulting in long periods without electricity both during the day and the night. Also fuel for transportation is a matter of concern to the Tanzanian economy since the annual cost of oil import amounts to more than 40% of Tanzania's annual export earnings. Increased production of electricity from fossil fuels will further tax the Tanzanian economy and increase production of greenhouse gases.

As one of its 4 priority objectives the Global Environment Facility seeks to implement projects

that can lead to a reduction of greenhouse gases. Biogas technology is an efficient and cost effective method for disposal of organic waste which at the same time reduces the release of methane, a greenhouse gas, into the atmosphere. By means of biogas technology organic waste can almost totally be converted to energy (production of fuel, or electricity production) and organic fertilizer.

Biogas technology is an efficient, well-demonstrated and cost-effective method of disposing of organic wastes without releasing methane into the atmosphere. Using biogas technology, large quantities of organic waste can be almost totally converted to energy (for electricity production, heating, or truck and automobile methane fuel) and organic fertilizer. Almost all of the country's more than 500 biogas units are small-scale plants designed for rural production of cooking or lighting gas from cow manure. Large-scale biogas production facilities have not been established in any African country with the exception of South Africa.

Today, the major part of the waste generated in Dar es Salaam, as well as in the other larger cities of Tanzania, is deposited in landfills. This waste treatment strategy suffers from the shortcoming of causing severe environmental problems, i.e. emission of methane and carbon dioxide and other substances, toxic residuals, potential contamination of ground water, pollution of the sea and the water ways, etc.

2. EXPECTED END OF PROJECT SITUATION

The waste treatment system of this project will have many environmental advantages and socio-economic effects and will make an important contribution to the reduction in CH_4 emission to the atmosphere and in the consumption of fossil fuel, thereby also reducing the net emission of CO_2. An integral part of the project is the establishment of Tanzania's internal capability for sustaining and replication of this type of project. Included are educational, governmental, and social infrastructures necessary for such activities. Below are outlined the expected specific results of the project with respect to greenhouse gas reduction, electricity production and waste treatment, and establishment of the Tanzanian capacity for sustaining of the project and further replicable projects.

2.1 Construction and operation of the municipal and industrial organic waste-treating biogas plant - amounts of waste to be treated, power production and greenhouse gas reduction

The overall reduction of greenhouse gas emission to be realized by treatment of the 1500 tons of organic waste generated in Dar es Salaam in biogas plants is equal to 7.4 million m^3 CH_4 annually. The substitution of fossil fuels by the biogas produced (from electricity and methane gas as transportation fuel) from this waste is equal to 41,900 tons of diesel oil, with a net CO_2 emission by approximately 154,000 tons per year.

The first plant, to be built in this project, will accept approx. 60 tons of waste daily, about 3% of the total produced in Dar es Salaam. The reduction of methane released to the at mosphere and net CO_2-reduction will therefore be 3% of the potential described above,

approx. 0.30 million cubic meters CH_4 per year, and the 1700 tons diesel oil equivalents

replaced by the biogas produced amount to a net CO_2 emission reduction of 6200 tons per year.

The biogas plant should be economically viable, but also able to generate profit by producing three products -- electricity, biogas to be used as fuel in cars, and fertilizer -- that have commercial value. Income from the sale of these products will be used to cover all operating costs of the plant and to promote the education in and the dissemination of biogas technology in Tanzania. Tanzania's national power company, TANESCO, has already agreed to accept a connection of this biogas plant to the public grid, and to pay market rates for the biogas generated electricity. Many opportunities also exist to sell this electricity to private sector industry in the vicinity of the biogas plant.

The expected profit to be generated from the plant (after annual operating costs are subtracted from income from sale of electricity and fees from removing waste, and assuming GEF allocation of Total Capital Costs [without the GEF Funding the annual costs to repay the loan on capital would negate the projects profitability]) ranges from US$245,000 to US$305,000/year. Over the expected lifetime of the pilot biogas plant of 25-30 years, this income could easily be used to build many other biogas plants.

2.2 Infrastructure for sustainability and for replicability through training

An integral part of the project is the establishment of Tanzania's internal capability for sustaining and replicating this type of project. Included are educational, governmental, and social infrastructures necessary for such activities. The backbone of these programs will be the education received, both technical and practical, by not only the Tanzanians immediately responsible for the daily operation and maintenance of the biogas plant, but also the University and Government officials, both national and municipal.

Training and education on bioenergy from waste for sustaining the first plant and replication of the project will be received and integrated into the program for all persons in the following categories:

A. University of Dar es Salaam, Applied Microbiology Unit (AMU). Personnel (advisers to plant manager)

B. Cooperation Board Members (and/or their representatives from the Ministry of Energy, City Council of Dar es Salaam, TANESCO)

C. Managers of various major waste suppliers and industries interested in acquiring the capacity for construction/operation of biogas plants, including staff from CAMARTEC.

The overall training programme will be based on:

1. Training at the University of Dar es Salaam, Applied Microbiology Unit

2. Training at a European technological institute.

3. Training at the joint waste plant in Europe, treating source sorted MSW, organic industrial waste and cow and pig manure.

4. Training at the Bioenergy Plant in Dar es Salaam (when construction phase is over).

It is the intention to implement a training programme whereby the plant manager and the key technical operational personnel are trained in Denmark. As soon as facilities exist in Dar es Salaam as much as possible of the training can be transferred to the plant.

During the first 2 years of plant operation, i.e. after finishing the construction phase, an experienced biogas plant operator will be attached to the Dar es Salaam biogas plant. He/she will supervise and assist the plant manager in order to ensure the best possible production of methane and thus carry out an "on the spot" daily training that will enable the plant manager and the technical operational workers to take over the operation gradually during a 2-year period.

In addition, the plant manager, technical workers and AMU personnel will participate in a training programme involving both theoretical and practical topics and exercises at a European technological institute (theory and practical exercises), and a European waste plant (practical training with the plant manager).

Further details on the training program, both in depth and technical aspects with respect to all groups involved, are to be found in the Annex IV.

3. TARGET BENEFICIARIES

- General population of Tanzania - The waste treatment plant will produce electricity, a sorely needed commodity in Tanzania in short supply, at a competitive price. Electricity produced will be delivered to the national power grid.

- General population of The City of Dar es Salaam - Municipal and industrial waste handling in Dar es Salaam has been an historical problem with collection and disposal being the major problem areas. The completed bioenergy plant will be a major collector, receiver and disposer of Dar es Salaam's organic waste, thus improving the living standard of the city dwellers and improving the general economy of waste disposal in the City to the benefit of both the people and industry.

- Ministry of Energy and TANESCO - The construction and operation of this new form of bioenergy plant for Africa will help the development of and cooperation among the various governmental bodies involved.

- University of Dar es Salaam - The Applied Microbiology Unit at Dar es Salaam University will be a major recipient of training and analytical/educational materials in their capacity as consultants to the bioenergy plant and in their role as the Tanzanian center for biogas-process evaluation for replicable projects.

4. PROJECT STRATEGY AND IMPLEMENTATION ARRANGEMENTS

The Ministry of Energy will have over-all responsibility for the plant. This will streamline and insure the starting phase of the project, especially since the Ministry of Energy has a special department, the Renewable Energy Unit, which is responsible for the implementation of projects in the field of new and renewable energy sources. The proposed organization, however, foresees a structure whereby a Board of Directors is appointed by the Ministry of Energy and that the members of the Board represent the different organizations that will have interest in the biogas plant. A Plant Manager will have the total financial and technical responsibility for the day-to-day operation of the plant with reference to the Board of Directors.

In the Pre-investment Feasibility Study ("TAKAGAS, ENERGY FROM WASTE IN TANZANIA) and here in ANNEX VII, a copy of the Draft Memo of Understanding regarding the ownership and organization of the biogas plant as well as a company charter is provided. This organization has been discussed and the Ministry of Energy has agreed to take responsibility for the establishment of this independent unit. As an important point it has been stressed that the income from the sale of electricity, methane, fuel and fertilizer will be used to cover the operation costs of the biogas plant including salaries, maintenance, spare parts etc. All further income will be used to promote biogas technology in Tanzania with the following three objectives:

1. To facilitate construction of other biogas plants (50%).

2. To undertake studies that analyze other types of waste e.g. from coffee, sisal and sugar plantations or other municipalities, in order to evaluate the potential for the construction of biogas plant at other locations in Tanzania (10%).

3. Training of personnel from Tanzania in subjects relating to biogas technology to ensure of a replicable project is produced (40%).

The pre-investment feasibility study has concluded that with the requested GEF allocation the biogas plant can be profitable from the sale of electricity generated, fees received for waste disposal, and fertilizer production and so the clear financial incentives to sell the electricity, fuel and fertilizer will encourage proper maintenance of the plant. The profits are to be earmarked for not only plant maintenance, but are part of an integrated program for education on many levels. Education at the university, public sector, general, and commercial level, all with the goal of producing the required technical and social structure within Tanzania for the genesis of indigenous replicable projects, is a major aspect of the project whole.

Other managerial and infrastructural details surrounding responsibility and operation of the bioenergy plant, and technical details regarding process selection and operation are to be found in the Pre-investment Feasibility Study.

5. REASONS FOR ASSISTANCE FROM UNDP

In view of Tanzania's many urgent needs, a project like this, however useful, will not be initiated without the support of GEF. The technology proposed, though solidly based on the extensive experience of similar programs in developed countries, has never been demonstrated in a developing country situation. This fact, and general resistance towards the adoption of new technology, *i.e.* biogas technology, would result in significant non-technical and financial barriers to overcome for a recipient nation that might wish to independently compose such a project. Without full GEF support for the first plant, the project would most likely never be implemented, despite the modest secondary potential for profitability, resulting in a huge missed opportunity for greenhouse gas emission-reduction from the proper disposal of both municipal and industrial wastes.

In spite of the anticipated financial viability of such a biogas plant, it is clear that multinational, regional and national banks are not likely to make loans for such an enterprise until its feasibility is fully demonstrated in Africa, for example in a GEF project such as this. Such a project has not been demonstrated in the African context but the technology is no more complex than existing and operating commercial establishments in Tanzania and the technology is well established in Denmark and other developed countries.

This project will also result in a better system of organized waste handling and management for Dar es Salaam. The extensive educational component aims at training the biogas plant staff, public sector members, University students and staff, the general public, interested industrial parties, as well as others from communities and countries who seek to learn about this technology for use in their own areas.

There is a huge potential for expansion of this technology beyond Dar es Salaam, as several agricultural industries within Tanzania produce large volumes of organic waste. Two of the country's key industries -- coffee and sisal processing -- produce waste which has been analyzed by UNIDO and found to yield high methane production through anaerobic digestion. Other significant sources of solid organic waste from industry and agriculture which are feasible for anaerobic digestion and biogas production include sugar processing waste and starch waste from the textile industry. On a national basis, it is estimated that biogas plants can reduce Tanzania's methane missions by 10 percent -- in a profitable manner that generates income and improves the quality of life for the people of Tanzania.

6. SPECIAL CONSIDERATIONS

Women

The proposed project will have impacts on the quality of life for Tanzanian women at many levels of society. Increased availability of electricity, and in this project without increased release of greenhouse gases, will help low income families to afford electricity for, e.g. home lighting. Such improvements impact women most directly as they are homebound and often confined to dark work spaces. Women are often the first to show interest in home lighting.

Domestic waste disposal is also a traditional part of women's activity, and this project, which includes the placement of accessible and hygienic waste disposal sites stationed around the city, will ease and make more safe this otherwise onerous duty.

The University of Dar es Salaam's Department of Civil Engineering and, especially, the Department of Botany's Applied Microbiology Unit, will have active roles as consultants to the project and center for evaluation of replicable projects. The University of Dar es Salaam is a co-educational school and so female, as well as male, students will now have the opportunity for education in modern bioenergy technology.

The Environment

This project, to construct and sustain a biogas plant in Dar es Salaam and create the educational, management and social structure for replicable projects in Tanzania and other developing countries, seeks to demonstrate, first within the African context, the environmental and energy-producing benefits from using municipal and industrial organic waste. The proposed plant will have capacity for treatment of about 60 tons of organic waste per day, or about 3 percent of the daily waste generated in the capital city. The project combines methane emission reduction, for greenhouse gas remediation, with new ways of producing electricity and fuel for transport and fertilizer for surrounding farms, all which also reduce global greenhouse gas release, helping to reduce Tanzania's dependency on oil imports, (which amounts to more than 40 percent of the country's export earnings), and partly alleviating the acute shortage of electricity currently faced in Tanzania. A detailed projection of the greenhouse gas reduction is presented in the Pre-investment Feasibility Study.

Technical Co-operation among developing countries

An integral part of this project is the use of profits derived from the sale of products from the bioenergy plant for replicable projects. In that connection, the University of Dar es Salaam's Applied Microbiology Unit has been earmarked to receive funds to act as a research/demonstration center for replicable projects and as a place where representatives from other interested developing countries can come and see a functioning bioenergy plant and receive an introduction into biogas technology. The ultimate goal is the technological exchange and transfer among the developing countries for dissemination of this type of greenhouse-gas-neutral bioenergy technology.

Co-operation with independent institutions

The following independent institutions and organizations are co-operating in the project

- The University of Dar es Salaam's Applied Microbiology Unit
- TANESCO
- CAMARTEC

Involvement with the Private Sector

Contact on several fronts, including waste collection, electricity sale, construction work, etc., has been made with private sector companies. Especially contacts have been made for the biogas plant to act as a receiver of particularly biodegradable, and thus potentially environmentally damaging, wastes from industries in the Dar es Salaam area. Waste collection will be in close cooperation with both the waste collection company and, in central Dar es Salaam, in connection with the City Council.

7. COORDINATION ARRANGEMENTS

The Renewable Energy Unit of the Tanzanian Ministry of Water, Energy and Minerals is a leader in bioenergy in Tanzania. The Unit, through the Ministry, is directly involved in all phases of this project and through the Ministry holds ultimate responsibility for the project.

Tanzania's efforts to promote biogas technology began in the 1970s. The Department of Small-Scale Industries (SIDO) of the Ministry of Industries, and the Center for Agricultural Mechanization and Rural Technology (CAMARTEC) are among the institutions which have been involved in promoting biogas technology. Tanzania has more than 500 small-scale rural units. CAMARTEC will be kept abreast of the state of this project and have been contacted to provide consulting on the Tanzanian situation of rural biogas use.

8. COUNTERPART SUPPORT CAPACITY

As stated earlier, and as described in detail in the Pre-investment Feasibility Study, various arrangements and Agreements between the parties responsible (Ministry of Energy, City of Dar es Salaam, TANESCO, University of Dar es Salaam etc.) for construction, support and replication of the project have been drawn and approved.

C. DEVELOPMENT OBJECTIVE

The GEF objective of this project according to the objectives of the GEF programme, is the reduction in the emission of methane and carbon dioxide to the atmosphere through reduction of uncontrolled anaerobic digestion of organic waste products and substitution of fossil fuel by methane generated from organic waste. The development of biogas technology and the use of biogas energy is emphasized in the 1992 Energy Policy of Tanzania. But still all of the country's more than 500 biogas units are small-scale plants designed for rural production of cooking or lighting gas from cow manure.

The development objective of this project is to initiate the establishment of medium and large scale biogas production facilities in Tanzania and other African countries. The objective is also to create the educational and management framework in Tanzania required to build up the necessary know-how for a sustainable development and replicability of biogas production facilities.

A pre-investment feasibility study carried out in Tanzania in October to December 1992 ("Takagas, Energy from Waste, Tanzania, UNDP 1992") has shown a large potential for replicable biogas projects in Tanzania for treatment of different organic waste resources. The sources investigated in the study (municipalities > 50,000 inhabitants and coffee and sisal processing industries) have the potential for generation of 12.5% of the current electricity production in Tanzania, thereby contributing significantly to the economic development of the country.

D. IMMEDIATE OBJECTIVE, OUTPUTS AND ACTIVITIES

The responsibility for implementation of the separate activities of this project are distributed between the following parties.

- The Ministry of Water, Energy and Minerals (MWEM)
- The City Council of Dar es Salaam
- Advisor 1 (Design and Construction)
- Advisor 2 (Training and Education)
- Applied Microbiology Unit, University of Dar es Salaam (AMU)
- Plant Manager; (to be appointed during start-up of the project)

In addition to these companies, TANESCO, CAMARTEC and Martinet, a private waste collection contractor, (or other waste collection companies appointed by the City Council) will participate in specific activities.

IMMEDIATE OBJECTIVE 1

Construction and start-up of a medium-scale demonstration biogas plant for treatment of organic municipal and industrial waste in Dar es Salaam.

Success criteria

The criteria of success is primarily to finish the building of the plant, to ensure a continuous supply of organic waste for the plant and to start-up the biological processes in the biogas reactor.

Output 1.1

A medium-size biogas plant for the treatment of approximately 60 tons of organic waste per day.

Activities	Timing	Responsibility
1.1.1 Detailed design of the demonstration biogas plant.	1-5	MWEM, Advisor 1
1.1.2 Ground preparation and fencing of the site for the biogas plant.	1-3	MWEM, Advisor 1
1.1.3 Selection and purchase of equipment for the biogas plant.	1-3	Advisor 1, MWEM,
1.1.4 Construction, erection and assembling of the biogas plant.	3-12	MWEM, Advisor 1
1.1.5 Connection to the public electricity grid.	10-12	MWEM, Advisor 1, TANESCO

Output 1.2

A detailed plan for the collection and transportation of organic waste resources to the biogas plant. The plan will be based on the preliminary study of available waste resources carried out in the PRIF-study.

Activities	Timing	Responsibility
1.2.1 Elaboration of a detailed plan of quantities of organic waste resources available in Dar es Salaam.	2-5	City Council, AMU, Advisor 1
1.2.2 Selection of the optimal composition of waste resources for the biogas plant and elaboration of a plan for collection of these waste sources. This plan will be made in close cooperation with City Council, Martinet or another waste management company and the waste generating industries.	5-6	AMU, Advisor 2
1.2.3 Selection of location and placing of waste containers.	5-10	City Council, AMU, Advisor 1, Plant Manager

Output 1.3

A biogas plant operating at full capacity.

Activities	Timing	Responsibility
1.3.1 In-service training and supervision of the plant manager and plant technicians. The staff mentioned will already received the education and training according to activity 2.2.1-2.2.2.	10-18	Advisors 1 and 2
1.3.2 In-service training of biogas plant workers.	11-15	Plant Manager
1.3.3 Upstart and commissioning of the biological processes in the biogas reactor.	13-20	Advisor 1
1.3.4 Upstart and commissioning of the electricity generating equipment	13-16	Advisor 1, TANESCO

IMMEDIATE OBJECTIVE 2

To ensure the sustainability of the biogas plant.

Success criteria

Verification of a reasonably operating budget for the biogas plant. Successful takeover of the operation and management of the biogas plant by local staff.

Output 2.1

A verified operating budget for the biogas plant with detailed figures for expenses and income based on signed agreements with purchasers of electricity and suppliers of organic waste products.

Activities	Timing	Responsibility
2.1.1 Agreement with TANESCO or interested private companies about the tariffs and mode of payment for electricity produced by the biogas plant.	1-6	MWEM
2.1.2 Agreements with The City Council of Dar es Salaam and/or the private waste collection company, who is going to take over part of the waste collection in Dar es Salaam City on contract basis, concerning tariffs and mode of payment for waste delivered to the plant. This agreement should be coordinated with tariffs for waste delivered to the landfill.	3-6	MWEM, Plant Manager
2.1.3 Agreements with different industries about delivery of waste products to the biogas plant.	3-6	MWEM, AMU, Plant Manager
2.1.4 Elaboration of maintenance plan for the biogas plant.	12-14	Advisor 1, Plant Manager

2.1.5	Preparation of a operating budget based on the output of activity 2.1.1 - 2.1.4.	14-15	Advisor 1, Plant Manager
2.1.6	Management of the biogas plant by experts.	18-36	Advisors 1 and 2, AMU

Output 2.2

Well educated and trained local staff for operation and management of the biogas plant.

Activities

		Timing	Responsibility
2.2.1	Education and training of the Plant Manager.	4-9	Advisor 2
2.2.2	Education and training of technicians.	4-9	Advisor 2
2.2.3	Education and training of workers, carried out by trained technicians under supervision of local experts, see 1.3.2.	9-16	Plant Manager, Advisor 2

IMMEDIATE OBJECTIVE 3

To demonstrate the possibility of using biogas as fuel for cars.

Success criteria

The possibility of using cleaned and compressed biogas as fuel should be demonstrated and disseminated. Cars/trucks belonging to the biogas plant should be equipped with aggregates for switching between ordinary fuel and biogas.

Output 3.1

Car/truck running on biogas.

Activities	Timing	Responsibility
3.1.1 Purchase, installation and commissioning of biogas cleaning and compression equipment at the biogas plant.	12-16	Advisor 1
3.1.2 Installation of conversion equipment in car/truck for running on dual-fuel.	4-12	Advisor 1

Output 3.2

Demonstration and dissemination of car/truck running on biogas.

Activities	Timing	Responsibility
3.2.1 Operating biogas driven car/truck in Dar es Salaam equipped with advertising sign for public awareness.	16-	Plant Manager, Advisor 1
3.2.1.1 Dissemination of the lessons learned through various papers and to relevant institutions.	16-28	MWEM, AMU, Plant Manager

IMMEDIATE OBJECTIVE 4

To upgrade the capacity and strengthen local educational, technical and administrative institutions in the biogas field, in order to be able to initiate replicable projects such as this one. This capability should be attained by enhancement of local know-how in the construction and operation of biogas production facilities, improved education of qualified personnel and strengthening of the administrative capacity of governmental institutions.

Success criteria

The main criteria of success is upgraded local institutions to a level which enables the involved institutions to take active part in initiation and operation of medium and large scale biogas production facilities. Distinguished by the different institutions, fulfilment of the success criteria involves:

AMU
- Capacity to educate academic staff in the latest chemical and microbial research methods in the field of bioenergy and technicians for operation of modern medium to large scale biogas plants. Capacity to act as a quality control laboratory for biogas production facilities and capacity for evaluation of replicable projects.

CAMARTEC
- Capacity to assist external consultant in construction of medium to large scale biogas production facilities and to carry out maintenance of existing facilities.

MWEM
- Capacity of the Ministry of Water, Energy and Minerals to elaborate master plans for bioenergy in Tanzania and to make plans for and initiate replicable biogas projects in Tanzania.

Output 4.1

Upgraded capacity and know-how of the Applied Microbiology Unit (AMU) at the University of Dar es Salaam.

Activities		Timing	Responsibility
4.1.1	Installation and commission of modern laboratory equipment for research and education in the biogas area at AMU.	8-15	Advisor 2

4.1.2	Education and training of academic staff from AMU at appropriate technical and economic institutions.	2-8	Advisor 2
4.1.3	Supervision of the AMU by external experts.	12-36	Advisor 2

Output 4.2

Upgraded capacity of CAMARTEC to include technical know-how of medium and large scale biogas plants.

Activities		Timing	Responsibility
4.2.1	Education and training of administrative and technical staff from CAMARTEC at a European technological institute and at the full-scale biogas plant in Europe.	2-8	Advisor 2

Output 4.3

Upgraded capacity of the Ministry of Energy (especially the Renewable Energy Unit), in order to enhance their capacity for planning of renewable energy from biomass, initiation of replicable projects, dissemination of knowledge about bioenergy and overall administrative capacity for supervision of biomass/bioenergy projects.

Activities		Timing	Responsibility
4.3.1	Education and training of academic staff from the Ministry of Energy at a European center.	2-8	Advisor 2

Output 4.4

A master plan for bioenergy in Tanzania and detailed plan for at least 5 replicable biogas projects concerning anaerobic digestion and biogas production from municipal organic waste and organic waste from sisal and coffee processing.

Activities	Timing	Responsibility
4.4.1 See activity 4.3.1.	12-18	MWEM, Advisor 2, AMU
4.4.2 Elaboration of master plan for bioenergy in Tanzania.	18-24	MWEM, Advisor 2, AMU
4.4.3 Elaboration of plans for replicable projects.		

E. INPUTS

5 GOVERNMENT INPUT

5.1 Personnel

The Government shall make available the services of the existing staff of the Ministry of Energy and The City Council of Dar es Salaam to the extent and times required for the successful implementation of the project. TANESCO, The University of Dar es Salaam, Applied Microbiology Unit and CAMARTEC shall make their staff and facilities available for specific project tasks to the extent necessary.

The following staff will be appointed for the project for a fixed duration:

	p/m	Value in Shs.

Ministry of Water, Energy and Minerals (MWEM)

Staff for project administration and staff for upgrading of institutional know-how, including staff for participation in the training programme and in development of plans for bioenergy, according to output 1.1, 2.1, 3.2, 4.3 and 4.4.

Administrative Director	24	900,000
Project officer, master plan for bioenergy	24	700,000
Project officer, plans for replicable projects	24	700,000
Secretary	24	50,000
Driver	24	400,000

City Council of Dar es Salaam

Staff for waste management coordination, according to output 1.2 and 2.1.

Waste management coordinator	24	900,000
Waste management officer	24	700,000
Secretary	24	350,000
Driver	24	400,000

The following staff will be appointed for specific tasks for the duration necessary to fulfil these tasks, including staff for participation in the training programme:

	p/m	Value in Shs.

TANESCO

Staff needed for preparation of specifications and assistance for construction and maintenance of connections to the public grid (output 1.1, 1.3).

Electricity engineer	12	350,000
Electricity technician	6	120,000
Driver	12	200,000

University of Dar es Salaam,
Applied Microbiology Unit (AMU)

Staff needed for coordination of local training, assessment of training needs and planning and quality control of waste resources. This staff will also cooperate with external experts in

upgrading the laboratory at AMU (Output 1.2, 1.3, 2.1, 2.2 3.2 and 4.1).

Project scientist	24	700,000
Laboratory technician	24	450,000
Driver	24	400,000

CAMARTEC

Staff for assessment of training needs and upgrading of know-how in medium and large scale biogas facility engineering (Output 4.2).

Training coordinator	12	350,000
Project engineer	12	350,000
Driver	12	200,000

Subtotal input personnel (1.1) **8,520,000**

5.2 Equipment and facilities

Office facilities for planning and collection management of organic waste resource (City Council):	1,500,000
Waste collection equipment, trucks etc. (City Council/Martinet):	5,000,000
Office facilities for project administration (MWEM):	1,500,000
Equipment for connection to public grid (TANESCO):	500,000
Site for the biogas plant (City Council):	5,000,000
Laboratory facilities and training coordination office (AMU):	2,500,000
Maintenance of equipment and sundry:	2,800,000

Subtotal input equipment and facilities (1.2): **18,800,000**

INPUT FROM GOVERNMENT AND NGO'S, GRAND TOTAL: **27,320,000**

Exchange rate: 1 US$ = 360 Tanzania Shs. (May 1993)

UNDP INPUT

5.3 Personnel

The UNDP input will be managed through The Ministry of Water, Energy and Minerals. The Ministry will use Advisors 1 and 2 as their external consultants.

	p/m	Value in US$
2.1.1 Project management		
The overall project management to be carried out in cooperation between MWEM and Advisor 1 as a subcontract adviser by MWEM, with MWEM having the overall responsibility to UNDP.		
a. Management expert, Advisor 1:	6	60,000
b. Commissioning expert, Advisor 1:	6	60,000
2.12 **Biogas plant construction and commissioning**		
The design and supervision of construction and commissioning of the biogas plant to be conducted by Advisor 1 as a subcontract with MWEM (Output 1.1, 1.3 and Activity 1.2.3, 2.1.4, 2.1.5)		
c. Biogas plant design engineer, Advisor 1:	10	100,000
d. Construction supervision expert, Advisor 1:	6	60,000
e. Waste collection management consultant, Advisor 1:	3	30,000
Subtotal personnel (2.1):		**310,000**

2.2 Training and biogas plant management of operations

The management of operation for the biogas plant for the first 2 years after finishing the construction phase is included in the training programme (2.2.2). The responsibility for the management is taken over when the biogas plant is commissioned by the construction advisor. The management of operation after the commissioning of the biogas plant and the training is carried out by Advisor 2 as a separate subcontract, concerning management and training, between Advisor 2 and MWEM.

2.2.1 Biogas plant operation and maintenance management.

a. Biogas plant operation expert, Advisors 1 and 2:	16	160,000
b. Local plant operation consultant:	18	60,000

2.2.2 Training

The training programmes include training personnel, accommodation of trainees, travel, training facilities and materials (Activity 1.3.1, 1.3.2, Output 2.2 and 4.1-4.4)

a. Training coordination expert, Advisor 2.	10	100,000
b. Education and training programme for plant manager and technicians and CAMARTEC personnel in Europe, Advisor 2:	16	160,000
c. Training programme for AMU staff (2 persons at Ph.D. level x 2 month), in Europe, Advisor 2:	4	40,000
d. training course for administrative staff from The Ministry of Energy, (2 persons x 2 month) in Europe, Advisor 2:	4	40,000
e. In country training supervisor, consultant, Advisor 2:	8	80,000
f. Education programme, short courses and workshops for potential plant managers, SADC representatives etc. at University of Dar es Salaam, AUM:		80,000
g. In-service training and seminars at the biogas plant:		50,000
Subtotal training and management (2.2):		**770,000**

2.3 Equipment

2.3.1 Laboratory equipment

Upgrading of the laboratory equipment at AMU, in order to meet the objectives of output 4.1.

a. Laboratory equipment for education and research in anaerobic digestion of organic waste:	44,000

2.3.2 Biogas plant and waste collection equipment

The biogas plant will be constructed with equipment purchased in Tanzania or imported and through subcontracts between The Ministry of Energy and Tanzanian companies under supervision of external experts from Advisor 1, according to input 2.1.2 (Output 1.1-1.3).

a. Medium-scale biogas plant:	2,010,000
b. Trucks for waste collection (3):	275,000
c. Gas conversion and gas filling equipment:	260,000
d. Containers (10) and transport tanks (3):	80,000
e. 4WD Vehicle for plant manager:	22,000
f. Monitoring stations for plant manager and staff:	65,000

2.3.1 Miscellaneous

a. Contingency, Advisor 1:	155,000

Subtotal equipment (2.3):	**2,911,000**

INPUT FROM UNDP, GRAND TOTAL:	**3,991,000**

F. RISKS

Risks associated with this program include:

- Poor coordination for collection of waste in Dar es Salaam City.

  Solution: The project is making contractual agreements with the City Council of Dar es Salaam and the private waste collection contractor, MARTINET, which is expected to take over part of the waste collection in Dar es Salaam City. As a back up plan, the project formulation team has made specific contacts and special arrangements involving pick-up and delivery of wastes on which the plant could run to near full capacity.

- Lack of payment by TANESCO for electricity delivered to the national grid.

  Solution: In addition to hard contractual agreements to be made with TANESCO, with central involvement of the Ministry of Energy, where line ministerial responsibility for TANESCO's operation and activities reside, many contacts have been made with several energy intensive industries in the near vicinity of the bioenergy plant which are eager to make direct arrangements with the plant for electricity purchases.

G. PRIOR OBLIGATIONS AND PREREQUISITES

According to the analysis of the project formulation team only one prerequisite exists: allocation of land for the bioenergy plant by the City of Dar es Salaam. To date, extensive discussions have been undertaken with the City Council, and land has been identified and initially approved by the City Council for donation, free of charge, to the project. The land is adjacent to the current and planned expanded city waste site and agreements for transfer of ownership from the City to the Bioenergy plant are under preparation. More on the site and strategy followed for locating and identifying the best plot are detailed in the Pre-investment Feasibility Study (see Annex).

H. PROJECT REVIEWS, REPORTING AND EVALUATION

(a) The project will be subject to tripartite review (joint review by representatives of the Government, implementing agencies and UNDP) at least once every 12 months, the first such meeting will be held within the first 12 months of the start of full implementation. The national project coordinator and/or senior project officer of UNDP shall prepare and submit to each tripartite review meeting a Project Performance Evaluation Report (PPER). Additional PPERs may be requested, if necessary, during the project.

(b) A project terminal report will be prepared for consideration at the terminal tripartite review meeting. It shall be prepared in draft sufficiently in advance to allow review and technical clearance at least four months prior to the terminal tripartite review.

In addition to the conditions stipulated, a Memo of Understanding concerning monitoring, as well as ownership and organization of the project, with details regarding frequency of financial review (currently suggested as quarterly) and plant operation, have been drawn up and submitted to the involved parties for review. Copies of the described documents are included in the Pre-investment Feasibility Study.

I. LEGAL CONTEXT

This project document shall be the instrument referred to as such in Article 1 of the Standard Basic Assistance Agreement between The Government of Tanzania and the United Nations Development Programme. The host country implementing agency shall, for the purpose of the Standard Basic Assistance Agreement, refer to the government co-operating agency described in that Agreement.

The following types of revisions may be made to this project document with the signature of the UNDP Resident Representative only, provided he or she is assured that the other signatories of the project document have no objections to the proposed changes:

a) Revisions in, or addition of, any of the annexes of the project document.

b) Revisions which do not involve significant changes in the immediate objectives, outputs or activities of a project, but are caused by the rearrangement of inputs already agreed to or by cost increases due to inflation.

c) Mandatory annual revisions which rephase the delivery of agreed project inputs, or reflects increased expert or other costs due to inflation, or take into account agency expenditure flexibility.

J. BUDGET

Project budget covering Government contribution in kind

Country: Tanzania
Project number: URT/93/G31/A/1G/99
Project title: Electricity, Fuel and Fertilizer from Municipal and Industrial Organic Waste in Tanzania: A Demonstration Biogas Plant for Africa

	DESCRIPTION	TOTAL		YEAR 1		YEAR 2		YEAR 3	
		p/m	Shs.	p/m	Shs.	p/m	Shs.	p/m	Shs.
10	PERSONNEL								
11	Personnel including maintenance of trainees salaries (E. INPUTS 2.2.2)								
11,01	Administrative director	24	900,000	12	450,000	6	225,000	6	225,000
11,02	Project officer, masterplan for bioenergy	24	700,000	6	175,000	12	350,000	6	175,000
11,03	Project officer, replicable projects	24	700,000	6	175,000	12	350,000	6	175,000
11,04	Waste management coordinator	24	900,000	12	450,000	6	225,000	6	225,000
11,05	Waste management officer	24	700,000	12	350,000	6	175,000	6	175,000
11,06	Scientific and engineering staff (4)	60	1,750,000	36	1,050,000	12	350,000	12	350,000
11,07	Technicians (2)	30	570,000	14	270,000	8	150,000	8	150,000
11,08	Secretary (2)	48	700,000	24	350,000	12	175,000	12	175,000
11,09	Drivers (5)	96	1,600,000	48	800,000	24	400,000	24	400,000
19	COMPONENT TOTAL	354	8,520,000	170	4,070,000	98	2,400,000	86	2,050,000
40	EQUIPMENT								
41	Non-expendable equipment								
41,01	Waste collection equipment, trucks, eco.		5,000,000		5,000,000				
41,02	Equipment for electricity grid connection		500,000		500,000				
42	Premises								
42,01	Site for the biogas plant		5,000,000		5,000,000				
42,02	Office facilities, waste management		1,500,000		1,500,000				
42,03	Office facilities, project administration		1,500,000		1,500,000				
42,04	Laboratory facilities, AMU		2,500,000		2,500,000				
49	COMPONENT TOTAL		16,000,000		16,000,000				
50	MISCELLANEOUS								
51	Maintenance of equipment		1,600,000		400,000		600,000		600,000
53	Sundry		1,200,000		400,000		400,000		400,000
59	COMPONENT TOTAL		2,800,000		800,000		1,000,000		1,000,000
99	**GOVERNMENT GRAND TOTAL**	**354**	**27,320,000**	**170**	**20,870,000**	**98**	**3,400,000**	**86**	**3,050,000**

Exchange rate 1 US$ = 360 Tanzania Shs.

Project budget covering UNDP contribution

Country: Tanzania
Project number: URT/93/G31/A/1G/99
Project title: Electricity, Fuel and Fertilizer from Municipal and Industrial Organic Waste in Tanzania: A Demonstration Biogas Plant for Africa

	DESCRIPTION	TOTAL		YEAR 1		YEAR 2		YEAR 3	
		p/m	US$	p/m	US$	p/m	US$	p/m	US$
10	**PERSONNEL**								
11,50	**Consultants**								
11,51	Management expert	6	60,000	4	40,000	2	20,000		
11,52	Construction supervision expert	6	60,000	6	60,000				
11,53	Commissioning expert	6	60,000			6	60,000		
11,54	Biogas plant operation management expert	16	160,000			10	100,000	6	60,000
11,55	Training coordination expert	10	100,000	7	70,000	2	20,000	1	10,000
11,56	In country training supervision expert	8	80,000	4	40,000	2	20,000	2	20,000
11,58	Biogas plant design engineer (2)	10	100,000	10	100,000				
11,59	Waste management consultant	3	30,000	3	30,000				
11,99	**Sub-component total**	65	650,000	34	340,000	22	220,000	9	90,000
17	**ACT**								
17,01	Biogas plant management consultant	18	60,000	6	20,000	6	20,000	6	20,000
17,99	**Sub-component total**	18	60,000	6	20,000	6	20,000	6	20,000
19	**COMPONENT TOTAL**	83	710,000	40	360,000	28	240,000	15	110,000
20	**SUBCONTRACTS (Biogas plant)**								
21	Ground preparation and fencing		110,000		110,000				
22	Biogas reactors and storage tanks		265,000		265,000				
23	Civil works and buildings		120,000		120,000				
25	Mechanical and electrical equipment		1,210,000		1,210,000				
25	Laboratory equipment		35,000		35,000				
26	Erection and assembling of biogas plant		100,000		100,000				
27	Connection to electricity grid		170,000		170,000				
29	**COMPONENT TOTAL**		2,010,000		2,010,000				
30	**TRAINING AND FELLOWSHIP**								
32	**Group training**								
32,01	Training for plant manager and technicians	16	160,000	12	120,000	4	40,000		
32,02	Education and training of AMU staff	4	40,000	4	40,000				
32,03	Training and study tour for MWEM staff	4	40,000	4	40,000				
32,04	Short courses and workshops at AMU		80,000		30,000		30,000		20,000
33	**In-service training**								
33,01	In-service training at the biogas plant		50,000		10,000		20,000		20,000
39	**COMPONENT TOTAL**	24	370,000	20	240,000	4	90,000		40,000

	DESCRIPTION	TOTAL		YEAR 1		YEAR 2		YEAR 3	
		p/m	US$	p/m	US$	p/m	US$	p/m	US$
40	EQUIPMENT								
41	Expendable equipment and supplies								
41,01	Operation and maintenance miscellaneous		100,000		100,000				
41,02	Construction and management miscellaneous		55,000		55,000				
42	Non-expendable equipment								
42,01	Laboratory equipment, AMU		44,000		44,000				
42,02	Trucks (3)		275,000		275,000				
42,03	Act for plant manager		22,000		22,000				
42,04	Gas equipment for truck/act		30,000		30,000				
42,05	Containers and transport tanks		80,000		80,000				
42,06	Gas filling station		230,000		230,000				
43	Premises								
43,01	Monitoring station for staff		65,000		65,000				
49	COMPONENT TOTAL		901,000		901,000				
99	UNDP, GRAND TOTAL	107	3,991,000	60	3,511,000	32	330,000	15	150,000
100	COST SHARING								
101	DANIDA		1,491,000						
109	COST SHARING TOTAL		1,491,000						
199	NET CONTRIBUTION, UNDP		2,500,000						

ANNEX 1. WORK PLAN

TASKS:	YEAR 1												YEAR 2												YEAR 3											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
BIOGAS PLANT:																																				
Design of biogas plant																																				
Ground preparation and fenching																																				
Biogas plant construction, erection and assembling																																				
Upstart and commisioning of biogas plant																																				
Elaboration of operation budgets and maintenance plan																																				
Operation management at biogas plant																																				
Waste resource and collection planning																																				
Agreements with suppliers of waste and electricity purchaser																																				
BIOGAS DRIVEN AUTOMOBILES:																																				
Gas filling station																																				
Conversion of car/truck																																				
TRAINING:																																				
Training of plant manager and technicians in Denmark																																				
In-service training of plant personnel																																				
Training of AMU, MOE and Carmatec Staff in Denmark																																				
In-country training, workshops and seminars																																				
REPLICABLE PROJECTS:																																				
Elaboration of bioenergy master plan																																				
Preparation of plans for replicable projects																																				

ANNEX II. SCHEDULE OF PROJECT REVIEWS, REPORTING AND EVALUATION

Proposed Starting Date:	1 Mar 1994

Description

1. Inception Report	1 Jul 1994
2. General Report on Plant Status and Economy	1 Nov 1994
3. General Report on Plant Status and Economy	1 Jan 1995
4. First PPER	1 Feb 1995
5. General Report on Plant Status and Economy	1 Apr 1995
6. General Report on Plant Status and Economy	1 Jul 1995
7. General Report on Plant Status and Economy	1 Nov 1995
8. General Report on Plant Status and Economy	1 Jan 1996
9. Second PPER	1 Mar 1996
10. General Report on Plant Status and Economy	1 Apr 1996
11. General Report on Plant Status and Economy	1 Jul 1996
12. General Report on Plant Status and Economy	1 Nov 1996
13. General Report on Plant Status and Economy	1 Jan 1997
14. Terminal PPER	1 Mar 1997

General Reports on Plant Status and Economy to be presented to Tanzanian Plant Board quarterly for the life of the Project.

ANNEX IV TRAINING PROGRAMME

A number of people will be trained both in Tanzania and in Europe, not only to ensure proper operation of the biogas plant but also to ensure dissemination of the results and to create the possibility of implementing replicable projects. The training will start with the training of the plant manager and technical operational workers. Additional training will be needed in the following categories:

A. Bioenergy Plant Board Members and/or their representatives.
ROLE - this is particularly focused on staff from the Ministry of Energy who will be given in-depth familiarization covering the administration of the Danish Biogas Program and an introduction to biogas technology.

B. University of Dar es Salaam, Applied Microbiology Unit (AMU) Personnel.
ROLE - Faculty members who have been involved since the inception of the project will further act as advisers to the current plant manager during this project and after handover of the plant to the Ministry of Energy. Faculty from AMU will have further involvement in replicable projects in co-operation with CAMARTEC staff.

C. CAMARTEC Staff.
ROLE - These persons will receive training in biogas technology especially directed towards analysis of new wastes and possibilities for replicable projects.

D. Managers of various major waste suppliers (for replicable projects).
ROLE - Familiarization with biogas technology.

The overall training programme will be based on:

- Training at a technical institute in Europe.
- Training at the joint waste plant in Europe, where source sorted organic industrial waste and cow and pig manure are treated in a very similar fashion as the planned plant.
- Training at the Takagas Plant Unit in Dar es Salaam (when the construction phase is completed).

A training programme will be implemented in which the plant manager, key technical operational personnel, staff from Ministry of Energy and other Board members, Faculty from AMU, and staff from CAMARTEC will be trained both in Europe and Tanzania. As soon as facilities exist in Dar es Salaam, as much as possible of the training can be transferred to the plant and the Applied Microbiology Unit.

1 TECHNICAL TRAINING PROGRAM

The training program for the plant manager, technical-operational workers, Ministry of Energy, AMU and CAMARTEC staff will include, as described above, theoretical lessons on the following topics, at the detail level appropriate for the respective groups:

- Theory of methanogenesis in biogas reactors - the feeding chain, block-points and inhibitions and relations to various waste types, effects of special additions/additives (bleaching earth, GAC etc.), metabolite monitoring for process steering, etc.

- Metabolite measurements, gas production, biogas potential and specific activity measurements, and measurement of other parameters for assessment of the process state and for process steering.

- The BioWaste Combined Organic Waste Treatment System - the salient points of the BioWaste System will be described and process management and steering will be discussed and analyzed with data from real plant operations.

The Plant Manager, technical/operational workers and AMU personnel will perform practical exercises covering measurement of the parameters to be used (total volatile fatty acid, ammonia, *p*H, alkalinity, volatile solids content, etc.) for process steering in order to familiarize them with methods used for "at-plant" measurement. At the biogas plant in Europe, plant personnel will be instructed and familiarized with procedures for operation, performance, breakdowns, and maintenance record keeping. The AMU personnel will, in addition, receive training in the latest research methods for measurement of the same and other parameters (specific activity tests for microbiological assessment of the state of the microbiological catalyst, preparation of samples for specific and group immuno-fluorometric analysis, etc.). The goal is that the AMU would be designated as the quality control laboratory for the plant, and in that role will be involved in calibration and verification of the methods used at the plant.

2 AMU AS A BIOGAS TECHNOLOGY TRAINING CENTER FOR TANZANIA

In addition, the plant Charter includes clauses describing the plant, along with the AMU, as a center whose goal is dissemination of renewable bioenergy technology in East Africa. In this capacity the AMU is charged with not only advisorial scientific assessment of the plant state and operation on the process microbiology side, but also promotion of bioenergy education. In that respect, the AMU personnel will be trained in state-of-the-art scientific methods and technology for research and assessment in the field of bioenergy and environment. All efforts will be made for the genesis, at the AMU, of a bioenergy center with its own in-house, self-reliant capability to identify, design and generate bioenergy technology and plans for the Tanzanian situation. This will include training in evaluation of new wastes for their potential as biogas sources for replicable projects, training in synthesis of waste treatment strategies given different and variable waste availability and treatment requirements, and training in basic biogas plant dimensioning and design.

In its role as a biogas research center, the AMU will also be educated to have the ability to act as a training and workshop center for other organizations and institutions, including major waste suppliers which are interested in bioenergy technology. Involved parties, such as CAMARTEC, a European sponsored organization that has installed more than 100 family/village size rural biogas units in East Africa, representatives of other SADC countries, and other bioenergy establishments can attend workshops and training sessions taught by the members of the Univ. Dar es Salaam AMU. These sessions will include biogas microbiology theory, examples of practical solutions to biogas problems, methods for optimization of the biogas process and other topics based on the interest of the attending parties, particularly pointed towards dissemination of biogas technology in East Africa for replicable projects.

ANNEX V EQUIPMENT REQUIREMENT

This annex describes the details of the proposed biogas plant for treatment of organic municipal and industrial waste in Dar es Salaam, including the technical equipment required for the plant. Further details can be added, when the design phase is finished and the equipment is purchased and when subcontracts with Tanzanian companies are agreed.

3 THE DEMONSTRATION BIOGAS PLANT IN DAR ES SALAAM

3.1 Design Basis and Mass Flow

The quantities of organic waste available is described in the PRIF study "TAKAGAS, ENERGY FROM WASTE, TANZANIA, UNDP 1992". From that, a selection is chosen to form the optimal input for the demonstration plant.

This selection is shown below:

Type	Amount ton/day	Dry matter ton/day	Feed for the biogas plant ton/day
Household waste	16.0	4.8	40.0
Market waste	20.0	6.0	50.0
Hotel waste	1.0	0.3	2.5
Abattoir waste	4.0[1)]	0.8	7.0
Brewery waste	10.5	4.2	35.0
Bleaching clay	5.5	1.4	11.5
Total	57.0	17.5	146.0

Table 1. Design basis of the demonstration plant. [1)] Including waste water.

The expected content of organic matter (volatile solids, VS) in the waste is 80% of total solids, making up 14 tons VS/day.

From this input, the expected output is:

Solid residue:	30 tons/day
Liquid residue:	20 tons/day
Gas produced:	6,400 m^3 biogas/day ≈ 4,200 m^3 CH_4/day
Energy content (35.9 MJ/m^3 CH_4):	150 GJ/day ≈ 41 MWh/day
Truck fuel:	200 m^3 CH_4/day
Available for gas engines:	4,000 m^3 CH_4/day ≈ 39 MWh/day
Electricity output, $\eta \approx 0.3$	11.8 MWh/day
Internal use of electricity:	1.9 MWh/day
Electricity sold to public grid:	9.9 MWh/day

3.2 System Description

Transport and Presorting

Organic waste from the abattoir next to the site can be transported manually by wheelbarrow, by container and truck or, for the liquid part, by gravitation in a pipeline, directly to the pre-storage tank.

Other types of waste will be transported by trucks, belonging to the plant, equipped with container handling equipment. The trucks are modified to be able to run either on petrol or biogas. 10 standard containers, loading approx. 10 tons each, will be provided and placed at the industries. The trucks will, according to demand, regularly deliver an empty container and take the filled one to the plant for discharging.

Market and municipal solid waste collected under the responsibility of the City Council or by private contractor will be transported to the biogas plant without extra costs as it is situated next to the dump site. As the biogas plant will be situated near the access road to the dump site, the loads suitable for biogas production can easily be redirected to the plant.

The industrial waste is, in general, considered sufficiently free of foreign substances to be discharged directly to the pre-storage tanks, whereas the household and market waste will contain some non-biodegradable and even potentially contaminating matter which has to be sorted out. This is done by discharging the waste on a concrete plate at the receiving station. From this place, the degradable waste is pushed into the shredder manually, whereas the plastics, metal and other objects will be sorted out and disposed of at the dump site.

Pre-storage

From the shredder, the waste falls into the pre-storage tank. The two parallel pre-storage tanks, 100 and 400 m^3 respectively, are chosen because some industrial waste is readily degraded with a high specific gas production compared to ordinary fruit and vegetable residues. Thus, the composition of the substrate to the digesters can be used for control of the gas production rate. In the pre-storage tanks, the waste is diluted with some recirculated liquid from the digested matter. The tanks are equipped with mixers to ensure that the solid waste is dissolved into the liquid to a homogeneous slurry in the tanks, with approx. 10% total solids (TS).

Digestion

From the pre-storage tanks, the slurry is dosed into the digester tanks with an active volume of 2 x 800 m^3. To pump the slurry, eccentric screw pumps are used. In the digester, the biomass is heated to approximately 55°C by heating coils. The necessary heat for the digesters is taken from the water cooling system of the gas engines. The digesters are completely stirred tank reactors with vertically
mounted external mixers.

At the top of each digester, a gas outlet and safety equipment are mounted to avoid too high or low pressure in the digesters.

Dewatering

From the digesters, the degraded biomass is pumped to a belt filter press, where the biomass is dewatered to a solid which can be handled and transported away. As the nutrients (nitrogen, phosphorus, potassium) are not removed during the process, both liquid and solid residuals are valuable fertilizers.

Transport of Fertilizer

The solid residue is loaded into containers and transported by trucks to farms or plantations where the fertilizer can be stored and utilized.

The liquid can be transported by the same trucks, equipped with a tank on a container frame.

Gas Utilization

From the top of each digester, the gas is led through pipes and drained for condensate. A gas blower maintains an appropriate gas pressure at approx. 0,1 kPa in the digesters, and the gas is then led to a small low-pressure gas storage, to equalize hour-to-hour differences in production and consumption.

The gas is fed into four gas engine generator sets, each of 250 kW electricity output. The generators are normally connected to the public grid, producing electricity both into the grid and for the purpose of the plant (pumps, mixers etc). In case of fallout of the public grid, the plant is automatically disconnected and runs its own independent local grid.

Approximately 5% of the gas production is compressed to 250 bars to be used as fuel for trucks and the manager's car.

3.3 Technical description of the elements

Receiving station

The receiving station consists of a plate of the in situ cast steel reinforced concrete, approximately 200 m^2. In the concrete plate, a groove equipped with a screw conveyer is used to feed the waste into the shredder.

When household waste is discharged at the concrete plate, the non-biodegradable objects are removed by the staff and the rest is pushed into the groove.

The shredder consists of a screw, which presses the waste up to a perforated plate, where a set of knives rotate to cut any matter passing into the holes. Thus, no solid particles with a diameter exceeding 5 mm will be present after the shredder.

The shredder is controlled manually from a switchbox mounted at the receiving station.

Tanks

All tanks (prestorage, digesters and the store for liquid) are made of in situ cast steel reinforced concrete. The bottom of the tanks is made approximately 1 meter under ground level. The concrete is reinforced with 120 kg. steel per m^3 of concrete.

Prestorage

The prestorage tanks are equipped with heavy mixers, which are able to produce a homogeneous slurry from waste and recirculated liquid.

The mixers are mounted on the wall of the tank with the motor outside the tank. Nominal power consumption is approximately 50 kW. The mixers are controlled either manually or by a timer system, built into the switchboard.

The prestorage tanks are each equipped with 2 pipes in the top for adding water and recirculated liquid and 1 from the bottom to pump out the slurry.

Digesters

The digesters are equipped with a mixer on a vertical axis, with gas-tight sealed bearings in the top. The gear and motor is mounted outside the tank. Nominal power consumption is approximately 10 kW. The mixers are normally in operation all the time, and are manually controlled from the switchboard.

In the lower third of the digesters height, a coil of steel pipe is mounted inside the tanks. Hot water from the gas engines cooling system is pumped through the tubes. A thermostatic controller is starting and stopping the pump according to the heat demand.

The digesters are each equipped with 3 pipes: a gas outlet in the extreme top position of the tank, an inlet at the top and an outlet at the bottom of the tank.

To monitor the state inside the digesters, each is equipped with two manometers on pipe stubs, one for the gas pressure mounted at the top and one for detecting the liquid level mounted at the bottom.

Each digester is also equipped with 3 thermometer sleeves, one in the upper part and one in the lower part for thermometers, and the middle one for a temperature transmitter to control the heat added to the digester through the coil.

Storage for liquid

The tank is equipped with a submerged centrifugal pump. The pump is mounted on a guider rod, which makes it possible to inspect and repair the pump without emptying the tank. Power consumption is approximately 10 kW. The pump is controlled either manually or by a timer at the switchboard.

The tank is equipped with an inlet pipe in the top and an outlet from the pump.

3.4 Other equipment for slurry handling

Pumps

In addition to the pump in the liquid tank, there is a pump at the river to supply fresh water to the process. The pump is a submerged centrifugal pump, placed in a well just beside the stream. The pump is controlled manually or by a timer in the switchboard.

To pump the slurry from the prestorage tanks to the digesters, and from the digesters to the belt filter press, 3 eccentric screw pumps are used. The 3 pumps are identical with a nominal power consumption of 5 kW. A spare pump is provided to increase reliability of the system. The pumps are controlled manually or by timers in the switchboard.

Belt filter press

The filter press is used to dewater the digested biomass, as it is pumped out of the digester tanks. The dewatered solid falls from the bottom of the filter press, down in a container. The liquid is led by gravity to the storage.

The belt filter press is equipped with electric motor of approximately 1 kW. The filter press is controlled manually, or can be controlled by the pump feeding the slurry to it.

Gas utilization unit

The gas system consists of gas pipes, gas blower, gas washer, and cooler, low pressure gas storage, gas motor/generator unit and a high pressure unit containing compressor and storage for vehicle fuel.

The gas blower is equipped with a frequency regulator controlled by pressure transmitters, mounted at the gas outlet of both digesters. The controller is built into the switchboard for the gas blower.

The gas is cooled in a gas/air heat exchanger, washed in a water spray and drained just before it is fed into the blower. The blower raises the pressure to 200 mbar and the gas is led to a gas dome of approximately 500 m^3 volume.

From the dome, the gas is led to the gas engines or the high pressure compressor for the vehicle fuel unit. The engines are dimensioned to 3 x 45% of the expected gas production, while the high pressure unit is dimensioned to approximately 5% of the gas production according to the estimated needs to run the plants own vehicles.

A gas flare is connected to the gas dome as well to ensure a safe handling of unused gas. The gas flare is controlled by a top level switch at the gas dome.

The gas engine/generator units are mounted with all necessary equipment for controlling etc. as turn-key packages, prepared to be controlled either by the applied load when disconnected from the grid or controlled by the available gas in the dome, when connected to the grid. If the public grid voltage drops beyond a certain limit, the grid is automatically disconnected. The generator output is at 11 kV, and the internal power supply is made through a transformer. The unit is connected to the existing 11 kV grid by a overhead line of approximately 2 km length.

The high pressure compressor is controlled by a pressure switch in the high pressure storage. From here, the gas tanks on the trucks and the car can be filled.

3.5 Operational Routines

This section describes the functions which have to be carried out by the staff in order to run the plant, and the necessary skills of the persons employed.

Transport
To drive the trucks, and take care of the daily maintenance of the trucks, there is a need for 5 full-time employed persons; 3 drivers and 2 for repair and maintenance and occasionally to substitute the drivers.

Apart from ability and skill at driving trucks, the job demands workshop experience in repair and maintenance of mechanical equipment.

Receiving of Waste
To take care of and ensure proper discharge of incoming waste and to sort out undesirable objects from the waste, 4 persons are necessary. In addition, they will be available for other tasks at the plant, including handling of fertilizer.

General Maintenance
To carry out the regular service and minor repair work on mechanical equipment, 1 person is employed for this purpose. A skilled worker in mechanics will be preferable.

Security guards
Three security guards will be responsible for the safety of the plant premises. They will also be responsible for calling a standby technician in case of emergency situations regarding the plant.

Management
To take care of the overall operation and development of the plant and processes, a manager will be employed. It will be required that the manager has experience and skills at planning and managing, and he/she should be intensively trained during the first period of operation, in which the project still offers management support. The first 2-3 years, there will be back-up for the manager. After this period, the back-up should decrease gradually to minimum 5-6 years after the start of the operation.

3.6 Economy of the place

The budget for building and operating the described plant is based on locally produced goods, imported goods which have been purchased locally, and commissioned goods purchased in other countries, as shown below.

Item	Tanzanian production	Import		Total
		Local purchase	Foreign purchase	
Ground preparation and fencing	110			110
Tanks	265			265
Other civil works, buildings	120			120
Mec. and elec. equipment		1,210		1,210
Erection and assembling	50		50	100
Lab. equipment			35	35
Connection to public grid[1)]	70		100	170
Construction costs	**615**	**1,210**	**185**	**2,010**
Design			100	100
Construction management and supervision	60		20	80
Project management			60	60
Unforeseeable	50	50	85	185
Design & management	**110**	**50**	**265**	**425**
Trucks, 3			275	275
Gas equipment truck/landrover			25	25
Gas filling station			250	250
Containers, 10	25		25	50
Transport tanks on container frame	15		15	30
Land rover for plant manager			22	22
Gas equipment (for above)			5	5
Monitoring station for plant manager and staff	65			65
Transport and gas handling	**105**	**-**	**617**	**722**
Laboratory	**-**	**-**	**24**	**24**

Training	340	-	270	610
Contingencies	100	-	100	200
Grand Total	1,270	1,260	1,461	3,991

Table 2. Investment, 1,000 US$. [1] This amount is assumed to be the share of the plant of the total costs for connecting the plant generators (approx. 1,000 kVA) to the general 11 kV grid. The prices are exclusive of any tax.

ANNEX VI JOB DESCRIPTIONS

1 PROJECT PERSONNEL

1.1 Project management

a. Project management expert

The project manager will be based in Dar es Salaam.

Duties
The main duties of the project manager will be overall coordination of the project activities in close corporation with the administrative director (Ministry of Water, Energy and Minerals). He will also be responsible for agreements on subcontracts with local companies concerning construction of different sections of the biogas plant.

Qualifications
The project manager shall have extensive experience in construction work in Tanzania and experience in cooperation with governmental institutions, NGO's and donor organizations. Furthermore, the project manager must possess thorough knowledge of Tanzanian industries in the fields relevant for this project.

See the Pre-Investment Feasibility Study for s fuller description of duties and responsibilities.

1.2 Biogas plant construction and operation

a. Biogas plant design engineers (2)

Duties
The main responsibility of the design engineers will be detailed design of the biogas plant facilities with respect to the equipment available and the technology feasible for use in a developing country.

Qualifications
The design engineers must possess long term experience in design and construction of biogas production facilities. At least one of the engineers must also have extensive experience in construction work in developing countries and at least one must be familiar with electricity production systems.

b. Construction supervision expert

Duties
The main duties of this expert will be coordination of the construction activities and in-situ supervision of the subcontracted local companies in order to ensure that their work is carried out according to the specifications stated in the subcontract. He will cooperate closely with the project manager.

Qualifications
The construction supervisor must have extensive experience in construction work in developing countries, preferably in Tanzania. He or she must also be familiar with, and have experience in, cooperating with Tanzanian companies.

c. Waste collection management consultant

Duties
The main duty of this consultant will be coordination of the collection of waste for the biogas plant. The duties will be: detailed coordination of the waste collection with the City Council and the private contractor MARTINET, strategies for location of containers and collection of waste from the different sources.

Qualifications
This consultant must have extensive experience in different types of waste collection systems and must be familiar with the quality criteria of waste required for biogas plants.

d. Biogas plant operation expert

Duties
The main duty of this expert will be to take over the overall responsibility for the operation and management of the operation of the biogas plant after commissioning. The duration of the management period will be 2 years from the end of the construction phase. Moreover, he or she will be involved in training of the plant manager and the local plant operation consultant. The training part will be closely coordinated with the training coordination expert having the overall responsibility for the training programme.

Qualifications
The biogas plant operation expert must possess an extensive knowledge and long term experience in biogas plant operation. He or she must also have detailed knowledge of the influence of different waste sources on the biogas processes and have experience in co-treatment of different waste sources in biogas reactors.

e. Local biogas plant operation consultant

Duties

The main duties of the local biogas plant consultant is to build up know-how and experience in operation and management of medium to large scale biogas production facilities, in order to gradually take over part of the operation responsibility. At the end of the project, this consultant should be able to function as an external consultant to the project manager in all aspects concerning biogas plant operation and process knowledge.

This consultant will also be able to assist the Ministry of Water, Energy and Minerals in the development and initiation of replicable projects.

Qualifications

At the beginning of the project, this consultant shall possess knowledge of anaerobic digestion of solid organic waste. He or she must have a university education in microbiology and biotechnology and have laboratory and analytical experience.

f. Training coordination expert

Duties

The main responsibilities of the Training coordination expert will be the organization and execution of the training programs for the various involved parties (Project, Plant, Administrative and Technical personnel) that will participate in the training programs to be held in Europe.

Qualifications

The Training coordination expert should have familiarity with biogas technology and biogas programs; knowledge of the structure and organization of the biogas technology in Europe is preferable. Skill at organizaing and fulfilling programs under budget and time restraints is required.

g. In-country training supervisor

Duties

The main responsibilities of the In-country training supervisor will be organizing and assuring execution of the various training programs for training the involved parties in Tanzania. This includes training at the biogas plant and the Applied Microbiology Unit.

Qualifications

Good organizational skills and knowledge of the Tanzanian situation with respect to the project is recommended as well as an ability to coordinate and work closely with the Faculty of the Applied Microbiology Unit, staff at the Ministry of Energy and staff at the biogas plant.

2 STAFF AT THE BIOGAS PLANT

1.3 Plant manager

Qualifications
The plant manager should preferably have a degree in chemical and process engineering or either a degree in electrical or mechanical engineering. Knowledge in bioprocessing, engineering and biogas technology will be an advantage.

Experience
The project manager should have at least a two year working experience in administration in bioprocessing industries, such as breweries, diaries or pharmaceutical industries etc. Experience in using electronic measurement systems and computer monitoring systems is preferable.

The plant manager must have good knowledge of finance and preferably experience from in the private sector on how to run a profit enterprise.

Responsibility
The plant manager will have the overall operational and administrative responsibility for the plant.

- Responsibility for the technical operation of the plant.
- Responsibility for the waste delivery to the plant.
- Responsibility for the overall finances of the plant.

1.4 Technicians

Three technicians will be needed to run the plant. It is preferable that these technicians are specialists in different areas of the know-how needed to run the plant.

Qualifications
The technicians should have a certificate/diploma in the following areas of expertise:

A: Technician with a full laboratory technicians course with an emphasis on biological techniques.

B: Technician in electrical techniques.

C: Technician in mechanical techniques.

Knowledge in biogas technology or related biological techniques will be an advantage for all three technicians.

Experience
The mechanical and electrical technicians should have at least two years of experience in workshops on repairing of industrial machinery. Experience in electronics and monitoring systems will be an advantage.

Responsibility
The technicians will work under the plant manager in undertaking either of the following responsibilities:

- Routine check and monitoring of the reactors.
- Daily maintenance of machinery, reactors, trucks and buildings.
- Maintenance of monitoring system and automatic data collection.

1.5 Supporting staff

The supporting staff (4 persons) will be responsible for overall cleanliness of plant premises and sorting of incoming waste. The staff will be trained while in service at the biogas plant.

1.6 Drivers

Five drivers will be needed. Their main working area will be collection of waste from industries and markets outside the area covered by the city council waste collection systems. The drivers will also be responsible for distribution of fertilizer from the plant.

1.7 Security guards

Three security guards will be responsible for the safety of the plant premises. They will also be responsible for calling a standby technician in case of emergency situations regarding the plant.

ANNEX VII Framework of cooperation and responsibility

OWNERSHIP AND ORGANISATION

DAR ES SALAAM BIOGAS PLANT

Draft memo of understanding - regarding ownership and organisation

Ownership:

1. The Dar es Salaam Biogas plant, hereafter named TAKAGAS, will be established as an economically independent unit.

2. The Ministry of Energy of Tanzania has responsibility for establishing the unit and the appointment of members to the Board of Directors.

3. After establishment and a 2-year period of smooth operations, the Ministry of Energy can consider the advantages of privatizing the unit.

4. Any financial income gained from privatization of the unit should be incorporated in the fund mentioned below.

5. The Ministry of Energy has the right to expand or close the biogas unit if the economic situation so requires.

Organization

1. The Board of Directors shall be appointed by the Ministry of Energy and represent the different organizations that have interests in the biogas plant.

2. In addition to the Ministry of Energy itself, these organizations include the Ministry of Environment, Tanesco, the City Council of Dar es Salaam and the Unit for Applied Microbiology at the University of Dar es Salaam. All together there should be no more than 6 representatives on the Board of Directors.

3. A draft business charter is enclosed.

4. The plant manager will, with support of the Board of Directors, have full economical and technical responsibility for the operation of the plant.

5. Each year the biogas plant shall present, in public, a financial status report on the biogas plant as well as plans and budgets for the coming two year period.

6. The income from the sale of electricity, methane, fuel and fertilizer should be used to cover the operation costs of the biogas plant including salaries, maintenance, spare parts, etc.

7. A maintenance plan should be worked out and part of the income should be reserved for these expenses.

8. During a 2-3 year period, supervision and assistance should be given by the engineering group responsible for the plant construction.

9. All further income from the biogas plant should be used for promoting biogas technology in Tanzania and a fund should be created for this purpose.

The objectives of the fund are:

a) To facilitate construction of other biogas plants.

b) To undertake studies that analyze other types of waste, e.g. from coffee, sisal and sugar plantations or other municipalities in order to evaluate the potential for construction of biogas plants at other locations in Tanzania and other East African countries.

c) Training of personnel from Tanzania in subjects relating to biogas technology.

COOPERATION CHARTER OF DAR ES SALAAM BIOGAS PLANT

1. This charter consists of a list of rules established to ensure the proper management of the Dar es Salaam Biogas Plant.

2. These rules refer to the Memorandum of Understanding that forms the basis for establishing the ownership and the organization of the biogas plant.

3. The Board of Directors shall at its first meeting elect a chairman among the members of the board.

4. The Board of Directors shall appoint the manager of the biogas plant.

5. The Board of Directors shall meet at ordinary board meetings at least 4 times a year. At each meeting the plant manager shall present a financial status report for the biogas plant as well as any other subjects that either he or a member of the board has asked to be included in the agenda.

6. The board meetings should be announced to all board members with at least one month's notice.

7. Extraordinary board meetings may be announced with 10 days notice if two of the board members agree or the chairman and the plant manager ask for a meeting.

8. The agenda and most written material should be sent to the board members at least 8 days before the meeting.

9. In order to be able to make decisions, at least three members of the Board of Directors must be present.

10. The manager and the chairman shall be present at the normal board meetings.

11. The manager shall ask the board to approve a maintenance plan and an investment plan. A running budget for these shall be prepared.

12. Any major discrepancy between the actual cost and the budget shall be reported by the plant manager at the board meetings.

13. In addition to the budget plan, the Board of Directors shall review at regular intervals the general biogas situation of Tanzania and the surrounding countries and discuss the possibilities for further promotion of biogas technology in East Africa.

14. An annual report shall be presented to the Board of Directors together with a financial report. The public has rights of access to the annual report.

15. The accounting shall be reviewed at regular intervals by an auditing company that has international status and is approved by the Tanzanian government.

16. Should a financial or other situation arise that requires closure of the biogas plant, this can be done provided the Board of Directors unanimously agrees to this. Before this is carried out, UNDP shall be notified, specifying the reason for this decision.

17. In the case of closure of the biogas plant, all values belonging to the biogas plant shall be given to the government of Tanzania.