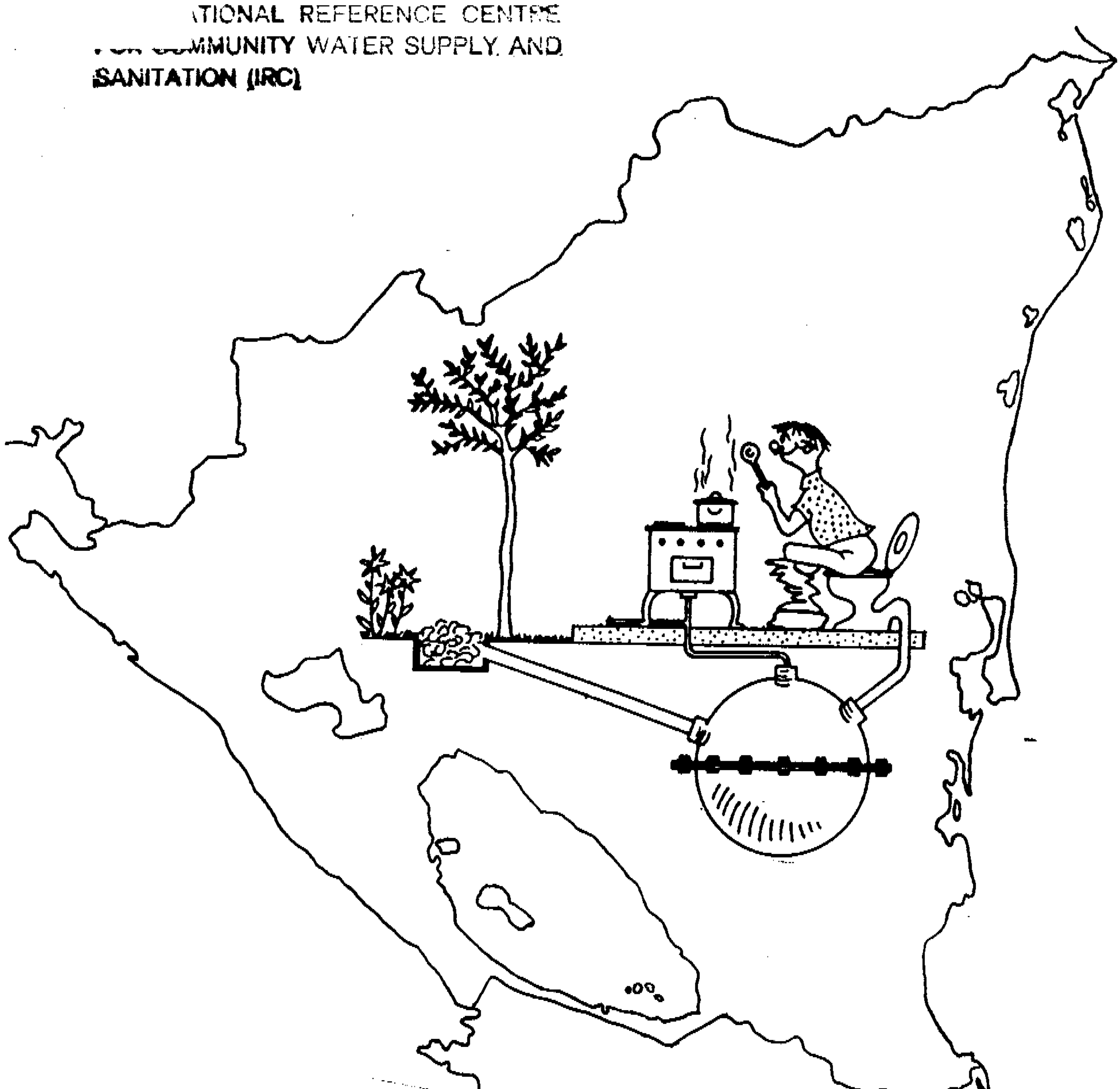
BIOGAS IN NICARAGUA

- two project analyses -



doctoraalscriptie bedrijfskunde van rick wasser

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contents:

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Preface and objectives of this study

During 10 months, from august 1985 until june 1986, I had the opportunity to perform my graduate studies for Chemical Engineering and for Business Management in the Central-american state Nicaragua.

This little country suffers at this moment of many huge problems: After the overthrow of the Somoza dynasty in 1979 the young state had to face the consequences of a world-wide crisis, which stroke the developing countries much harder than the industrialized world. Since 1979, Nicaragua has lost more than half of her income out of export, through the falling of prices on the world market. Next to this, Nicaragua got involved in an international conflict with neighboring states, internal armed opposition and, above all, the powerful United States of America, intervening in the conflict.

These problems go in hand with a disastrous internal economic situation, which is best characterized with scarcity and inflation.

In this situation the Nicaraguans want to reconstruct and develop their country.
Local institutions, but also many foreign and international organizations try to realize improvements especially through the execution of development projects, in the fields of public health, agrarian development, water and sanitation, rural energy supply, industrial development, and many others.

During my staying I visited many of these organizations.
It stroke me that most of these organizations had considerable problems to operate. and that it was very difficult to identify the causes of these problems.
It was not only the very turbulent and difficult economic and political situation that Nicaragua had arrived in. Neither it was only the difficult management and control of the aimed activities which delivered most substantial problems.
In most cases the causes of these problems seemed to be related with a complex mass of facts and developments, which could hardly be overseen.

During my investigations towards the solution of environmental problems in the Matagalpa region I got in contact with biogas technology, and a number of organizations, responsible for the dissemination of this technology in the country.
Between those organizations many differences existed in the rate of success they had in the achievement of their objectives: One of the local projects had a failure rate of 100%, whereas a german project, which had only recently started with a more massive dissemination of the technology, had more promising results.

Taking these two programmes as a starting point it was my objective to identify the most important factors of success and failure in these projects: **To identify the extent to which programme management, or the difficult environment of Nicaragua should be held responsible for occurred failures.**

The underlying reason to do this was the desire of the MIDINRA-Matagalpa office to start a biogas extension programme in her region.

This study has been written for the organizations involved in the dissemination of biogas technology in Nicaragua. At the same time it serves as a graduate study for Business Management of Twente University, The Netherlands.
The rather big size of this final draft is to be blamed on this double set of objectives: Serving as well the Nicaraguan organizations and the scientific context the report was to be written in. For the Nicaraguan organizations it is good that many data and facts are collected in one report now. Too many small discussion papers and loose remarks and impressions circulated. These have been combined in one view now.

I should be grateful to many people, who helped me to collect data and order the obtained information in this report.
In the very first place people in Nicaragua:

* Don Eliseo Ubeda G, my direct responsible at the MIDINRA office in Matagalpa, and, in the same office, many people from DRIFA who helped me collecting my data;
* The INE Oficina para Fuentas Alternas de Energía in Managua, where Cándido Tablada, Guadalupe Baquedano, Reynaldo Vegas, Mira Brown were more than helpful to me;
* The GTZ programme co-operatives Günther Ullrich and Rolf Georg, providing me the information I needed;
* ENPRA Managua, of which organization Sofía Bonilla and José García Bas should be mentioned.

In Holland the commission of the Business Management Department and of the Technology and Development Group of Twente University should be thanked for their patience and their suggestions.

The report remains my personal view of the situation.
I regret that we didn't have the opportunity to discuss the conclusions before printing this final draft.
Before translating it in Spanish, however, such discussion surely will take place, and may give rise to some alterations.

Utrecht, june 21, 1987

Rick Wasser

List of abbreviations

APP	Area Propriedad del Pueblo (area of Public Property)
B/C-ratio	Benefit/Cost ratio
bbl	barrel of oil (= 159 liters)
BEP	Biogas Extension Programme of GATE/GTZ
BND	Banco Nacional de Desarrollo (National Development Bank)
BORDA	Bremer Arbeitsgemeinschaft für Ueberseeforschung und Entwicklung (Bremen Overseas Research and Development Association)
C$	Nicaraguan Cordoba's
CBA	Cost Benefit Analysis
CEPAL	Comisión Económica para América Latina, UN economic commission for Latin America
CIERA	Centro de Investigaciones y Estudios de la Reforma Agraria (Centre for Research and Studies in the Agrarian Reform)
CITA	Centro de Investigación de las Tecnologias Apropriadas (Research Center on Appropriate Technology)
DINOT	Departemento de Investigación y Orientación Tecnológica, of the UNI
DRIFA	Dirección Regional de Ingeniría e Fomento Agropecuario (Regional Directory of Engineering and Agricultural technical Support), department of MIDINRA
ECLA	see CEPAL
EEC	European Economic Community
EGA	Escuela de Agricultura y Ganadería, Estelí (School for Agriculture and Husbandry in Estelí)
ENAMARA	Empresa Nacional de Mataderos de la Reforma Agraria (National Enterprise of Slaughterhouses of the Institute of Agrarian Reform)
ENAPLAST	Empresa Nacional de Plastico (National Enterprise of Plastics)
ENPRA	Empresa Nacional Porcinera de la Reforma Agraria (National Pig-farm Enterprice of the institute of Agrarian Reform)
FAO	UN Food and Agricultural Organization
FIDA	Fondo Internacional de Desarrollo Agricola (International Fund for Agricultural Development)
FNI	Fondo Nacional de Inversiones (National Investment Fund)
FSLN	Frente Sandinista de Liberación Nacional (Sandinistic Front of National Liberation)
gal	US gallons (= 3.79 liters)
GATE	German Appropriate Technology Exchange
GDR	German Democratic Republic
GNP	Gross National Product
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Institute for Technical Co-operation)
i.r.r	internal rate of return
IFAD	see FIDA
IIE	mexican biogas reactor design
INAA	Instituto Nicaraguense de Agua potable y Alcantarillado (Nicaraguan Institute for drinking Water and Sanitation
INE	Instituto Nicaraguense de Energía (Nicaraguan Institute of Energy)
INEC	Instituto Nicaraguense de Estadistica y Censo (Nicaraguan Institute of Census and Statistics)
INRA	INstituto de la Reforma Agraria (Institute of Agrarian Reform)
IRENA	Instituto Nicaraguense de Recursos Naturales y del Ambiente (Nicaraguan Institute of Natural Resources and Environment)
JMR	Junta Municipal de Reconstrucción (Municipal Junta of Reconstrucción)
K	Potassium
lb	pound (= 454 grams)
lt	liter
m^3_{dig}	Cubic meter of digester volume

MIDINRA	Ministerio de Desarrollo Agropecuario y Reforma Agraria (Ministry of Agricultural Development and Agrarian Reform)
MINSA	Ministerio de Salud (Ministry of Health)
MIPLAN	Ministerio de Planificación (Ministry of Planning)
N	Nitrogen
NH_4	Ammonium
OAS	Organización de los Estados Americanos (Organization of American States)
OFAE	Oficina de Fuentas Alternas de Energia (Office of Alternative Energy Sources), part of the Planning Department of INE
OLADE	Organización Latino-Americano de Desarrollo de Energia (Latin-amaerican Organization for Energy Development)
P	Phosphor
PF	Plug Flow reactor
PVC	Poly-Venyl Chloride, a plastic
R & D	Research and Development
SIDA	Swedish International Development Authority
T & E	Training and Education
UCA	Universidad de Centro America (Central American University)
UNAN	Universidad Nacional Autónoma de Nicaragua
UNI	Universidad Nacional de Ingeniria (Technical University)
UPE	Unidad de Producción Estatal (State farm)
US $	US Dollars
Xoch	Xochicalli - mexican biogas reactor design

Chapter 1: Introduction

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Chapter 1: Introduction

1.1 Biogas: An introduction

Since the early seventies, the idea of applying biogas digesters in developing countries has gained popularity. The results, reported from the Chinese People's Republic, where biogas technology was introduced on a large scale, and to a somewhat lesser extent, the experiences from India, have made biogas technology an important issue for many Third World governments, foreign aid organizations and individual development workers.
Undoubtedly, the main reason behind this is the increasing difficulties which developing countries face in obtaining cheap and durable energy sources: On a national level, many Third World countries are heavily dependent on the import of fossil fuels, using up a large part of the often scarce foreign exchange. At the same time large areas are rapidly deforested, at least partly because wood is still the most important local energy source in a number of developing countries. The resulting erosion problems are huge; Many families belonging to the rural or urban poor require an ever larger part of their income and/or time to obtain the minimum amount of fuel necessary for basic activities such as cooking. It is widely believed that biogas technology, as with other renewable energy sources, could solve part of the above mentioned, and other problems.

With the term "biogas technology" is meant the application of the principles of anaerobic fermentation of organic matter (dung, excrements, plant material or agro-industrial wastes) with as a (sub-)goal the production of biogas (a combustible, which consists of methane (50-70%), carbon-dioxide and some other gases), and/or the enrichment of the nutrient values of natural fertilizers.[1]
As such, biogas technology is primarily applied in agricultural situations: The presence of a constant and sufficient supply of organic wastes, and the possibility to use the enriched digester slurry are conditions that make Biogas technology especially interesting for agricultural and agro-industrial applications.

Reasons for the application of this technology can be summarized as follows:

1. energy
The gas, formed in the anaerobic fermentation process, is a fuel of high energetic value (± 24 MJ/Nm^3), that can be used to produce heat (burners, stoves, ovens, radiant heaters), lighting, electricity and mechanical power, and in this way can replace more traditional fuels, such as firewood, dung-cakes, coal, (propane-) gas, diesel, gasoline and electricity.

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[1] M. Arnott, 1985

2. agriculture
During the anaerobic fermentation process, a number of processes take place that cause the organic material to be more suitable for fertilization purposes: Present (pathogenic) bacteria die off, and nutrients, present in the prime matter, are made more accessible to be used by the crops.

3. health
As is widely known, the lack of sanitary systems in developing countries can be a cause of the appearance of many infectious diseases, such as diarrhea, gastero-enteritis, typhus and dysentery.[2]

As a simple sanitary system, through the effect of parasite killing, biogas technology can contribute to a more hygienic situation in rural areas.

4. environment
As a sanitary system, it also may have a positive impact on environment: Where intensification of agriculture in many cases leads to an increase of pressure on human environment, biogas offers a simple system to reduce pollution hazards.
If the produced biogas is used as a substitute for firewood the forests are spared, and deforestation is fought.

5. economy
All above mentioned effects will have their economic consequences: If biogas technology can be applied at reasonable costs, the beneficiary may find it a money saving investment; For the economy as a whole can be remarked, that biogas technology may lead to the saving of foreign currency (oil derivates, fertilizers, medicines) and have a positive economic impact.

The motivation of a farmer to install a biogas system can vary widely from case to case, and may have little to do with the motives mentioned above:

- There can be no doubt that the winning of energy has a high place value among user incentives. However, various cost-benefit analysis have shown that a biogas system is not profitable if only the energy production is concerned on the benefit side;[3]
- All the same, the greatest inducement of all could appear to be the urge to live an easier, more "modern" life (as long as the costs of installation stay within acceptable limits): The utilization of a reliable, "modern" energy supply that saves on the costs of fuel and fertilizer and provides better hygiene on farm level, but also an elevation of **status** are among the motives of "beneficiaries" to participate in biogas programmes.[4]

The spread of agricultural biogas systems in developing countries varies widely from region to region. Most countries began introducing state-coordinated programmes only a few years ago.

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[2] See, e.g, R. Feachem, 1977
[3] See, e.g, Moulik, 1982
[4] E. Kijne, 1983

However, most notably in Africa, the production of gas has been extensively limited to a few scattered farms and institutions, where interested individuals have installed small systems on their own initiative. As early as 1984, though, some quantity of biogas was being produced in practically every country on earth.
The leading nation by far is China, where roughly 7 million biogas plants are already in operation. Compared to that scale, even India's 220,000 biogas systems seem relatively modest in number. A few other countries have several thousand plants each, i.e. Brazil, Korea and Nepal, whereas somewhere between 100 and 1,000 systems are in use in Kenya, Taiwan, Pakistan, Shri Lanka, Thailand and Latin America.

After the year 1978 the results of a number of evaluations on the performance of biogas plants showed that in China and India a substantial part of the constructed plants did not function:

- From China was reported that up to half of the installations which were centrally planned no longer functioned well; two million digesters could not be repaired, while another two million had severe operational problems.[5]
- In India evaluation studies reported that up to 30 % of the installed installations did not function. Besides, questions were raised on the economic feasibility of biogas technology. Several investigators concluded that investment in biogas could not economically be justified in many cases.[6]

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[5] See, e.g, P. Evers, Han The, 1984
[6] T.K. Moulik, 1982

1.2 Biogas in Nicaragua

In Nicaragua biogas technology has been applied since 1982, in a programme managed by the national institute for energy (INE)[7], in cooperation with the Latin American Organization for Energy (OLADE). At about the same time the Center for Appropriate Technology of the Institute for Land Reform (CITA-INRA) started some experimental activities with biogas, also supported by OLADE. From 1983 on, the German Technical Cooperation Program (GTZ) supported this programme (see 1.2.3).

In the years to come, more organizations got interested in the new technology, such as the National Pig Firm (ENPRA), the Ministry of Agriculture and Land Reform (MIDINRA), the University of Engineering (UNI), the Ministry of Health (MINSA), the Institute of Water and Water Distribution (INAA) and the Institute for Environmental Affairs (IRENA).
However, up to 1985, only INE (1.2.1), CITA-INRA (1.2.2) and ENPRA (1.2.3), together with their foreign supporting organizations OLADE and GTZ, developed implementing activities on biogas in Nicaragua.
For that reason, they will be considered first in this analysis.

In 1986, after the successful implementation of a biogas plant in Matagalpa, the Regional Department of Engineering and Public Works (DRIFA) of MIDINRA, Region VI got interested in an implementation programme of biogas plants in Matagalpa-Jinotega region, in the Central North part of the country.
In chapter 8 more attention will be paid to this programme.

1.2.1 The INE-OLADE biogas programme (1982-'86)

This programme started in 1982 with a subsidy of the FAO to the Latin American Organization for Energy (OLADE) to develop biogas technology in a number of latin american countries.

The introduction of biogas technology was thought to be able to contribute to the solution of some national economic problems: The outputs of the biogas process (biogas and fertilizer) would replace imported oil-products and chemical fertilizers, while, at the same time, hardly any imported goods (equipment, materials) would be needed.
Macro-economic considerations were the main motives to introduce biogas in Nicaragua.

Other considerations to launch the programme were:
- The technology was thought to be sufficiently technically developed; Because of it's successful implementations in China and India, application in Latin America was thought to give little problems;
- Regional expertise on biogas technology seemed to be guaranteed in the form of inter-american research centers (such as ICIATI in Guatemala), that already had experience in the application of biogas technology;

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[7] See the list of abbreviations

- Nicaragua had rather suitable conditions for biogas application: There was enough prime matter (organic wastes), such as cattle dung, and agricultural wastes from the coffee and dairy industries. Furthermore, those activities caused environmental problems.
  Nicaragua, as a tropical country, has a good climate for application, and in general there is enough water to ensure a good performance of the fermentation process.

Aim of the programme was to select an optimal reactor design for biogas plants for the specific applications in the local situations.
At the same time, however, the installations were to serve demonstration ends, to promote a larger scale dissemination of the technology.

During 1982-'83 11 biogas plants were constructed, to ferment various organic materials.
They were located at various places all over the Pacific and Central Zone of Nicaragua, with the idea that in this way the technology would be used at the locations were it would be needed, and where the basic conditions were right for biogas applications.

The implemented plants were seen as pilot-plants, and were mostly located at state-owned farms, which were being developed at that time in Nicaragua.
The operation of the plants was supposed to be performed by the local people, who were to enjoy the use of the produced gas as well. Operation would be attended by the Office for Alternative Energy of INE, where a division of Biogas had started with some personnel and equipment.

In 1983 all constructed plants were out of work: Technical, environmental and social circumstances caused the plants, one by one, to cease functioning, and the fresh biogas-team from Managua was insufficiently equipped to overcome all plant break-downs. It was clear now, that the technology was not as ready for demonstration as had been supposed, that the physical capacity and the local experience of INE was insufficient , and that the decentralized implementation of the technology was a considerable handicap to manage all biogas plants.
In chapter 6 a detailed analysis of the INE programme will be presented.

During the following years participation, and in some cases even the cooperation and toleration of the beneficiaries stopped.
The Managuan biogas team tried to repair and re-activate the plants for 4 years. Occasionly some experiments were performed with the installations, but none of them ever really functioned for a substantial period (say, more than a year).
In 1986 the year budget of the biogas team, which up to that point was financed by INE, was refused by the National Investment Fund (FNI). In june 1986 the office was closed.

1.2.2 The CITA-INRA programme (1980-1984)

The Nicaraguan Research Center for Appropriate Technology (CITA), as a part of the National Institute of Land Reform (INRA), also started it's activities in cooperation with the Latin American Organization for Energy Development (OLADE).

CITA-INRA concerned itself with the development of appropriate technologies, with the objective to overcome Nicaraguas economic foreign dependency. For that purpose they had the disposition of a research center at Santa Cruz (Esteli), where various forms of appropriate technology were tested, in the field of rural energy production and utilization, agriculture, sanitation and water supply.
Biogas technology would fit in the scope of their activities.

CITA-INRA wanted to experiment with biogas-technology in on-site situations, such as agricultural cooperatives. Aim was to come to a diffusion of the technique in a smaller scale than the INE-programme.

In the period before the cooperation with the German programme, CITA-INRA built installations in 4 locations of which two can be described as experimental.

In 1984 all of these built installations were out of use, albeit that two of them were experimental installations.

In november 1982 the programme started a cooperation with the German Institute for Technical Cooperation (GTZ). See for a description of this programme § 1.2.4.

In november 1984 MIDINRA is decides to stop the programme, and to replace the German biogas team to the National Pig Firm ENPRA, who already had shown her interests in biogas technology with the construction of the only still functioning biogas plant built outside the framework of the GTZ programme.

1.2.3 The ENPRA - programme (1982 -)

The Empresa Nacional de Porcinas de la Reforma Agraria (the national pig farming enterprise of the institute of land reform) is the only biogas extension programme which still exists at this moment in Nicaragua.

ENPRA's activities in the field of biogas began with the personal initiative of one of the employees to construct a biogas plant for the provision of fuel for the kitchen of one of the farms. The plant was loaded with a very small fraction of the waste streams which were produced in the 5000 pigs counting farm.
This activity turned out to be very successful: In those days the Mauricio Duarte plant was the first really good functioning plant in Nicaragua, and still it is a plant which belongs to the most productive ones.

ENPRA is pressed more and more to take care of her waste streams: The pig farms produce a huge amount of organic waste which in many cases molests the surrounding population for its smell and water pollution.

When the biogas project in CITA-INRA was stopped, ENPRA invited GTZ to continue their activities within her organization, with the objective to come to solutions of their environmental problems. These solutions should be combined with biogas technology. One of the main targets was the education of ENPRA staff to continue the activities after the Germans had gone.

1.2.4 The GTZ biogas programme (1982-1985)

The german biogas programme started in Nicaragua in november 1982 in the Nicaraguan Research Center for Appropriate Technology CITA-INRA.

This programme started with a team of two german (agricultural engineers) and two nicaraguan (one chemical engineer and an engineer/project leader)technicians, and aimed at the construction of:

- small biogas plants for families and (small) cooperatives;
- bigger installations for (agricultural) schools, and major (cattle, pig and chicken) farms, as well as state farms, major cooperatives and private enterprises.

Their activities can be divided into the following phases:

1. Inventory and evaluation of the biogas plants that already existed on the moment of project take off;
2. Planning and construction of demonstration plants at agricultural schools;
3. Planning and construction of family plants, official education programmes, research on the quality of bio- fertilizer;
4. After transferring to ENPRA: Planning, design and construction of biogas plants on a small and a larger scale, especially for the waste-treatment of the ENPRA farms.

All built installations are of the same type of design: The "BORDA" design is a modificated China-type digester, that is known for its simplicity, little requirements for construction and operation, and also for a somewhat smaller gas-production per cubic meter in comparison with other, more "advanced" designs (see annex 1).
Use is made of only three different types of prime matter, i.e dung of cows, pigs and chickens. These organic materials are well known for their gas-producing qualities, and need little further technical investigation when introduced in new surroundings: The process parameters of the digestion of these materials are well known.
Futhermore it should be remarked that the programme has limited itself to a small number of regions. It was not tried to come to a widespread diffusion of the technology, but to concentrate at Rivas and Managua region.

The german support of the project lasted until 31st of december 1985. For a mixture of political and operational reasons the biogas interference of the Germans was suspended by the Bonn-(CDU/CSU) government.

1.3 Scope of the report

During almost one year I had the opportunity to work within the Regional office of the Nicaraguan Ministry of Agricultural Development and Land Reform in Matagalpa.
One of the by-products of my presence in this organization was the induction of a biogas programme for the Matagalpa Region, financed by the non-governmental development organization NOVIB.
During the completion of the project proposals, I was surprised by the abundant presence of Nicaraguan and foreign organizations, aiming to introduce biogas technology in the agrarian setting.
Also the problems of introduction of this technology struck me:
Of 14 biogas plants constructed before 1983, only one installation functioned well in 1986!
Trying to avoid the (inevitable?) competition between the different institutions, I tried to learn form their successes and failures with the introduction of biogas in the difficult present situation of Nicaragua.
I was so lucky to have excellent relations with as well the German- Nicaraguan GTZ-ENPRA project, and the INE office of alternative energy sources.

In this report I will describe the state of the art of Biogas technology in Nicaragua: After a global introduction in biogas technology (chapter 2) I will analyze the conditions under which biogas technology may be useful in Nicaragua. Therefore a description will be made of the actual situation in this central-american country (chapter 3). In chapter 4 a social-economic analysis is presented regarding the application of biogas technology in this country.

In the chapters 5-7 a detailed analysis is made of two terminated biogas extension programmes in Nicaragua: The INE and the GTZ programmes (chapters 6 and 7, respectively). In chapter 5 an analytical framework is derived, which is used in these analyses.

In chapter 8 the major conclusions of the former chapters will be summarized and synthesized to an overview, while recommendations will be derived for the proposed biogas extension programme of MIDINRA in Matagalpa.

Chapter 2: Biogas technology - Technical aspects

contents:

2.1 Principles and use of biogas technology

Biogas technology is based on a rather simple principle: anaerobic digestion. Anaerobic digestion is the biological breakdown of organic matter by living organisms (bacteria) in the absence of oxygen. A liquid organic fertilizer, carbon dioxide and flammable methane gas are the primary products of the digestion of organic waste by anaerobic bacteria. A natural place for this bacteria activity would be a swamp.

Composting can be seen as the opposite of biogas technology: It is based on aerobic digestion. Aerobic digestion involves the breakdown of organic matter by organisms that live in the same oxygen rich environments as we do. Compost fertilizer and carbon dioxide are the main products of aerobic digestion.
Fig. 2.1 charts these two processes for decomposition.

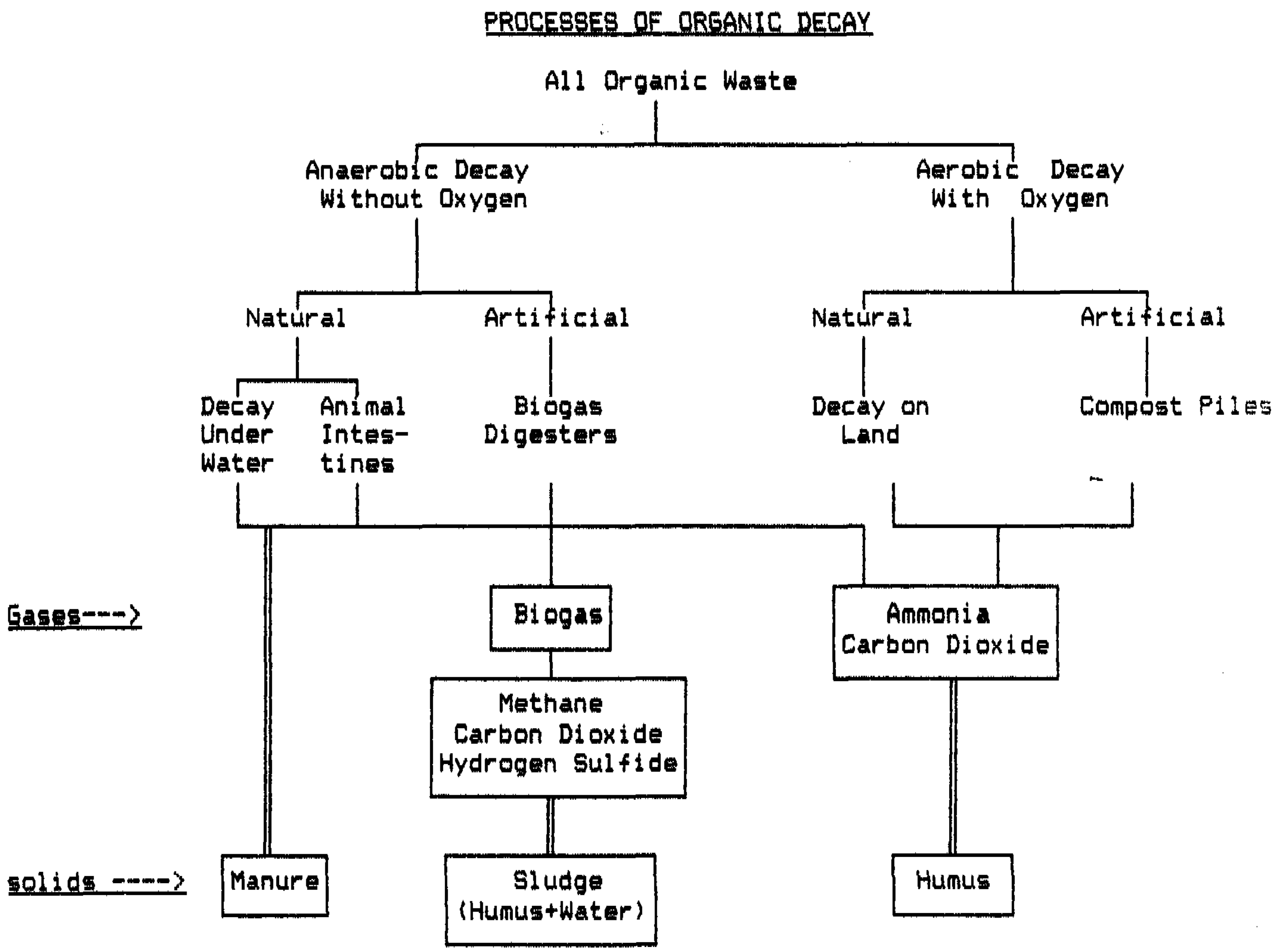

fig. 2.1: Aerobic and anaerobic digestion
source: M. Arnott, 1985

Biogas technology is a bio-technology in which the anaerobic digestion takes place in a controlled way, purposing the production of biogas and the bio-fertilizer.
The anaerobic digestion of biogas systems takes place in airless metal, concrete or brick tanks which can be built under or above-ground.
Manure + water only, or mixed with other organic wastes, are placed in a digester and are permitted to digest. The biogas which is produced during the process will rise to the top and is collected in a separate gasholder, or in the digester itself for use as fuel for cooking, lighting, refrigeration or providing power for small engines.

A biogas system may be a two or three cubic meter digester with built-in gas storage tank and simple stove burner. A biogas system may also be one or more 50-150 cubic meter digester with slurry mixing basin, settling, aging and fish ponds, stationary engine, heat exchanger, electric generator, two or more gas storage tanks, and several auxiliary pieces of equipment.
Fig. 2.2 depicts the basic determinants for the design and capacity of a system.

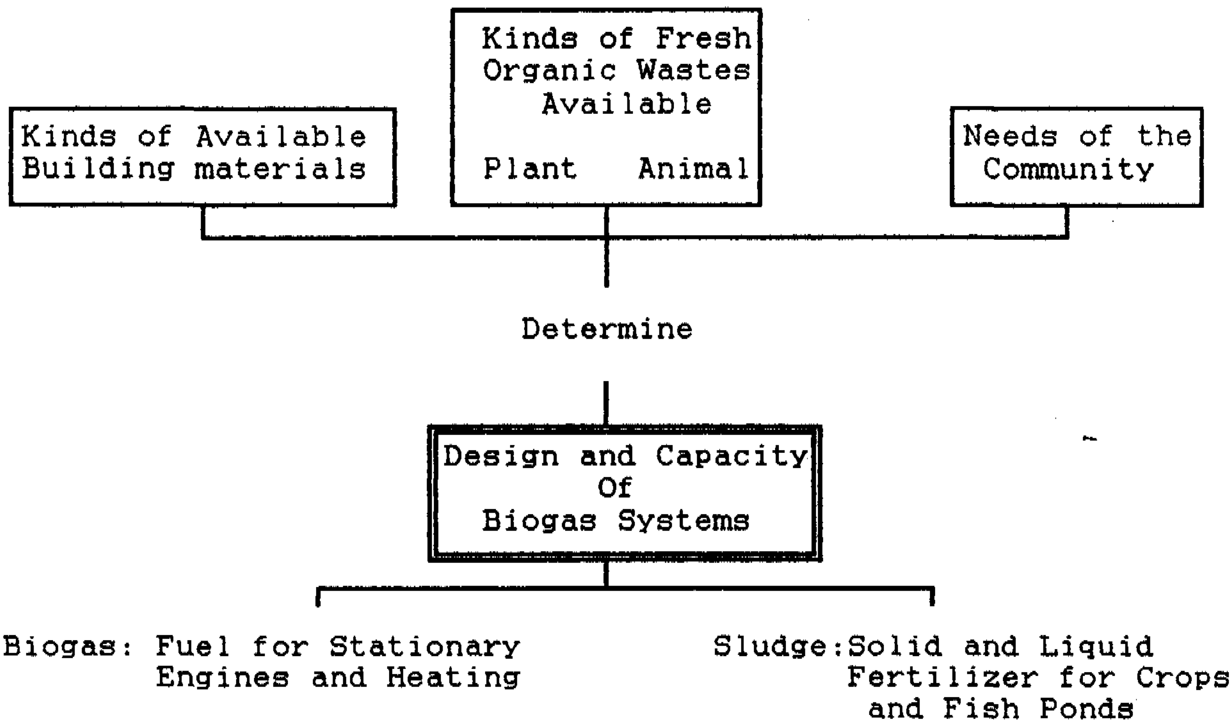

fig. 2.2: The design of biogas systems: Inputs and outputs
source: M. Arnott,, 1985

The tank may have any of a number of designs, of which ssome are known for their low technical and material requiirements, while others are real "high-tech" systems, in which for example all kinds of process control systems are inevitable.

What are the primary purposes for building biogas systems?

1. The humus in the organic fertilizer gives nutrients to and conserves the topsoil. Topsoil, the medium in which plants grow, should be seen as a natural resource which is "mined" by farmers. Chemical fertilizers contribute to the increasing worldwide problem of topsoil erosion. The nutrient value of digester sludge, while harder to quantify than chemical fertilizer, is a high quality fertilizer for crops and fish ponds.

2. Methane (which is 60 to 70% of biogas) is the primary ingredient in natural gas, which is a piped gas used to fuel stoves, water heaters, homes, etc. In rural agricultural areas where bottled gas, gasoline and diesel fuel is expensive, biogas is ideally suited for use in automotive-size stationary engines for the production of mechanical and electrical power.

From this it can be concluded that biogas technology primarily can be useful in the following situations:[1]

1. There exists a recognized lack of organic fertilizer: Farmers are aware of problems of topsoil erosion and see biogas technology as a solution to their problem.
   Mainly in Asia this point of view is shared: Farmers in India, China and other countries have a long tradition of intensive agriculture, and are aware of the value of good organic fertilizers;
2. There exists a recognized lack of energy sources: In many third-world countries rising populations and increasing topsoil erosion cause a severe shortage of firewood.
   This shortage can be felt so intensively that it can be called a real crisis: The "firewood crisis" causes huge problems in (especially) rural areas of many 3rd world countries. Many people belonging to the rural (or urban) poor require an ever increasing part of their income and/or time to obtain the minimum amount of fuel necessary for basic activities such as cooking;
   In many rural areas of developing countries biogas can serve as a lighting fuel: Biogas lamps have been developed that provide lighting in places which public electricity hasn't heard of yet;
   Also in rural areas the provision of conventional, oil-based fuels often causes many problems: If it is there, it is very expensive. In such situations, biogas-technology may provide an alternative as a fuel for stationary engines, such as pumps, straw-cutters, coffee-dryers, etc.

Possible positive side-effects of biogas technology are fourfold:

* Improved sanitation: The organic wastes that are processed in the systems would otherwise be breeding grounds for disease-causing or transmitting bacteria, parasites and insects;
* Improved ecological situation: The application of bio-fertilizer and the saving of firewood may lead to a diminishing topsoil erosion and deforestation;

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[1] M. Arnott, 1985

* Improved household economy: Saving on commercial firewood and chemical fertilizers, as well as saving time on firewood collection, may have a positive economic impact on the beneficiaries household;
* Improved national economy: Indirectly, biogas technology may have a positive impact on the national economy by saving foreign currency on chemical fertilizers, conservative energy sources and medicines, while also the preservation of ecology forms a potential saving on the national economy's bill.

2.2 Biogas systems

In fig. 2.3 a general biogas system is shown, within which the following sub-systems can be distinguished:

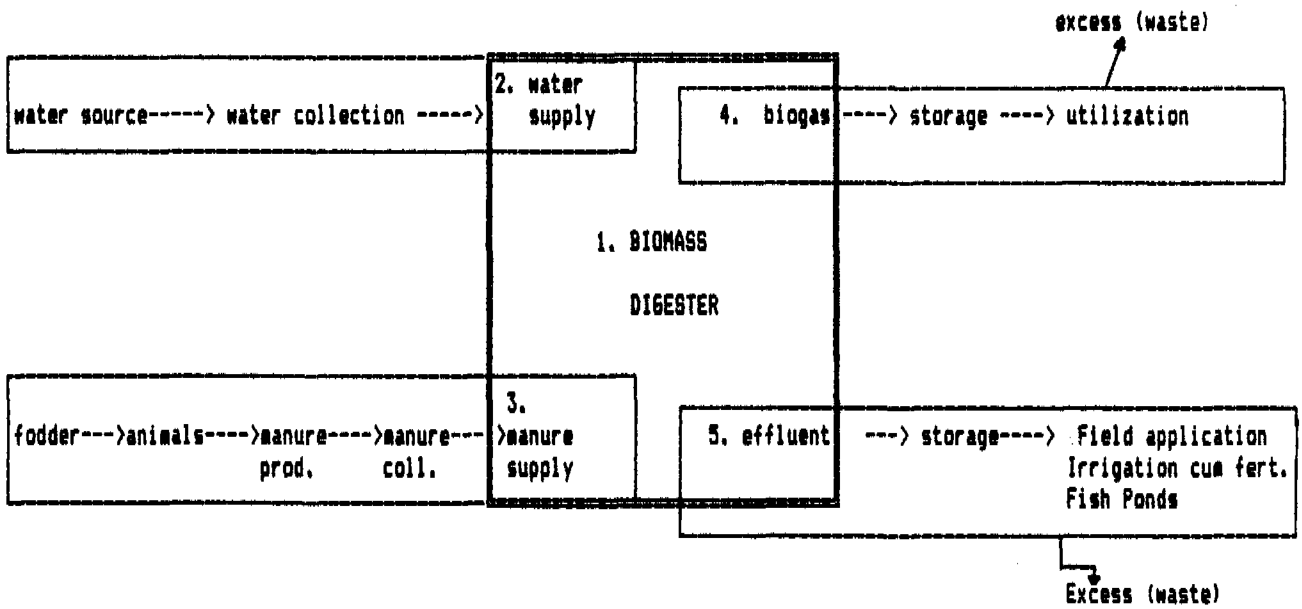


fig. 2.3: Schematic overview of a dung digesting biogas system
source: E.Kijne (1983)

In the part to come tthe various sub-systems will be discussed:

2.2.1 The biomass digester

All biomass digesters principally are baased on the same concept: It is a tank which contains a certain amount of organic material during a certain periood of time, needed to produce enough biogas or to kill parasites to a sufficient extent.
Under tropical conditionns (average temperature > 25 °C) the mean residence time of biomass in a digester lies between 15 and 60 days, depending on temperature and composition of primary matter (reactor feed).

In this period the natural processes of anaerobic digestion occur "automatically". The only task of an operator is to take care of daily in- and outflow of a flow

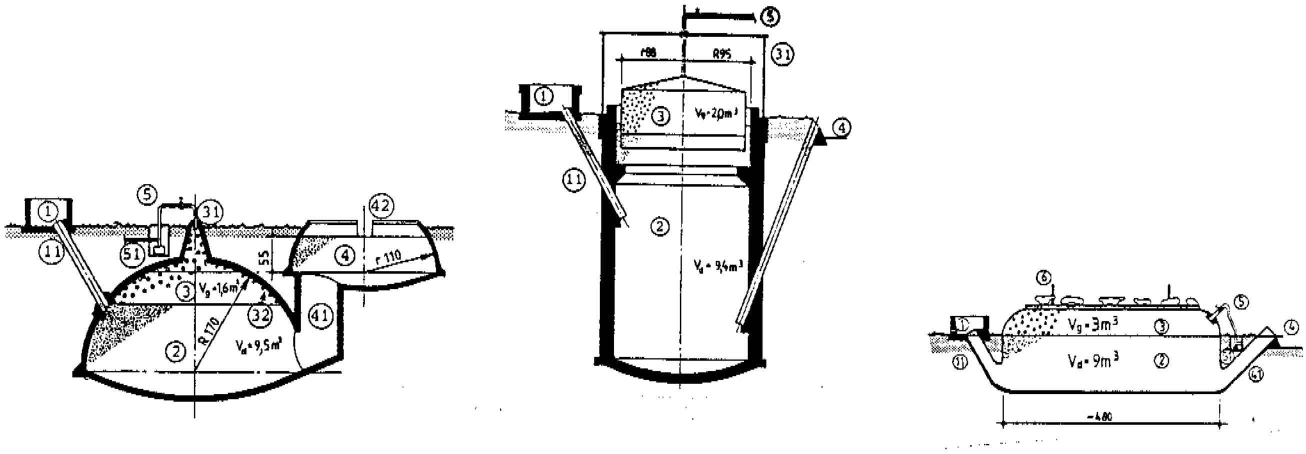
$$Q = V_R/R \ m^3/d, \text{ with}$$

V_R = Reactor Volume (m^3), and
R = Mean Residence time (days)

Up to now, hundreds of different designs have been made to come to an optimal gas-production in biogas tanks. For application in rural areas of developing countries, three main types can be distinguished:

* The Chinese fixed-dome digester
* The Indian floating gasholder digester
* The plug-flow digester (see fig. 2.4).

These different digester types are discussed in annex 1.



(a) fixed dome (b) floating gasholder (c) plug flow

fig. 2.4: Digester designs

2.2.2 Water supply

A very important, but often overlooked constraint for the installation of a biogas plant is the need of sufficient, relatively clean water throughout the year.
The organic matter which is to be loaded into the digester in most cases has to be diluted to a dry matter content of 10%, i.e: 2- 2.5 times.

The "Las Piedrecitas" plant in Matagalpa, for example, has problems since in the dry season not enough water can be supplied to clean the stables and fill the digester. At the moment of planning the digester this problem hardly could be forseen; In the two dry seasons that have been so far, the situation got worse very fast.

Of the ± 20 biogas plants that are out of function in Nicaragua, 4-5 are short of water during at least part of the year.
Start-up of the anaerobic digestion process takes much time: Only after ± 4* the theoretical retention time (≅ 60 days) the digester will be started up. For that reason, and for reasons of economic feasibility, a yearly 3-5 month stop for lack of water cannot be afforded.

2.2.3 Organic matter supply

The raw materials of biogas digestion are organic plant- and animal-matter. This organic material can be animal manure, crop waste, weeds from lakes and rivers as well as from land, or the organic waste from restaurants, kitchens, market places, slaughter houses or agro-industrial factories.

In Nicaragua coffee pulp wastes, banana leaves, urine and manure of people, pigs, cattle and chicken, as well as wastes of cheese factories, slaughterhouses and coffee waste waters were the applied prime materials.

The organization of filling a digester with water and organic matter appears to be a very important issue: The daily work needed to keep a digester going should be restricted to a minimum; If not, people will consider a biogas plant as a time- and labor consuming thing, that isn't worth the trouble.

For example: 3 installations have been built to digest coffee pulp. In "Los Alpes"-Matagalpa- the digesters were situated higher than the pulp storage. A consequence was that, every 4 weeks, 6 m^3 of pulp had to be lifted into the reactor, and mixed with cow dung and chopped banana leaves (that had to be brought from elsewhere).
Together with the fact that very little gas was produced, the people of the farm never used it. Only if people of the Biogas Office in Managua came down to Matagalpa, they would tolerate them, and sometimes even help them to load the tank. But they didn't believe in the project at all.

8 Animal-dung digesting plants have problems, or do not function, because of problems with the supply of organic matter: The installations of La Borgoña, El Tamagas, Marcell Pallais Checa (Tipitapa) (all INE's), UCA and Los Laureles (CITA-INRA), ITESPAP, and San Jacinto and Buenos Aires (GTZ) all had problems with the supply of reactor feed.[2]

Two reactors were built at farms, intending to use the dung of neighboring farms, or collecting it on the land. In practice, the installations seldomly functioned (Buenos Aires, San Jacinto). At the "Buenos Aires" farm, the cow dung should be collected from the fields. Although the woman really wants to use the gas for cooking, her husband doesn't care to fill the plant. The woman can't, since nicaraguan women traditionally do not work in agriculture.[3]

2.2.4 The use of biogas

As has been stated before: Biogas is a fuel which can be used to replace conservative energy sources such as dung cakes, fire wood, gasoline, diesel and (for lighting) even electricity, in most of their applications.
For that purpose, many user facilities have been developed as conventional marketed products, but also as a design for self-production. Especially in Asia many of the gas-stoves and lamps are home-made, in many cases of all kind of domestic waste materials.
In Nicaragua the market for biogas user products is rather limited. For that reason it is quite difficult to purchase stoves, lamps, and engine adaptions. ENPRA, however, does provide stoves and lamps to her clients.

The use of biogas is economically not the most interesting part of a biogas system: Various cost-benefit analyses have shown that a good use of the dung will yield more than the savings of firewood brought about with the use of biogas.[4]
Still, often the primary reason for the user to build a plant is the production of the <u>fuel</u>. Reasons for this will be discussed in chapter 4.

In this section, the main applications of biogas will be discussed:
1. Biogas as a cooking fuel;
2. Biogas for lighting;
3. Biogas as an engine fuel.

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[2] N. Bobulesco and G. Ortolano, 1986
[3] M. Rothweiler, 1985
[4] See Moulik, 1982, or chapter 4 of this work

ad 1: Biogas for cooking

Motives for the development of biogas digesters are mainly based on their ability to supply a source of energy which can replace the various cooking fuels which are generally used in rural households in developing countries: firewood, dung cakes, kerosene and butane gas. Firewood is the fuel which is almost uniquely used in rural Nicaragua.

Biogas is a smokeless and safe cooking fuel which allows instant and easy use for cooking. It gives more comfort to the women. However, cooking on gas implies a considerable change in habits. Conventional fuels and stoves are mostly kept as a stand-by and used also for secondary purposes, such as room heating and insect expulsion, for which biogas is less appropriate.

In "Las Piedrecitas", for example, the cook always kept a wood-fire, possibly for 3 main reasons:

1. The wood-fire could heat faster;
2. The smoke expelled the mosquitos, scorpions and other insects;
3. It had been her habit always to keep the fire burning for more than 25 years.

Since the provision of firewood was no problem (every month a truck from the state-enterprise, responsible for the farm, brought 2 m^3 of firewood) she never really stopped using it.

Cooking stoves were provided by the german project (which had the disposition of a small workshop with a good outfit), or directly bought in a shop in Managua. The letter were meant for professional use of bottles butane gas (restaurants), and therefore expensive, but could easily be adapted for the use of biogas.
It also was possible to have them constructed by local craftsmen.

ad 2: Biogas for lighting

Biogas can be used for lighting purposes, at remote places which are not supplied by the public electricity system.
Lamps were available in Nicaragua (again: Only in Managua), although rather expensive. For that reason the GTZ-project purchased them in Brazil.
It should be possible, however, to have them made by a local craftsman (as is practice in India and Indonesia).
Biogas light is of a rather poor quality and radiates a substantial amount of heat which is not always appreciated.

ad 3: Biogas and stationary engines

Any internal combustion engine, except a two-stroke, can be adapted to run on biogas.
Methane makes an excellent fuel for internal combustion engines, because it has a high energetic value and it is a very clean fuel.
Conditions for using biogas for this purpose are:

* There should be a constant and abundant supply of biogas, of a constant gas pressure;
* The engine should be adapted to the use of methane as a fuel;
* Using diesel engines, biogas never can replace the complete fuel demand: Diesel savings up to 80% can be achieved. Gasoline engines can be run for a 100% on biogas.

In Nicaragua, biogas as an engine fuel was only applied for demonstration ends, and by ENPRA (where the german biogas project was located), at the "El Repliege" farm in Ticuantepe. Here, the german project had donated a 36kW electric generator, to supply the water pumps of the pig-farm.
However, the over-production of biogas (± 50-70% of the total amount of gas) was wasted, since no agreement could be reached with the (competiting and electricity monopolist) INE. The huge installation (2*136 m^3 digester volume) had been built before reaching agreement on delivering electricity to the public system.

2.2.5 The use of bio-fertilizer

From an economic point of view the fertilizer is often the most important product of a biogas system. On the other hand, it's value, especially in Nicaragua, is very much under-estimated.

The modern method of agriculture usually compares fertilizers by using their chemical analysis, particularly their relative amounts of nutrient elements: N,P and K (Nitrogen, Phosphorus and K-Potassium). This is because of the large quantities of these three elements in plants, in comparison to the quantities of other elements.

In chemical terms, the dried solid sludge from digesters is a poor fertilizer. But when used in the large volumes that digesters produce sludge in, the whole sludge, liquid plus solid, is a good to excellent fertilizer in terms of chemical analysis. The difference lies in the fact that most of the fertilizer is in the form of ammonia nitrogen, which will rapidly evaporate or wash away when the solid portion is dried.

It has been proven that the nitrogen in the waste which goes into a digester remains in the sludge that comes out to a greater degree than it does with composted waste. In NPK terms, the biogas process produces a better fertilizer than the compost process does.Basically the whole NPK value of the original plant and animal waste remains and is usable by the growing crops. Studies claimed that biogas sludge has three times more nitrogen than the fertilizer produced by the best compost process.[5]

The main difference between organic (digester sludge, compost) and chemical fertilizers is humus. Humus is rich organic matter which, in addition to having value as a fertilizer, helps soil together, reducing the damage that can be caused by top-soil erosion.

In Nicaragua, the case of bio-fertilizers is a difficult one: Of the biogas plants I visited, only one or two used the produced fertilizer. In most cases, it was simply wasted.
Two main reasons can be assigned for this:

1. Chemical fertilizers are too cheap for the farmers. The world market price being about $20.= per 50 kg, prices in Nicaragua were between $1 and $2! Together with the "modern look" quality of chemical fertilizers, bio-fertilizer was no more of interest to the farmers.
2. There is no tradition of using organic wastes for humus or fertilizer; Only in the coffee sector, plant residues (coffee pulp) are used for fertilization purposes.

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[5] e.g Parikh, 1976

2.3 User systems and the biogas market in Nicaragua

Three different user systems for biogas applications can be distinguished, based on scale of operation and user ends:
1. Family plants
2. Community plants
3. Industrial plants.

2.3.1 Family plants

Speaking about biogas in India or China, almost always the <u>family plants</u> are referred to: Digesters of 3-6 m^3 of volume, providing enough biogas to cook the meals of 4-9 persons.

Motives for a farmer to build a biogas plant for his family may be:[6]
a. financial: The farmer expects credit acquirements, savings on fuel and fertilizer, or extra crop sales;
b. comfort: Biogas as a fuel for cooking provides comfort for the women cooking the meals;
c. health: Biogas will lead to a more hygienical situation in the kitchen, especially in comparison with the situation in which firewood is used. Around the stables and/or compost piles insects get less chance to breed, and parasites in the compost are better eliminated;
d. labor/time: In cases where fuel was not purchased (firewood!) the introduction of biogas leads to a considerable saving of time, collecting firewood. But also in chopping firewood time is saved.
e. Status: Having a biogas installation in a rural situation will provide a farmer status in the group, and provide more contact with the outside world (many visitors come to watch the plant).

The main use of biogas in the family situation is cooking and (to a lesser extent) lighting.

It is the most de-centralized form of biogas-implementation. As a market in Nicaragua it seems to be quite interesting, referring to the fact that 7 out of 14 built GTZ plants were family plants.

The most important problems which appear with family-size installations can be summarized as follows:
* <u>Socio-cultural problems</u>:
  The biogas plant has to fit in the agricultural situation where it is implemented, and the plant has to be accepted. Cooking on biogas does imply many changes in cooking habits and using bio-fertilizer does require a different approach to agriculture. In many situations these problems can be solved by good educational and training programmes, and through the farmers participation in planning and construction of the digester.

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[6] See also: E. Kijne, 1983

* Socio-economic problems:
  Various studies have shown that, at least in India and China, benefit-cost ratios of small scale biogas plants might be quite low, sometimes even below 1. Financial supports from the government are used to make the use of biogas more attractive. Especially financing can be a problem for less well-to-do farmers: Since investment in biogas plants may be substantial, and the plants only pay back over a number of years, credits and financial supports are often needed to achieve implementation.

2.3.2 Community plants

Community plants are biogas systems from which the benefits should come to an entire community.
Examples are biogas plants
* as a common energy source for two neighbors;
* for the members of an agricultural co-operation with a common stock of cattle;
* for a coffee farm, to prepare the meals of the coffee pickers.

Essential is, that the gas is used for the same, simple purposes as with family plants: The gas is used for domestic purposes (cooking, lighting), while the fertilizer is used for the (common?) crops.

Basically, two distribution systems for the produced gas can be distinguished:
1. Centralized use in common kitchens, schools, community or workers' houses;
2. Decentralized use, in which case the gas has to be piped to the different individual users.

In Nicaragua the central policy of land reform encourages the formation of agricultural cooperatives. Especially in those where cattle or other husbandry is present, biogas plants will form an attractive energy source.
As a matter of fact, 17 out of 29 plants, present in Nicaragua, are community plants. In the majority of the cases, they are built at state farms, where the workers get food (1-3 times a day) in central kitchens. In these kitchens, the gas is used to replace firewood.

Problems which are encountered with the introduction of community plants are somewhat different then with family plants:
* Since community plants are of larger volume than family plants (10-60m^3), the cost-benefit ratio will be more favorable (see chapter 4);
* In Nicaragua it is quite easy to get favorable bank-loans on productive investments for cooperatives and bigger enterprises. In this way, biogas plants can reach poorer groups, which is not very likely in case of the small family plants (because of high initial investment);
* The main problems with community plants have social and organizational grounds: Who operates and maintains the plant, and how will the products (gas and fertilizer) be used and/or divided over the community.

In the case of community plants for state enterprises with centralized kitchens, the problem of organization calls: The workers are hardly motivated to do the daily loading of the tank, since the state enterprise or the farm owner gets the economic profits out of the plants.

* Technical and social problems will be encountered in case of de-centralized use of the fuel: Dividing gas over more houses will give problems of a vulnerable piping system, but also other problems of distribution: If the production of gas is not abundant, some people (read: The last users on the pipe) will always be short of pressure and gas. This will give rise to frictions within the community.
  In general, centralized use of the gas can be recommended.

In the community "La Borgoña" the use of a biogas plant (build in 1981) still has been postponed since disagreement exists about who will have to operate the plant. It appears that working with dung has a very low social status in Nicaragua, and simply nobody wants to do it.[7]

2.3.3 Industrial plants

Industrial plants are biogas systems at big farms or agro- industries, that do not use the produced gas in the first place for the community's domestic use, but for some other, productive end. Examples are the following biogas applications:

* The production of biogas in an anaerobic wastewater treatment plant, used for treating coffee wastewaters. The produced gas is used for drying coffee.
* The production of biogas from the waste of bigger pig farms: The produced gas is used to run a water pump, for heating piglets and as an energy source for the aerator, used to purify the effluent from the biogas installation.

Motives to build an industrial biogas plant may differ from the reasons to build family- or community plants:

* In general, the economic profit of using biogas will be the most important factor: At a larger scale, biogas plants can be profitable from the users point of view;
* Another very important motive for applying biogas system in an industrial context is as a sanitary system. When producing on a larger scale the waste flows will become more harmful to environment and public health, so that pressure inclines to diminish contamination.
  In these cases, biogas technologies are an attractive treatment alternative for being a cheap treatment system and an energy supplier in one;
* In Nicaragua quite another reason to invest in biogas exists: Many industries and farms have a lot of cash money in national currency. Since one needs foreign currency to buy investment goods like tractors and tools, and foreign currencies are very hard to get, and since inflation is high (in 1985: 350%) interest exists to invest in a biogas plant, independent of the question whether its investment will be earned back. For richer farmers there is almost no alternative investment that can be bought in Cordobas, so it surely is worth trying!!

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[7] N. Bobulesco and G. Ortolano, 1986

* A forth reason to build a biogas plant for industrial application can be the insurance against irregular supply of fuels (firewood, oil-derived fuels) or fertilizer. With a biogas plant one is more self-dependent on these issues.

In Asia and in the most industrialized countries the industrial application of biogas is almost a common good. In Nicaragua, however, the national pig farm ENPRA has been the first and only (so far!) to use biogas for industrial purposes.

Since a few years the directory board of ENPRA is pressed to diminish the pollution her farms produce: Most of the farms are situated near populated areas, and no real treatment of the produced wastes exists.
The waste threatenes the drinking water supplies and the population washes cloths downstream her drains. It is told that some persons died for diseases and infections caused by the contaminations.
The problem is, that there is almost no expertise in the country on waste treatment.
When the CITA-INRA biogas project closed down at the end of 1984, ENPRA asked GTZ to continue their project within ENPRA, to get experience.

In coffee production the draining of large quantities of heavily contaminated wastewaters are a big problem; Around Matagalpa the drinking water supply is annually contaminated during the coffee harvest; In Carazo (near Managua) the same problem occurred.
In Matagalpa an investigation was started to treat the wastewaters with anaerobic treatment processes. For Carazo this investigation came to late: In 1985 the production units were closed.

Problems to be encountered in these kind of biogas applications are:

1. Technical problems:
   Problems of upscaling and more technified use of the biogas as a fuel (electricity generation, engine drive, industrial heating) will require more expertise to design and inform the user;
2. Education:
   Since every user will have to put a specified person responsible for the biogas installation, organizational problems may be fewer. However, the responsible for the installation will have to be better prepared for his job, and must at least be a technician who knows enough about the system and its application to be able to perform daily operation and maintenance, as well as casual trouble shooting.
3. Expectations:
   People who install biogas plants for their industrial application often have high expectations of it. Especially in a developing country, biogas is considered as a "high tech" and is believed to solve a variety of problems.
   It will not always be easy to convince the user of biogas' limitations.

In the ENPRA farm "El Repliege" a 36 kW electric generator (initial investment: DM 40,000.-)was installed, to supply the water pumps of the pig farm, and to deliver electricity to the public system. The installation of the generator was completed in the first months of 1986, when the official german cooperation to the project already had ended. One biogas expert of the project stayed longer, (beyond the official project, to accompany the installation and train the responsible technician. Within 6 months after the expert had gone, the generator broke down. There were no local craftsmen to repair the machine, and up to now it is not certain whether the installation will ever run again.

Chapter 3: The environment - Nicaragua

In this chapter a general overview is given of the environment in which the biogas extension programmes operate. In order to comprehend the analyses of the chapters 4, 6 and 7 it is necessary to introduce the reader to the contemporary political and economic situation of the country and, more especifically, of the agricultural sector.

3.1 Nicaragua - general introduction

geography

Nicaragua is the biggest of the central american republics, with an area of 148.000 km². She shares her borders with Honduras (north) and Costa Rica (south), and is separated from El Salvador by the small Gulf of Fonseca.

fig. 3.1: Nicaragua in Central America

As the other central-american countries Nicaragua can be divided, by relief, into three parts: (i) the Central Mountain Area (the Cordillera), which forms the watershed between (ii) the gradually declining area towards the Caribbean Coast, and (iii) the rough Pacific Coast.

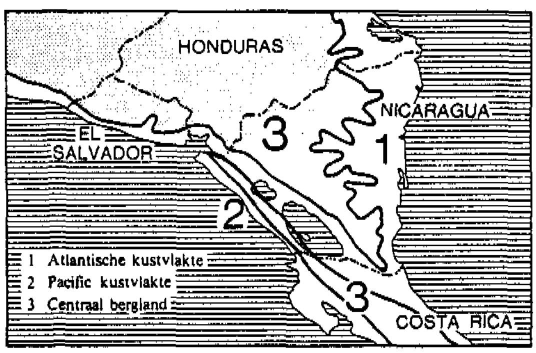

fig. 3.2: Natural regions

Approximately 90% of the nicaraguan population lives in the pacific lowlands. This is due to the fertile soils originating from about twenty volcanos, forming part of the well known volcanic area of Central America.
Climate is tropical, sub-humid with a dry period (from january to half of may).

In this area many agricultural crops are cultivated, such as cotton, bananas, rice, sugar, maize and beans.

The pacific area has often been hit by eruptions of volcanos and by earthquakes of which the latest, in 1972, destroyed the inner-city of Managua.

The west-side of the Central Area is still relatively densely populated with small farmers and, where temperature and rainfall permit, the growing of tobacco and coffee. Other parts of the highland are mainly used for extensive cattle breeding.

The atlantic zone (or caribbean), which accounts for 50% of the total nicaraguan area, is covered with tropical humid woods and swamps. Climate is humid with rains during the whole year.
Besides a few small harbors (Puerto Cabezas, Bluefields) it is a very empty country with little economic activity.
The caribbean lowland is mostly in a virgin state. Indian tribes, such as the Miskitos, have lived here since ages, practicing their "slash-and-burn" agriculture.
Next to this wood and some mines have been exploited. Bananas and sugar are cultivated in the areas round the harbors.

population

In 1983 Nicaragua had about 3 million inhabitants, which makes it, compared to other central american countries, a very sparsely populated country.

Department	total population	pop./km²
Chinandega	228.573	48
León	248.704	47
Esteli	110.076	51
Madriz	72.408	45
Nueva Segovia	97.765	27
Jinotega	127.159	13
Zelaya	202.462	3
Matagalpa	220.548	32
Boaco	88.662	21
Managua	819.679	243
Masaya	149.015	216
Carazo	109.450	100
Granada	113.102	114
Rivas	108.913	50
Rio San Juan	29.001	4
Chontales	98.462	16
Nicaragua	2.823.979	23

fig. 3.3: Population and density by department in 1981
source: INEC, Anuario estadistico 1981

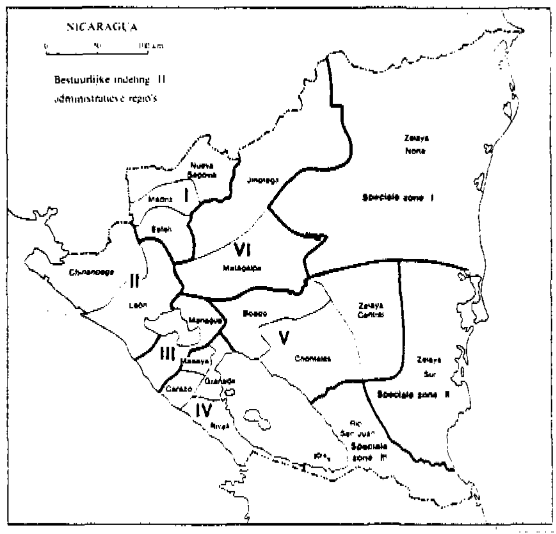

fig. 3.4: Division of Nicaragua in departments

Nicaragua has experienced some major internal migrations of her population:

* In the spanish colonial era many indians fled to the atlantic coast, to escape from the miserable circumstances at the cattle haciendas;
* With the rise of the coffee culture, at the end of the 19th century, workers moved from the pacific coast to the mountains. At the same time the economic main point moved from León to the new capital Managua (1852);
* From 1950 an increasing competition for ground (with on the background the conflicting interests of the subsistence food cultures and the production of export crops) caused many people to move to the cities. Especially Managua grows very fast (± 5% in 1984, with 3.3% the national mean population growth) and is one of the major problems for the contemporary government of Nicaragua.

Population * 1.000	1950	1963	1971	1979	1985
Managua	163	235	399	653	875
other cities	206	393	497	751	998
Total urban	369	628	896	1.404	1.873
Total rural	688	908	982	1.285	1.399
Total Nicaragua	1.057	1.536	1.878	2.689	3.272

fig. 3.5: Division of urban and rural population
source: INEC

Most concerning aspects of this urban migration are the decreasing productive sector in the rural area, and with it, the increasing informal sector in the cities:

Working population (* 1.000)	1980	1985	change (%)
- in agriculture	380	412	8 %
- not in agriculture	493	635	29 %
* formal sector	255	240	- 8 %
* informal sector	238	395	69 %
total	873	1.047	20 %

fig. 3.6: Composition of the working population since 1980
source: INEC

The nicaraguan population will further increase in the near future. Central America always had high birth rates, but until far in the 20th century they were compensated by the high mortality rates. Since the improvement of public health care these mortality rates decline, and the population grows with more than 3% per year, which is among the highest in the world.

The population pyramid shows a very young population: In 1984 47% of the people was younger than 15 years.

Especially in the first three years after the revolution government has exerted herself to improve the very poor social situation of the nicaraguan people. Most authors agree that the sandinist government succeeded in this intention:

- In the litracy campaign of 1980-'81 illitracy diminished from over 50% (in 1978) to about 13% in 1984. Next to this major effert on education were exerted through the extension of free education for all children, and initiation of an adultary education programme.
- Other improvements in the social situation were carried through in public health care: Vaccination campaigns, preventive health care, free medicines and free medical consults have diminished the occurance of various diceases considerably. See also fig. 3.7.

selected social indicators

	1978	1984
illiteracy	50	13
education expenses (mln. C$)	341	1.484
education expenses (% of GNP)	1.32	5.01
number of children in nursery schools	9.000	70.000
scholars/students	501.680	1.127.428
participation in adult education	0	194.800
teachers	12.706	53.398
people under protection of social ensurance	460.000[1]	930.000[2]
public health budget (mln. C$)	373	1.528[2]
doctors	1.309[1]	2.087[2]
clinics	177[1]	463[2]
hospitals	40	46[4]
medical consultations	2.400.000[1]	6.500.000[2]
vaccinations	923.000[1]	3.304.000[2]
cases of - polio	101[3]	0[2]
- malaria	18.418[3]	12.907[2]
measles inciden ion /100.000	36	3.4[2]
child mortality (per 1000 births)	121	71

[1]1977; [2]1983; [3]1979;

fig. 3.7: Social indicators.
source: J. Collins, 1985; J. Ph. Poley 1986

3.2 History and development

3.2.1 History up to 1979

Nicaraguan history is a long, tragic history of interventions.

Since 1502, when Columbus first set foot on the coast of what is now the republic of Nicaragua, it had to suffer from spanish domination as a colony (until 1821), english occupation of the atlantic coast (1840-1898) and numerous american interventions, whether political or military.

Since the military intervention by the north-american hireling William Walker, in 1855, the government of the United States has applied the so called "Monroe doctrine".

The United States declared themselves as the "defender of the latin-american republics against the european colonial powers", and in 1823 president Monroe presented this doctrine to the north-american congress. This Monroe-doctrine was based on the principles of both isolationalism and 'Pan-Americanism': The United States would not intervene in European affairs and the European countries would no longer oppress the latin-american republics which were recognized by the government of the United States ('America for the americans').[1]

Soon it appeared that these principles of non-intervention in spanish america would not be applied by the United States themselves: Mexico lost half of her territory to the States, namely the contemporary states of California, New Mexico, Arizona, Nevada, Utah and a part of Colorado.[2]

In the course of the 19th century, for example, Puerto Rico was colonized by the United States, while Cuba was brought under north-american military 'protection', which gave the right of military intervention "whenever life, property or individual freedom were in danger".[3]

In 1903 president Theodore Roosevelt expressed in his annual speech to the congress the so called 'Roosevelt Corollary', which was an updated version of the Monroe doctrine: According to Roosevelt the civilized nations had the right to intervene in countries where misgovernment and lack of order prevailed, and the United States were to apply this right on the western hemisphere.[4]

After a series of political interventions[5], the US intervened militarily in 1909 and 1912. Main issue are the politics of the liberal dictator Santos Zelaya, who refused the north-americans the right to dig a canal through Nicaragua (the later Panama canal).

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[1] George Pendle, 1963, p. 110-115
[2] Pendle, p. 130; A.L. Constandse, 1963, p. 197-198
[3] K. Liedtke, 1983, p. 81
[4] Pendle, p. 177
[5] For an overview: See e.g. T. van Toor, 1983

The american army stayed, apart from an interruption between 1925-'26, from 1912 to 1933.

In this year they were dislodged by the army of general Augusto César Sandino, consisting of poor farmers, tenants and workers. Sandino signed an armistice with the new president, who was appointed by the Americans.

One of their last actions in Nicaragua was the formation of the National Guard, leaded by Anastasio Somoza Debayle, who murdered Sandino during a peace conference with the new president, and cruelly persecuted the members of his movement.[6]

In 1936 Somoza had fortified his position to such an extent that he managed to be elected for president of Nicaragua, and to start a Somozist dynasty, which lasted three generations, until 1979. During this period Nicaragua developed as americas most reliable ally in Central America. Nicaragua was one of the leaders of the intervention of an army of hirelings, which intervened in 1954 in Guatemala to terminate the progressive government of Jacobo Arbenz. Arbenz had tried to entore a land reform act on the property of the United Fruit Company.[7]

In 1979 the dictator Anastasio Somoza II was defeated, in a civil war, by the army of the Sandinist Liberation Front (FSLN). This victory had been made possible through the support of the nicaraguan middle-class, which had started in 1978 after the murder on the chief-editor of the liberal paper "La Prensa". Under pressure of the OAS and after the american refusal for more help to Somoza the latter fled from the country on july 19th 1979. The National Guard surrendered.

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[6] J. Ph. Poley, 1986, p. 19
[7] van Toor, 1984, p. 8

3.2.2 Political and economic development since 1979

On july 20th 1979 the Junta de Gobierno de Reconstrucción Nacional was installed in Managua. The Junta existed of representatives of the FSLN (Daniel Ortega), and of various civil organizations, such as the COSEP (the organization of private entrepreneurs) and of the formal opposition parties under Somoza.
Common starting points of government policy were:

* striving after political plurality;
* development of a mixed economy, and
* an international non-allied policy.

Next to this the State-council was installed, in which the FSLN did have a majority (50% + 1 of the votes). In the State-council political parties, unions and other social organizations were represented. The FSLN had a practical majority in this council (50% of the seats + 1).
Local government was delegated to the Juntas Municipales de Reconstrucción (JMR). At first their task was the coordination of the emergency aid and the reconstruction in the most literary form.
Gradually the practice of local government got more important.

In november 1984 general elections were organized to choose a president, a vice-president and a constitutional board. The FSLN won these elections with a 63% of the votes.

Soon it appeared that the process of reconstruction was more laborious than it was imagined shortly after the revolution.

- The strongly growing collective sector and the increase of purchasing-power of majorities of the society could not be maintained.
- The fulfillment of basic needs (in food, public health and education) was partly at the expense of the former privileged classes, which started to leave the country on an increasing scale.
- During the revolution, already, much capital was destroyed or withdrawn from the country. The level of investment in the private sector decreased to about zero. This made the realization of the so called 'mixed economy' more and more difficult.
- The production at the state enterprises, established at the former properties of the Somoza family, was too low to compensated for the losses.

The pressure the sandinist government had to cope with was augmented by the critical and, since Reagan's presidency (1981), hostile attitude of the United States. Bilateral aid was adjourned and the US used their influence in the World Bank and the IMF to prevent financial support to Nicaragua.
Western Europe continued to support, while increasing help came from the socialist countries, especially Cuba and the Soviet Union (see fig. 3.8).

In 1982 the US for the first time spent 19 million US dollars to support the so called 'contra-revolucionarios', or 'contras', who terrorize the country in the northern and western part. Since 1980 more than 4,000 nicaraguans have been killed in the

(internal) struggle with the contras, and the economic damage is dramatic (see fig. 3.8).
This, apart from the continuous threat of invasion and mobilization, which paralyses most productive activities.

	exports f.o.b. 1977	1980	1981	1982	1983	1984[a]	imports c.i.f. 1977	1980	1981	1982	1983	1984[a]
Central America[b]	21,0	16,7	14,0	12,8	7,7	8,6	21,6	33,9	21,1	15,1	15,1	9,3
ALADI[c]	2,7	0,0	2,2	3,4	2,1	-	14,8	20,3	26,0	27,3	23,1	-
EEC	28,4	28,7	19,5	23,4	25,9	31,1	12,6	7,9	11,4	14,0	9,5	13,1
USA	22,8	36,0	25,8	21,9	18,2	10,1	28,9	27,5	26,2	18,9	19,2	15,1
Japan	11,0	2,9	11,2	11,1	15,4	26,4	10,1	3,3	2,8	2,4	2,3	2,9
Canada	0,5	6,2	5,1	4,4	1,4	2,9	0,8	1,3	2,4	1,7	2,4	3,7
COMECON[d]	0,9	1,8	7,3	7,4	12,8	5,5	0,3	0,2	3,3	11,5	16,4	26,1
others	12,9	7,8	15,0	15,3	16,6	-	11,2	5,6	6,7	9,1	12,0	-
Total	100,2	100,1	100,1	99,7	100,1	84,6	100,3	100,0	99,9	100,0	100,0	70,2

[a] provisional data; estimated on period january-september
[b] Costa Rica, El Salvador, Honduras and Guatemala
[c] Argentina, Brasilia and other lat-am.cntr.
[d] a.o: Soviet Union, GDR, Bulgaria.

fig. 3.8: Structure of foreign trade, in per cent, 1977-1984
Source: ECLA, 1985

	1980	1981	1982	1983	1984	total
Material losses and loss of capital goods	0,5	3,9	10,8	57,5	24,4	97,1
losses in production	0,9	3,4	22,7	104,7	169,3	301,0
total	1,4	7,3	33,5	162,2	193,7	398,1

fig. 3.9: Direct costs of the military aggression against Nicaragua (1980-'84) (mln US$)
Compare to fig. 3.9.

Six years after the sandinist insurrection, in 1985, the foreign debts of Nicaragua have risen to over 4 billion dollars, the deficit on the government's budget to about a quarter of the GNP, and inflation to about 350% (in 1986: 650%).

The following reasons have been given:[9]
* The worldwide economic crisis, which strikes the underdeveloped countries much harder than the industrialized world;
* Nicaragua is confronted with a worsening of its terms of trade: prices of coffee, cotton and sugar (nicaraguas traditional export products) have fallen in the last few years, while prices of the industrial import products keep rising (e.g: in 1973 Nicaragua bought with 1 bag of sugar 10 barrels of oil; In 1985 5 bags of sugar must be paid for 1 barrel!). A consequence was that the export volume (in US $)

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[9] G. Dijkstra and A. Laenen, 1986

declined considerably (see fig. 3.11), whereas the production of export crops remained constant, or increased (fig. 14).

* Since the revolution, Nicaragua is re-structuring her economy. The sandinists want to change two characteristics of the old economic structure: the economic dependence of the industrialized world, and the huge internal social-economic disparity. This process requires important changes in the social and institutional structures, and causes tension between the ruling and the possessing classes.
  The most serious consequences of the tensed situation are a huge capital flight from the country, decreasing private investments and emigration of a substantial part of the middle- and upper-class population;
* But probably the most important cause of the poor economic situation is the economic and military war which Nicaragua is in with the USA. Comparing the data of table 3.9 and 3.10 offers an insight in the meaning of the losses, caused by the military aggression for nicaraguan economy. (Note that only direct economic losses are counted. Also the blockage of international loans should be counted. Total 200 million US$ over 1980-'84).[9]

	1978	1979	1980	1981	1982	1983	1984	1985[a]	1986[a]
GNP (Mln. US$)	1155	850	935	984	973	1018	1004	978	978
GNP/cap. ($)	442	316	337	344	329	333	316		
growth GNP (%)	-7,8	-26,4	10,0	5,3	-1,2	4,7	-1,4	-2.6	0.0
growth GNP/cap (%)	-10,7	-28,4	6,7	2,0	-4,4	1,2	-4,7		

fig. 3.10: Nicaragua's Gross National Product (GNP) (1978-'86) (1970 dollars)
(a) source: Plan económico 1987 other source: CEPAL, 1985

Fig 3.11 shows the developments in the balance of payments over the same period. Unofficial figures for 1986 show imports for 888 million, and exports for 218 million dollars. This gap is closed by monetary financing, resulting in a screaming inflation (600% in 1986).[10]

	1978	1979	1980	1981	1982	1983	1984[a]	1986[b]
Exports fob	720	672	495	553	447	463	428	218
Imports fob	658	511	909	1037	829	933	902	888
balance	62	161	-14	-484	-382	-470	-474	-670
current account	-34	90	-491	-563	-514	-528	-517	
foreign debts	961	1136	1588	2200	2730	3324	3918	
interest/exports (%)	14,3	8,9	16,2	30,9	37,8	17,9	27,8	

(a) unofficial data (b) source: Plan económico, 1987 others: source: CEPAL, 1985

fig. 3.11: Development in de national balance of payment (1978-'84) (mln. US$)

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[9] G. Dijkstra, p. 57

[10] Plan económico 1987

Fig. 3.12 and 3.13 summarize the most important sources of foreign exchange in the country, and the way this is spent.

	1973	1978	1980	1981	1982
1. Exports of goods and services, of which:	59.5	70.9	44.9	42.6	42.1
a: Agricultural sector	62.4	67.9	65.6	72.5	73.8
b: Others	37.6	32.1	34.4	27.5	26.2
2. Donations	9.7	0.9	6.9	4.2	3.9
3. Loans and credits	26.6	9.3	31.1	52.8	53.7
4. Others	4.2	18.9	17.1	0.4	0.3
Total	100.0	100.0	100.0	100.0	100.0

fig. 3.12: Sources of foreign exchange
source: Barricada, 5 september 1983

	1973	1978	1980	1981	1982
1. Imports of goods of which:	55.0	50.5	68.2	67.8	65.0
a: consumer goods					
durable goods		24.9	24.2		14.7
non-durable		8.4	4.9		7.6
b: resources					
petrol and derivations		15.0	19.6		22.6
agricultural resources		6.2	7.0		4.4
industrial resources		30.5	28.0		23.6
construction resources		4.3	3.3		5.9
other resources		-	0.6		0.1
c: capital goods					
agriculture		2.1	2.7		3.7
industry		12.7	6.9		11.2
transport		4.3	2.8		4.2
2. Imports of services	16.7	14.4	9.0	8.4	7.7
3. Payment of debts	18.5	35.1	22.8	13.4	27.2
4. Others	9.8			11.4	0.1
total	100.0	100.0	100.0	100.0	100.0

fig. 3.13: Use of foreign exchange (1973-1982)
source: Barricada, 5 september 1983

At a national level Nicaraguan economy can be characterized, above all , by scarcity.
In spite of the good results in producing subsistence crops, e.g, the Nicaraguan citizen experiences a constant scarcity of basic food products. This is mainly caused by the wage- and price-policy the sandinist government has developed since 1979: This policy aimed at the fullfilment of basic needs for all classes of the population, and on levelling wages and salaries. Priority in this policy were the rural areas, where people obtained, for the first time in their lifes, regularly products such as sugar, oil and soap.
Because of the low prices, which did not keep pace with the rising inflation, demand for these basic products rised considerably, (especially in the cities) with as a consequence: The development of a black market.

Figs. 3.14 and 3.15 show the development in consumption and prices of basic food products in Nicaragua, until 1982.

product	unit	1972/75	1976/78	1980/82
maiz	lb	211	192	185
beans	lb	39	42	48
rice	lb	55	43	70
flour	lb	35	49	41
oil	lb	18	20	22
sugar	lb	86	104	97
eggs	*12	2,5	5,3	6,8
meat:- chicken	lb	2,8	4,9	9,5
- pig	lb	5,7	5,4	7,3
- beef	lb	23,3	32,4	21,4
milk	gal	4,4	5,1	5,8

fig. 3.14: development of consumption per capita..
source: Barricada, february 6th, 1984

	maiz (lb)	rice (lb)	beans (lb)	milk (lt)	sugar (lb)
official price	1.00	2.90	2.85	3.00	1.70
official price without subsidies	1.67	4.48	4.84	5.89	2.87
black market price	5.50	8.00	8.00	7.00	8.00

fig. 3.15: official prices and market prices
source: Barricada, january 9th, 1984

Black market did not only develop in food products. Many products are subsidized, e.gg. in the construction, textile and leather sector. Practically every product is scarce, and can be bought on the black market at a morefold of the official price.
In chapter 4, in social cost-benefit analysis, this will be highlighted for the prices of construction materials.

3.3 The agricultural sector

As is illustrated by the data of fig. 3.12 the agricultural sector is very important to Nicaraguas economy: It produces about 75% of total export products, of which the most important are coffee, cotton, sugar, meat, bananas and sesame.

Biogas technology operates mainly in the agricultural and agro-industrial sector. In this paragraph more information is given on the structure of the nicaraguan agricultural sector, and more especifically to the changes that occurred since the 1979 revolution.

3.3.1 Agriculture before 1979

Traditionally, agriculture in Nicaragua was directed at the cultivation of substistence crops. The traditional farer in Nicaragua is a small farmer, growing his "basic grains" (rice, maize, beans and sorghum).
Since the second half of the 19th century an export oriented sector is being developed, in hands of relatively few big farmers. This sector had had a semi-feudal structure, in which large numbers of poverished, landless and rightless workers lived and worked, with their families, on the property of a few landowners.[11]

Already at the end of the 19th century coffee was cultivated in a large scale. This product remained the most important export crop until 1945.
After 1950, when cotton prices rose very fast on the world market, the cotton area increased, within five years, from 20.000 to 170.000 manzanas.[12]
This extension was not achieved at the expense of the coffee area, since it was mainly concentrated in the northern pacific region. The small farmers in this zone, who cultivated food-crops and breeded cattle, were driven away from their land with economic or violent means. The deprived farmers migrated, for a substantial part, to the less suitable grounds of the east mountain area, or the west atlantic zone, the so called "frontera agricola".[13] Another part migrated to the urban areas.
In the sixties the production of export crops was more diversified after the price of cotton had fallen. Especially the production of sugar cane, and later of tobacco, increased fast. Cattle breeding was stimulated through the rapidly rising demand for meat on the world market.
Government policy was almost exclusively directed at the modern agro-export sector, and the maintenance of a labor-reserve for the production in this sector. She restricted the possibilities

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[11] Van der Heyde calls the strategy of development of the agricultural sector a "repressive agro-export model" (Van der Heyde, 1985)

[12] 1 manzana = 0.70 ha

[13] FIDA, 1980, p.15

for small farmers to occupy new land, by cutting the credit possibilities.[14]
Next to this the prices of foodcrops were kept low, so that the small farmer did not have the possibility to extend his production.[15]
The agricultural area was under-utilized: Only 5.4% of the totally available land was permanently cultivated in 1975. 43% of the total area was used as pasture. See also fig. 3.16.

Area (x 1000 manzanas)	1975	%	Potential	%
agricultural area	906,5	5,4	4.016,0	23,9
pasture	6.638,0	39,5	7.220,5	42,9
forests	8.168,0	48,6	2.538,8	15,1
others	1.055,9	6,3	2.995,3	17,8
total	16.768,4	99,8	16.770,6	99,7

fig. 3.16: Contemporary and potential land-use (1975)
source: IFAD

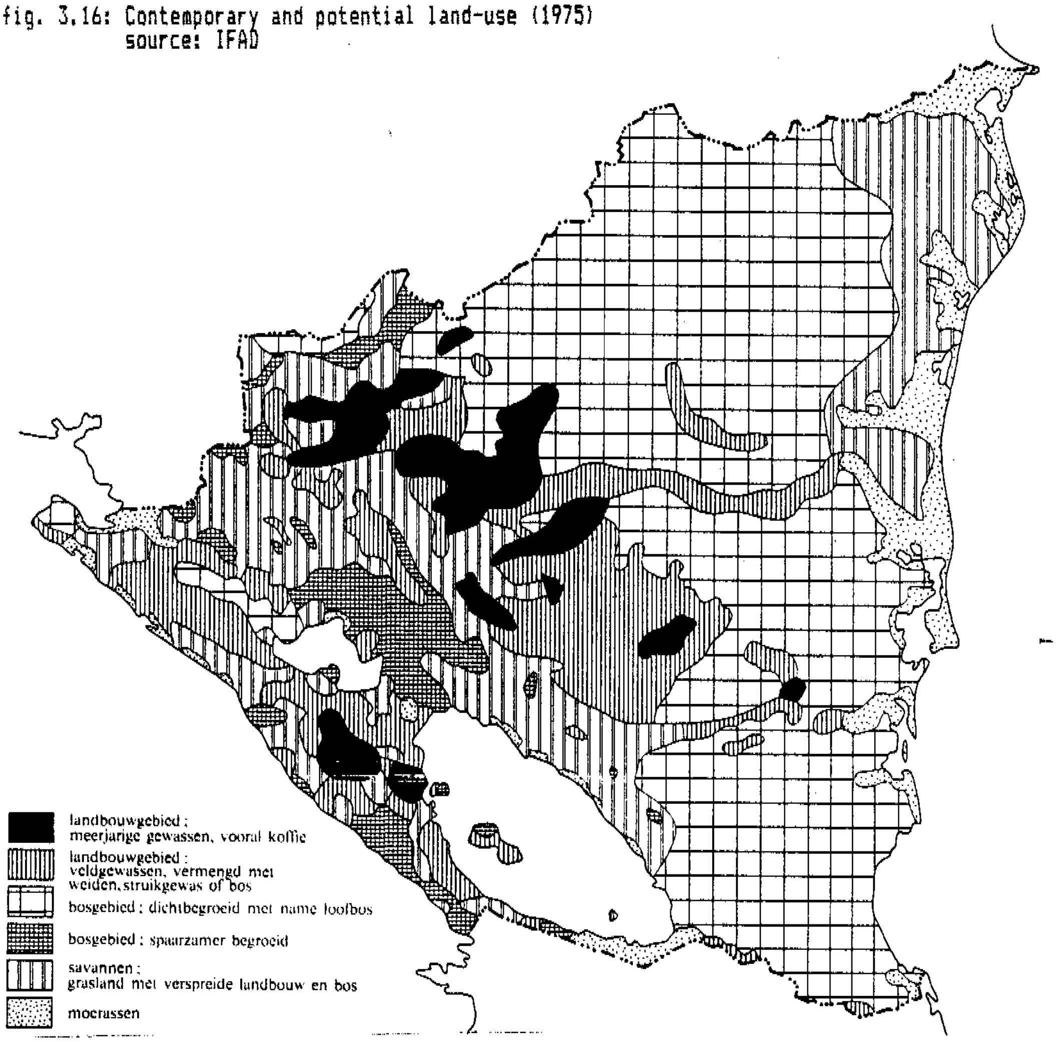

fig. 3.17: Land-use and vegetation. Source: J. Ph. Poley

14 Westrienen, 1983, p. 72
15 Blokland, 1982, p. 101

The produced economic surplus was controlled by a small number of Nicaraguan families, the Somoza-clan and some multinational companies. The Somoza-clan controlled the financial system, foreign trade, state and an important part of the production sector.

3.3.2 Agrarian reforms since 1979

After the 1979 revolution a programme of agrarian reforms was initiated, which aimed at the transformation of the production sector, in such a way that it would be possible to satisfy the basic needs of the people (work, income, consumption), especially at the target groups of the revolutionary process (small farmers and the agrarian and industrial working class).[16]

The programme of reformations contains two main lines:

1. The economic transformation, containing changes in the sectoral composition of the production. This point signifies a re-definition of the production structure of the country: Which products are to be produced for the internal, and which for the foreign markets.
   A very important issue in this connection is the improvement of the (foreign) exchange relations.
2. The agrarian reformation, containing changes in the distribution of land, in the policy towards credits and information, and the formation of an important sector of co-operatives and state enterprises.

More in general the reformation programme aims at initiation of a process of rural development, directed at a better utilization of human and natural resources. This development should benefit the national masses.

In fig. 3.13 is shown to which results the first objective, the economic transformation, has lead: The production of basic food crops has been more than doubled, while export crops remained constant. (The decreasing export volume of Nicaragua is mainly to be blamed on her worsening trade of exchange; see fig. 3.10.)

One of the most important instruments the government has to control the economic transformation is the programme of the agrarian reformation. The re-structuring of the division of land: The nicaraguan small farmer is traditionally a producer of food products.

Fig. 3.18 shows the development in the division of land since 1978.

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[16] ANICS, 1982

Product	A R E A			PRODUCTION			PRODUCTIVITY/ha		
	1977	81	84	1977	81	84	1977	81	84
Export									
cotton	100	94	57	100	52	83	100	119	145
coffee	100	116	115	100	111	120	100	95	105
sugar	100	112	124	100	112	126	100	100	102
sesame	100	238	233	100	159	190	100	67	82
tobacco									
Food									
rice	100	151	222	100	165	273	100	110	123
beans	100	143	149	100	135	159	100	87	106
maize	100	98	99	100	111	154	100	113	156
sorghum	100	101	152	100	191	387	100	191	255
Cattle									
cow-meat				100	66	83			
pig-meat				100	85	99			
milk				100	61	82			
poultry				100	137	241			
eggs				100	91	129			

fig. 3.18: Development of the agrarian production (1977-'84) (1977 = 100)
source: MIPLAN, Programa Económico 1984

	1978	1982	1983	1985
Individual producers	100	74	65	62
0-10 manzanas	2	3*	1	1
10-50 manzanas	16	13*	7	7
50-200 manzanas	30	30	30	30
200-500 manzanas	16	12	13	13
> 500 manzanas	36	16	14	11
Co-operative sector	-	2	15	19
CCS**	-	-*	10	10
CAS**	-	2	5	9
State-sector	-	24	20	19

* 1982: small farmers (0-50 mza) including CCS's
** for a description of the various co-operatives: See page 3.19

fig. 3.19: Development in land division (in % of total area)
source: R. Ruben, 1986

This re-allocation of land has taken place, since 1979, in what may be considered as three phases:[17]

1. the formation and consolidation of the state sector (1979-1983);
2. the development of the co-operative movement (1983-1985);
3. the allocation of land to individual farmers (1985-...).

The three sectors (state sector, co-operative movement and the private sector) have their specific characteristics and task-objectives. These will be discussed in the following paragraphs:

1. the agrarian state sector

The state enterprises (Empresas de la Reforma Agraria) (ERA's) were mainly founded by the law concerning the nationalization of the former Somozists properties of december 1980. Later this sector was extended with land which was expropriated according the law on the Land Reform of august 1981.
The most important reasons for the formation of state enterprises were:[18]

- To ensure the technological leading position of the farms;
- To ensure the production of export crops, at which those Somoza farms were specialized;
- To avoid the division, and ensure the advantage of the economy of scale of these farms.

The following types of ERA's can be distinguished:[19]

1. Agrarian enterprises (cotton, coffee, rice, sugar cane, cattle). These are large scale agrarian enterprises (average: 17500 ha), in joined, connected area, with a high degree of specialization in one production activity;
2. Agro-industrial enterprises: Sugar industries, coffee processing enterprises, slaughter-houses, dairy factories, cotton pitters, etc;
3. Service enterprises. These import and/or distribute equipment and other inputs, such as seeds and agro-chemicals, or supply services in the field of mechanization, artificial insemination, etc;
4. State projects, such as, e.g, husbandry projects, the sugar plan (construction of the sugar refinery TIMAL), and others. See fig. 3.21.

During the first three years of the agrarian reform (1979-1981) the productive role of the state sector was most important. The organization of the state enterprises, and the development of management and production systems were the most important tasks in this period.[20]

Most important problems in this period were in the field of production and labor relations. In production maintenance of the (capital-) efficiency and planning caused most problems. In the field of labor the state enterprises were confronted with a

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[17] redaction ENVIO, 1985
[18] Collins, 1982, 61-65
[19] Mayorga, 1982, pp 105-106
[20] Mayorga, 1982, p. 106

striking lack of workers, a declining productivity, and work-motivation problems.[21]

From 1983 on the role of the state sector is the support to the other, more productive sectors. The role of the state sector now is to improve the production circumstances of these producers by means of the provision of production means and services, with the aim to increase the productive capacity.[22]

The relative low efficiency and effectiveness in production of the ERA causes a decrease in the direct participation of the state sector in production. In 1984 a net reduction of the area for ERA was planned, and the number of state enterprises declined from 187 to 97.[23]

	Part in production (%)		Part in land area (%)		Index area productivity	
	Agr. exp.	Int. cons.	Agr. exp.	Int. cons.	Agr. exp.	Int. cons.
State sector	24,0	15,7	26	10	0,92	1,57
Large-scale private sector	37,3	14,7	40	10	0,93	1,47
Small and medium sized	32,7	35,6	14	41	2,34	0,87
co-operatives	6,0	34,0	20	39	0,30	0,87
total	100,0	100,0	100	100		

fig. 3.20: Area, production and productivity estimations per sector (1982), in export and internal consumption
source: Ruben and de Groot, p. 22

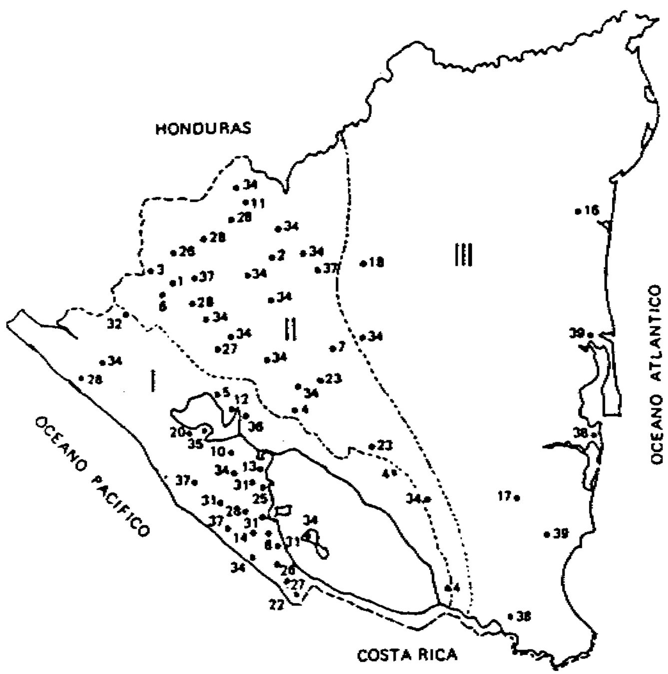
2. the co-operative movement

The co-operative movement, which was supported from 1979, was to meet the following objectives:[24]

a. The co-operative movement was to offer an organizational framework for small farmers as a class, avoiding domination by other sectors;
b. Creation of conditions for an effective use of modern technology;
c. Promotion of complete and permanent employment in rural areas, and to counteract urban migration;
d. She was to ensure the participation of the small farmers in management, and in the (military) defence of the farms;
e. Extension of the planned system and of the collective provisions in the rural areas.

[21] Ruben and de Groot, p. 16
[22] see, a.o, MIPLAN, Plan Económico 1987
[23] MIDINRA,1984, p. 23
[24] MIDINRA, 1982, 24-41

Mapa de Nicaragua con zonas agroecológicas



NICARAGUA

I Pacífico
II Norte Central
III Trópico Húmedo

• Ubicación de proyectos por zonas.

Proyectos inversionistas del Ministerio de Desarrollo Agropecuario y Reforma Agraria, MIDINRA: Ganaderos, agrícolas, agroindustriales y de reforma agraria

1. Desarrollo cooperativo rural integral Pueblo Nuevo.
2. Proyecto de tabaco Guaná-La Vigía.
3. Desarrollo rural integral del Valle San Luís.
4. Plan de inversiones EMARROZ.
5. Desarrollo arrocero EMARTASAL.
6. San Juan de Limay.
7. Proyecto lechero Muy Muy-Matiguás.
8. Proyecto de levadura a partir de melaza, Ingenio Benjamín Zeledón.
9. Desarrollo ganadero Asociación Nicaragua-Libia, ANILIB.
10. Proyecto agroindustrial para pasta de cacao.
11. Producción de alimentos, Valle de Jalapa.
12. Desarrollo rural integral San Ramón.
13. Proyecto arrocero Los Malacos.
14. Proyecto arrocero Ñocarime-El Dorado.
15. Semilla certificada de arroz.
16. Desarrollo rural integral Tasba Pri.
17. Proyecto de cacao Nueva Guinea.
18. Desarrollo rural integral Carlos Fonseca.
19. Desarrollo cooperativo de producción de alimentos.
20. Planta de sales minerales.
21. Banco de material genético para hatos de ganado Brahman puros.
22. Empresa comercial de hatos Gaspar García Laviana.
23. Desarrollo ganadero Boaco-Chontales.
24. Empresa para material genético Modesto Duarte.
25. Ampliación de Industria Frutera Gran Lago S.A., IFRUGALASA.
26. Planta desfibradora de henequén.
27. Producción agroindustrial de hortaliza Valle de Sébaco.
28. Producción de tabaco Burley Valle de Jalapa.
29. Matadero avícola Raúl González.
30. Ampliación de compañía agrícola Claudia Chamorro.
31. Producción de plátano criollo.
32. Proyecto de desarrollo integral Chinandega Norte, CHINORTE.
33. Fortalecimiento de la reforma agraria y desarrollo rural integral.
34. Desarrollo produccional de granos básicos en la reforma agraria.
35. Proyecto lechero Chiltepe.
36. Complejo industrial Tipitapa-Malacatoya, TIMAL.
37. Proyecto de renovación de cafetales.
38. Proyecto agroindustrial de palma aceitera africana.

The Law on the Agrarian Co-operatives of august 1981 mentions various possible forms of co-operative organizations. Most important of these are the Credit and Service Co-operatives (CCS), the Co-operative without Separation (CSM) and the Sandinist Agrarian Co-operatives (CAS). Of these forms the CAS works with collectivicated capital, work and land; In the CSM and CCS the individual farmers labor on their own land, more or less separated from the land of the other co-operative members.

In 1985 about 45% of the small producers (< 50 mza) was organized in co-operatives, producing 20 per cent of the GNP. The co-operatives especially produce beans (72% of total national production), maize (54%), sesame (44%) and coffee (25%).[25]

3. the private sector

The private sector consists of big and small farms;
- The large-scale private sector is especially active in production of export crops: 73% of the area is covered by these crops, of which cotton, sugar cane and coffee are the most important.
- The small and medium sized private farms produce coffee (export) and basic food crops (maize, beans, rice) (41% of total production), and have an important share in the production of cattle (47% of total production).

Fig. 3.20 shows that, in spite of the agrarian reformation, 54% of the land, and 70% of total production is still in private hands. It is not very likely that the collective sector will expand at the expense of the private sector:
On june 14th 1985 the minister of MIDINRA declared the complete northern part of the department of Masaya to a special zone for agrarian development and reformation. 5200 ha of land, most of which belonged to big private producers and state enterprises, were transferred to 1300 landless families.

This event started a more widespread re-allocation of land, from which especially former landless workers and marginal farmers benefited. Co-operatives and, above all, small and medium sized farms were formed.

At this moment the agrarian reformation is being developed along the following lines:
* Phasing out the state sector, where possible. The ERA get a task to support the co-operatives and small and medium producers;
* Another task for the state sector is the development of large-scaled projects with foreign financial and technological inputs;
* Promotion of co-operatives and small private farms, in order to improve the production of basic food crops;
* Insuring and promotion of the production of export crops, mainly produced by the private and state sector.

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[25] CIERA, 1984, p. 24

3.4 Conclusions: The importance of biogas for Nicaragua

Considering the contemporary political and economic situation in Nicaragua the products of biogas technology may serve the following purposes:

* A biogas extension programme puts emphasis on the agricultural sector. Promotion of this sector is one of the starting point of sandinist policy.
* One of the aspects of the agricultural policy of this moment is the promotion of milk production. Several milk projects are being developed in the country (Chiltepe, Heroes y martyres de Pancasan), in which a transformation is proposed from extensive cattle breeding to the more intensive milk husbandry (see fig. 3.21). Biogas technology links up to this development, offering a single technology for waste-treatment, energy source and fertilizer production, which fits well in this specific situation.
* If the produced biogas is used as a replacement for (imported) oil deratives, it helps to fight the enormous gap on the balance of payments (see fig. 11).
  Saving of chemical fertilizers will serve the same end. Chemical fertilizers are imported in Nicaragua, and therefore charge the balance of payment.
  See further the social cost-benefit analysis presented in chapter 4.
* Biogas extension programmes correspond to the emphasis government lays on social development: Biogas as a sanitary system may serve as a health promoting device in rural areas. Especially the occurrance of zo-onoses (diseases, translated via animals) and excreta-related diseases can be diminished.
* Next to this biogas technology may play a role in the solutio of various pollution problems in Nicaragua: Various agro-industries discharge their (mainly organic) wastes directly in surface waters, and, in doing so, contaminate the environment and sources of drinking water. Especially the coffee industry, dairy process-industry and cheeses factories should be mentioned in this respect.
  Biogas technology may offer a partial) solution in fighting these problems.
* On a micro-level biogas offers a possibility of investment to farmers constructed locally, with locally produced materials. These kinds of investments possibilities are scarce in Nicaragua.
  In the financial cost-benefit analysis of chapter 4 more attention will be paid to this aspect.

Chapter 4: Socio-economic analysis

contents:

Chapter 4: Socio-economic analysis

4.1 Introduction

Since financial and material resources often are very scarce in developing countries, economic aspects of biogas technology need to be examined closely.

The economic evaluation of biogas technology under specified conditions is a rather ambiguous, although necessary step:
Ambiguous, since the process of economic evaluation is generally quite difficult, since it involves the gaging of numerous parameters, the future development of which will be influenced by a multitude of imponderables.[1] This is illustrated by a large number of studies on the economic viability of biogas plants in India: The KVIC-biogas-extension programme has been economically evaluated by almost 20 authors, for at least the same number of different circumstances.
The calculated "pay back period" of small-scale biogas plants varied from 2 to ∞ years, depending on the valuation and approximation of technical and economic parameters, and the local setting (see § 4.2.2).
Furthermore there is the ever lasting discussion about the valuation of non-quantifyable side-effects of the introduction of biogas, such as health- and environmental effects.
In literature, discussions have lead to an obscure tangle of arguments on the smallest details of the evaluation, not seldom depending on the authors "believe" or conviction on the feasibility of biogas technology.

Nonetheless, such evaluation - often demanded by planners, politicians, etc. - can still serve as a very valuable tool in implementing biogas programmes, if it is regarded as a method to identify the conditions under which the application of the technology is (most) feasible.

In my opinion the efforts to come to an economic analysis of the application of biogas in Nicaragua are justified for the following reasons:

* Until this moment no such evaluation exists. Biogas extension programmes in Nicaragua have been executed without much notion of the economic consequences of the technology for the farmer, or for the economy as a whole.
  This could be justified when the programme still had an "investigative" character (such as INE's), but as soon as extension of the technology was a goal (ENPRA, GTZ, MIDINRA), there should at least be the possibility to inform the user of biogas about the economic consequences of his choice of energy technology, and compare them to other techniques that have the same user ends.

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[1] See, a.o, Andrew Barnett's study (A. Barnett, L. Pyle and S.K. Subramanian, 1978)

* At this moment, two programmes are at a point of a serious (re-)consideration: In INE the question is raised whether the biogas programme should be continued, and if so, to which topics should the programme put its attention.
  In MIDINRA interest is growing in biogas technology: One or two demonstration plants have caused high expectations, and the outlook of saving foreign currency through the application of biogas technology has attracted the attention of planners on central level. This has resulted in a proposal for a biogas extension programme in Region VI (Matagalpa-Jinotega), which is about to start;[2]
* The local economic situation makes a closer look necessary to the expenditure of resources: The economy is worsening very fast, caused by the shortage of foreign currency, and investment on "saving technologies" should be appraised to have (at least) a global idea of the possible and plausible effects of introduction and extension in this field.

For that reasons, the economic study of biogas technology in Nicaragua should give an insight in the following aspects:
1. Under which conditions can the application of biogas technology be economically feasible from the user's point of view?
2. Under which conditions can it be feasible from national economy's point of view?
3. How does the economic feasibility of biogas technology compare to alternatives, serving the same ends as biogas technology, as well from the user's, as from national economy's point of view?

The analysis may need refinement on some details. This mainly is a consequence of the lack of data on the costs and performance of biogas plants in Nicaragua.
This lack is caused by the limited number of functioning biogas plants, the limited period of experience with the plants, and the absence of the habit to regularly monitor the plants. Most data are the results of interviews with users, technicians of institutions, and data collected by myself, extended with data from evaluations performed in other countries, and approximations.
Where literature values are used a source will be mentioned.
The results may be of limited reliability, and should be used with reticence.

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[2] MIDINRA, 1986

4.2 Economic analysis of biogas projects: General considerations

4.2.1 Social and financial analysis

Economic cost-benefit analysis can be divided into two main techniques: Financial and social C-B analysis.[3]

Financial CBA conventionally identifies "the money profit accruing to the project-operating entity, whereas social CBA measures the effects of the project on the fundamental objectives of the whole economy.[4]
Financial CBA is based upon market prices, including taxes and subsidies, and can be applied at the household, firm, sectoral or national level, according to the purposes of the evaluation. It is a cash-flow analysis, that regards the expected or effectuated money flow over the total project life-time, and can as such be seen as an economic appraisal method analyzing the costs and benefits of a project from the user's point of view.

Social CBA is typically undertaken at the national level and uses shadow (or accounting) prices that reflect the true economic worth to the society of the in- and outputs of the project. In doing so, it may assign different weights to income generated by the project according to the consumption level of the income recipient.

Financial and social CBA of development projects can, again, be performed basically in two ways:

1. A comparison of the "with and without" situation usually takes place within the framework of the formal cost-benefit-analysis (CBA). Through this analysis relevant inputs and outputs are valued form the user's, or the society's point of view.
2. Andrew Barnett (1979) pleads an approach based on opportunity costs: The evaluation of the impact of an investment is, in principle, the comparison of the situation "with the investment" and the situation "with the next best alternative investment".
   In his analysis he proposes these alternatives need not necessarily be connected with energy or fertilizers - the outputs of a biogas plant. He states, that "the next best alternative investment is likely to be another investment in the village: such an investment might be in an irrigation pump, in land drainage, in paying' off previous debts, in buying new land, etc".[5]

Barnett's point of view, based on the concept of "economic costs", would lead to a most unpractical and almost impossible task for the investigator, who pretends to make a statement on the economic viability of the technology in a whole country, generalized for different social groups. Numerous alternatives would have to be

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[3] Roemer and Stern, 1975
[4] Squire and van der Tak, 1975, p. 16
[5] A. Barnett, 1979, p. 67

considered, appraised in detail, and (as far as possible) they would have to be compared with each other.

This analysis is a compromise between the two approaches:
A "with and without" financial and social CBA will be made, of biogas technology under Nicaraguan conditions.
In this analysis the biogas alternative will be compared with other possible investments that have the same output (energy and fertilizer).
This comparison will be realized in the **valuation** of biogas and bio-fertilizer as products of the biogas process.

4.2.2 The evaluation of biogas projects

The economic evaluation of biogas projects copes with some specific problems of valuing inputs, outputs and technical performance of a biogas plant.
Considering the biogas system (see chapter 2.2, fig. 3) the main inputs of a biogas system are manure, water and labor. Outputs are fuel (biogas) and the effluent fertilizer.
Besides this, the introduction of a biogas system may have some additional side-effects:

* health effects:
  As a biogas plant may function as a sanitary system it influences the occurrence of excreta-related diseases. Furthermore it may reduce the occurrence of zoonosis (infections that may be transmitted from animal to man and vice-versa).[6]
* environmental effects:
  As far as the produced biogas is used as a substitute for firewood (which is mostly the case in Nicaragua) its application will have a positive effect on the problem of deforestation. Using the biogas effluent as a fertilizer will act against top-soil erosion, since the land will be kept in better condition through the supply of organic matter.

The main problems of the economic evaluation of biogas technology are the valuation of inputs, outputs, technical parameters and additional effects.

<u>valuation of inputs</u>
Prices of key inputs are estimated differently by different authors. Cow dung, for example, can be valued in three ways:[7] At its cost of production, ie regarding dung as a (residual) output from a livestock enterprise; at its cost of purchase or collection or at its opportunity cost (its value in the best alternative use) as measured, e.g by the costs of replacing dung for cooking by some other fuel (in Asia) or by its value when being used as a fertilizer.
Similarly, the inclusion, or not, of the costs of land, labor (especially family labor), water and local raw materials costs has caused substantial differences between studies as to the apparent economics of the plant.

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[6] For an overview: See S. Cairncross and R. Feachem, 1983
[7] T.K. Moulik, 1982

valuation of outputs

Biogas is not traded, and therefore has no market price, hence it has to be valued according to equivalents which are traded.
Several fuels can be considered as alternatives, especially for cooking where firewood, charcoal, dung (Asia), other gases, electricity and kerosene have all been used.
This availability of alternative fuels gives considerable discretion to the analyst, since the investment in a plant can be made to show negative or positive returns, according to the assumption made.[8]

The same problem counts for the valuation of the effluent: This nitrogen-rich fertilizer may be valued as a chemical fertilizer (according to its nutrient composition), not regarding the value of organic matter contained by the slurry.[9]
A better way of valuing it, is the **marginal surplus** a farmer yields through the application of the effluent. But here the problem arises of lack of data: For every crop the marginal surplus would be different, and this approach would probably lead to a rather academic discussion.

technical parameters

Technical parameters have been given different values by different analysts for the same size and type of biogas unit using the same feedstock under the same operating conditions.
In the studies reviewed the most important points of discussion were: The relative nitrogen contents of composted dung and digested slurry, the gas production and methane contents of the gas. Other disputable points are the economic lifetime of the plant, and the end-use conversion efficiency of biogas in comparison with other fuels.
This problem is compounded by the fact that there are genuine differences in output associated with variables such as quality of feedstock, and temperature.

valuation of side-effects

The evaluation of positive environmental effects is a rather delicate matter in a social analysis. Estimations of forest degradation due to fuel wood dependence are difficult to make, especially when firewood consumption is not the only cause of deforestation.
The evaluation of health-effects may play a role in as well a financial as a social analysis. Studies in Asia have shown that, in cases where biogas technology is applied, considerable savings on the family medicine bill can be achieved, leading to savings of foreign currency for the economy as a whole (if the medicines come from abroad).
Again, lack of data (on the occurrence of diseases in specific rural areas, let alone the effects of the introduction of biogas technology to it) makes a useful incorporation of these effects in an economic evaluation almost impossible.

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[8] F. Blankenberg, 1983, p. 20-21
[9] T.K. Moulik and A.S. Prasad, 1983: 53-54

4.2.3 Structure of the economic analysis

The financial and social analysis presented in this chapter concerns the application of biogas plants for the fermentation of cow-dung in Nicaragua.
The analysis is limited to the BORDA type of biogas plants that has been successfully implemented in the Nicaraguan situation: The GTZ/ENPRA project has introduced 18 installations of this type so far, of which 90% is functioning more or less satisfactory (see also chapter 6).

Two alternative designs will be evaluated: One of the fixed-dome type (the produced gas is stored in the upper part of the fermentation tank) and a dome type with a separate gas storage, of the floating metal gas-holder type (see fig. 2.4).

The evaluation will consider 5 sizes of plants, i.e. of 5, 10, 15, 20 and 30 m^3 of fermentation volume (excl. gas storage). The 5-10 m^3 tank represent the family scale installation, whereas the 15-30 m^3 tanks represent the community and industrial scale plants.

The designs are based on the assumption of 30 days average residence time, and 10% dry matter contents. Dung production is assumed to be 12.5 kg dung.$(cow.day)^{-1}$, 22.5% dry matter contents.

In general the produced gas (0.4 $m^3.m^3_{dig}.day^{-3}$, with 85% effective plant use per year) is assumed to be used for cooking purposes, substituting firewood (which is the almost unique cooking fuel used in rural areas of Nicaragua).
The application of biogas as a fuel for stationary engines (substituting diesel, gasoline or electricity) will be considered as well.

The effluent slurry is assumed to be used as a substitute for chemical fertilizers.

Sensitivity analysis will be executed to show the influence of reactor designs, fuel- and fertilizer-applications and economic parameters on the economic feasibility of the system.

4.3 Financial analysis

4.3.1 Costs and Benefits

Investment

The direct costs of investment for a biogas plant can be divided into personnel costs, construction materials, kitchen and tube materials and transport of materials.
Applying market prices of april 1986 the following costs were obtained for the different plant sizes:

	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
1. personnel	C$ 109,400	C$ 163,300	C$ 210,000	C$ 261,800	C$ 323,100
2. construction materials	38,400	60,000	79,200	96,100	126,200
3. kitchen and tube materials	44,500	84,500	84,500	114,500	114,500
4. transport	3,600	6,100	7,800	9,700	12,800
total	195,900	314,000	381,500	482,200	576,600

fig. 4.1: Costs of a BORDA-type fixed-dome installation

A justification of these costs is included in annex 2, in the form of a detailed cost-analysis of the plants.

In the same annex a cost analysis for a BORDA-plant with a metal gasholder is shown. A summery of that analysis is found in fig 2.

	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
1. personnel	C$ 229,500	C$ 363,500	C$ 468,700	C$ 570,800	C$ 747,800
2. construction materials	114,900	186,100	239,800	290,100	378,300
3. kitchen and tube materials	44,500	84,500	84,500	114,500	114,500
4. transport	3,600	6,100	7,800	9,700	12,800
total (incl. gash.)	392,600	640,300	800,900	985,200	1253,500
metal gasholder:	216,000	352,700	450,700	547,900	711,500

fig. 4.2: Costs of a BORDA-type installation with separate metal gasholder

Capital costs and discount rating

Estimating the costs of capital in Nicaragua is rather difficult and arbitrary: The economy fights with an instable inflation of 350% per year (1985), with as a consequence that people choose risk-avoiding investments. Most popular investment is in dollars, although this is made very difficult by government regulations. Black market is present in foreign exchange, materials and basic food, and is a way for investors to insure against inflation.

It is very difficult to obtain credits because of the uncertain inflation situation. The only way to lend money is through the banks.
The banks are nationalized. They lend money on productive (as opposed against consumptive) investments for a period of one year, against ± 30% interest per year.
This can be seen as a form of subsidies for productive investment, since the interest is more than compensated through the loss of value of the money caused by inflation.
In this way an actual interest of

$$[(100 + i)/(100 + p)] * 100 - 100$$
$$= [(100 + 30)/(100 + 350)] * 100 - 100 = - 63\% \text{ per year,}$$

with i=market interest rate; p = average inflation rate;

The discount rate, used in CBA, is a "shadow interest rate", and can be described as the marginal interest, or marginal productivity of capital.[10] This is the equilibrium point in the supply- and demand-curve of capital against interest, or the interest beyond which an investment will be called "productive".
The marginal interest is composed of at least three factors: inflation, interest rate and a more subjective figure, namely the value of capital over time.

Handling inflation in CBA is difficult, since inflation is very hard to predict: It is generally considered easier not to inflate figures but to use estimates based on today's prices and to use the real interest rate (i.e. the interest rate, corrected for inflation). This simplification is only justified, however, when all prices are expected to rise at the same rate.[11]
This assumption is a simplification: In Nicaragua, e.g, the government tries to temper inflation by letting wages rise to a lesser extent than prices.[12]
Inflation is very irregular and impossible to predict in Nicaragua, so that the only way to handle inflation is to make the assumption as mentioned above.

Real interest rates in Nicaragua are very low: As has been stated before: It is very difficult to find risk-avoiding investment possibilities, so that real interest rates must be very low, or even negative.
In this analysis real interest will be assumed zero.

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[10] Roemer and Stern, 1975, p. 54
[11] Roemer and Stern, p. 74
[12] See, e.g. Volkskrant, june 9th 1987

The only factor left, determining the discount rate, is the value of money over time: Money received today is always worth more than the same money received in the future.

Considering those nicaraguan circumstances it does not seem unreasonable to count with a very low discount rate, based on real interest. In this analysis a discount rate of 4% will be worked with. In the sensitivity analysis different values will be considered.

Costs of inputs

In this paragraph 4 inputs are considered: dung, water, labor and maintenance.

dung

The valuation of cow-dung is rather difficult in Nicaragua, since it is not used as a fuel, and seldomly applied as a fertilizer. For that reason, two cases are to be distinguished:

1. The case that the plant effluent is used as an organic crop fertilizer: In this case the input dung is to be valued on its nutrient composition;
2. The case that plant effluent is not used: Input dung is valued zero.

Nutrient composition estimations are based on literature values, where mainly the nitrogen content of the dung is evaluated. It appears that the P and K composition of the dung remains constant during the anaerobic digestion process; NH_4-Nitrogen contents, however, increases: Parikh assumes 1 kg of dry dung (22.5% TS) gives 0.5 kg of fertilizer with 1.5% N when composted,[13] and Bhatia assumes, from the same amount of dung, 0.5 kg fertilizer with 1% N.[14]
For digested slurry these figures are, according to the same authors, 0.72 kg of fertilizer with 2% N and 0.73 kg with 1.6% resp. These data lead to the assumptions as shown in fig. 4.3.

Chemical fertilizer's market prices are very low in Nicaragua. An average price for nutrients (N,P or K) was calculated at C$60.=/kg (april 1986).
From these figures a net nutrient profit of 31.3 kg $N/m^3_{dig}.y$ (or C$1880.=) can be assumed.
Next to nitrogen, the bio-fertilizer also contains other nutrients such as Potassium (15 kg $K/(m^3_{dig}.y)$ and Phosphorus (20 kg $P/(m^3_{dig}.y)$.

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[13] Parikh, 1976
[14] Bhatia, 1977

	Parikh[15]	Bhatia[16]
input value of dung		
- (g N/kg dung)	7.5	5.0
- kg N/ m^3_{plant}.year	40.6	27.0
output value of slurry		
- (g N/kg dung)	14.4	11.7
- kg N/ m^3_{plant}.year	77.9	63.3
N production		
- kg N/m^3_{plant}.year	31.7	30.8
Value (C$)*	1902.=	1848.=

*Tbased on 85% effective plant use and C$60.=/kg nutrient price

fig. 4.3: Value of cow-dung and bio-fertilizer according to various authors.

<u>water</u>
Water is absolutely neecessary for the functioning of a biogas plant. An amount of 56601/m^3_{dig}.d is needed. Nevertheless, the opportunity costs of water for biogas plants is valued zero: In case there is not sufficient water a plant should not be built; In case there is ennough water, opportunity costs are zero, and only labor costs sshould be accounted for.

<u>labor</u>
Since it is usually assumed that the equal amount of labor required to collect dung forr other uses (manure, stable cleaning) as for the biogas plant, no extra value is assigned in financial analysis for labor costs of dunng collection.
The other main tasks for daily operation are mixing water and dung, feeding the plant, stirring and spreading an equivalent amount of slurry onto the compost pit. This work can be valued less, or equal to maintaining a compost pile.
Consequently, in case the effluent is used as a fertilizer and effluent use is a substitute for composting fresh dung, labor opportunity costs of daily operation should be valued zero;
In case the effluent is not used (or the dung was not used before the introduction of a biogas plant), 0.05 hr/m^3_{dig}.d can be accounted with (45 min. daily for a 15 m^3 plant seems justified). Local farm personnel salary: C$600.=/day (april 1986), 85% operating efficiency/yr, 8 hours working time/day gives C$1163.=/$m^3_{dig}$.y labor costs in that case.

[15] Parikh, 1976
[16] Bhatia, 1977

maintenance
Every two years the tank should be emptied completely, while once in four years a maintenance of the gas-holder (for a fixed-dome type) should be counted with.
Once in two years: 0.2 working days/m^3_{dig};
Once in four years: 0.5 working days/m^3_{dig}.
So that in year 2, 6, 10 and 14 C$120.= should be spent, and
in year 4, 8, and 12: C$420.=
In case of a metal gas-holder, yearly maintenance of the gas-holder should be counted with: 1 l of paint for every 8 m^2, and 16m^2 per person per day is counted with.
Next to this, the gas-holder will probably need complete renewal after 7.5 years, because of corrosion.
Maintenance costs for the various biogas plants are summarized in fig. 4.4.

plant\year	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15
fixed dome															
- 5 m^3	0	600	0	2100	0	600	0	2100	0	600	0	2100	0	600	0
- 10 m^3	0	1200	0	4200	0	1200	0	4200	0	1200	0	4200	0	1200	0
- 15 m^3	0	1800	0	6300	0	1800	0	6300	0	1800	0	6300	0	1800	0
- 20 m^3	0	2400	0	8400	0	2400	0	8400	0	2400	0	8400	0	2400	0
- 30 m^3	0	3600	0	12600	0	3600	0	12600	0	3600	0	12600	0	3600	0
metal gasholder															
- 5 m^3	104	704	104	704	104	704	104	216080	104	704	104	704	104	704	104
- 10 m^3	170	1370	170	1370	170	1370	170	353017	170	1370	170	1370	170	1370	170
- 15 m^3	218	2018	218	2018	218	2018	218	451382	218	2018	218	2018	218	2018	218
- 20 m^3	265	2665	265	2665	265	2665	265	548934	265	2665	265	2665	265	2665	265
- 30 m^3	343	3943	343	3943	343	3943	343	713294	343	3943	343	3943	343	3943	343

fig. 4.4: summary of maintenance costs of various types and sizes of biogas plants.

Benefits - output valuation

In the financial analysis only the material benefits of a b iogas plant are counted for, ie fuel production and dung valorization.

1. Biogas

The valuattion of gas output depends upon three complex considerations: a) the quality and quantity of gas; b) the mix of end-uses and the price and type of fuel considered relevant for estimating replacement costs.

a) An average biogas production of 0.4 $m^3/(m^3_{dig}.d)$, or 124 $m^3/(m^3_{dig}.y)$ is assumed, which is an average of the values encountered in Nicaragua (0.3-1.0 $m^3/m^3_{dig}.d$), with 85% operating effectiveness per year. As an average methane content of the gas, 60% is assumed, which is a common literature value.[17] The produced biogas is thus assumed to have a caloric value of 0.6*39.8(= caloric value of methane) = 23.9 MJ/m^3.

b) domestic use
Using the gas for cooking purposes, it is most likely to substitute firewood in the local situation.
Wood is half Nicaragua's total energy source. It is 90% of the fuel used by households.[18]
Firewood is a fuel of low caloric value and low burning efficiency. As a general rule, the burning of firewood will yield 15 MJ energy per kg, with a heating efficiency of 12%.
Biogas, when used in an economic way, has a much higher heating efficiency (50-60%). As a consequence, when comparing biogas with firewood it can be calculated that the efficient caloric value of 1 m^3 of biogas is equivalent tot he efficient caloric value of 7.3 kg of firewood.
An evaluation of INE on the average firewood consumption in Nicaragua showed a result of 916 kg/pers.year.[19]
This would equal a consumption of 916/7.3 = 126 m^3 of biogas/year, or 0.35 m^3/day.
A global survey among biogas users showed an approximate gas-use of 0.4 m^3/pers.d, depending on community-size and cooking habits.

This signifies that the biogas production of 1 m^3 of biogas- plant may substitute 124*7.3 = 905 kg of firewood, or almost the firewood-need of 1 person.

The official price of firewood was C$ 2,000 per marca (1.8 m^3, or 1260 kg) in april 1986, excl. transport costs, so that this amount equals 905/1260 * C$2000.- = C$ 1436.-
Transport costs of firewood should be added. The official price for transport of 1 ton of firewood was C$56.=/km in april 1986 (Nuevo Diario, 9-3-1986).

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[17] See, e.g, L. Sasse, 1983 and Werner, Stöhr and Hees, 1986
[18] INE, 1981, pp 101-105
[19] INE, 1981

A swedish study from 1984 concluded that a high proportion of households obtain their wood fuel through commercial channels. In cities around 90% of the users buy their wood; Even in rural settlements with less than 1000 inhabitants, 40% of the population buy their firewood.[20]

The above mentioned price of firewood is based on the market price of april 1986. Estimations of cost-prices, assuming a labor-wage of C$1,000.- per day for private wood choppers, using manual tools, came to the same approximative price of C$2,000.- per marca.

When commercialized, prices may rise up to 20 times this price per kg, depending on the supply and demand situation (In Matagalpa I purchased firewood for C$ 100,- per manojo (1.4 kg), which is 45* price per marca!).

into: / to convert	marca	carreta	1m³ solid	1m³ stacked	taco	raja grande	raja corr.	manojo	kg
marca	1	1.7	1.8	2.4	105	286	420	900	1,260
carreta	0.8	1	1.3	1.9	83	227	333	714	1,000
1 m³ solid	0.6	0.7	1	0.7	64	173	254	545	763
stere (1 m³ stacked)			1.4	1					534
taco					1		2.7	5.5	12.0
raja grande					0.4	1	1.5	3.1	4.4
raja corriente					0.3	0.7	1	2.1	3.0
manojo					0.1	0.3	0.5	1	1.4
kg					0.1	0.2	0.3	0.7	1

note: The above weights are measurements from 1984. The weight of manojos varies for different areas and over time. INE measurements gave a countrywide average of 2.6 kg in 1980, and 2.05 for the Managua area. Delgadillo found an average of 1.4 kg. for the Managua area in 1984.

fig. 4.5: Table of equivalences for nicaraguan wood fuel units
source: SIDA, 1984

industrial use

When biogas is used for engine driviing, the caloric value of biogas will be used with an efficiency of 23-30%, resulting in an average gas usee of 0.5-0.7 m^3/kWh_{mech}.

If co-generated to electricity, high transform efficiency rates of mechanical to electrical energy can be reached, depending on the generator.

A value of 0.9 kWh_{elec}/kWh_{mech} is reasonable.

As can be calculated, this leads to the conclusion that, compared to diesel, 1 m^3 biogas may substitute 0.36 l of diesel, so that the annual biogas production per m^3 plant equalizes 44.5 l diesel.

[20] SIDA, 1984

With the current (april 1986) diesel price in Nicaragua of C$ 110.-/USgal (=3.78 l), this would mean a saving of C$ 1288.- $/m^3_{dig}.y$.

As compared to gasoline biogas yields of 1 m^3 plant would equal ± 36 l of gasoline or (gasoline: C$ 180/USgal) C$ 1700/$m^3_{dig}.y$.

Biogas used for electricity generation would yield 177 kWh per $m^3_{dig}.y$ (with an engine generator), which would equal (with the subsidized electricity prices of C$ 8.00/kWh_{el}) C$ 1417.- $/m^3_{dig}.y$.

	amount/m^3gas	amount/$m^3_{dig}.y$	value(C$)
<u>domestic</u>			
- firewood	7.3 kg	905 kg	1436 + transp.
<u>industrial</u>			
- diesel	0.36 l	44.5 l	1288
- gasoline	0.29 l	36.0 l	1700
- electricity	1.4 kWh	177 kWh	1417

fig. 4.6: Value of biogas as a fuel, when substituting conventional sources.

<u>2. Plant effluent</u>

When plant effluent is used, two approximations can be applied:

1. Valuation as in fig. 4.3, where the calculations of fertilizer value are based on the nutrient contents with and without digestion. In that case, anaerobic digestion is compared to composting.
2. In some situations in Nicaragua it would be more appropriate to value (input) manure zero: Many farmers do, at this moment, not use the organic matter of the produced manure.
   Now, two possibilities of effluent use are present:
   - The biogas-effluent is not used either, so that this process benefit is wasted. In that case, biogas technology-is merely seen as a energy supplier. Benefits from the production of bio-fertilizer are to be valued **zero**.
   - In some cases it was observed, however, that the introduction of biogas lead to the use of organic fertilizer in agriculture. This may especially be the case when applying biogas technology in cattle farms. In such cases the dung can only be applied at cultivated cattle-food if the dung is treated through, e.g, anaerobic digestion.
     In such a case, the increase of value of the manure is from zero (before biogas application) to 71 kg N, 15 kg P and 20 kg K, or 106 kg of nutrients per m^3_{dig}.year. Market price of these nutrients would be 106 * C$ 60.- = **C$ 6360.- /m^3_{dig}.year** (see fig. 4.3).

4.3.2 Results for family and community plants

Results

Family size plants (5-10 m^3) and community plants (>10 m^3) have in common that, according to our definition, they are only used to substitute cooking fuel, i.e. firewood.

As appeared from figs. 4.1-3, the fixed dome type is the cheapest plant type for this purpose, while it is also a technically satisfying solution.

Since costs are up to 2* as high for the floating metal gasholder type, the fixed dome is considered in this part of the analysis: For industrial applications a floating gasholder is more appropriate (see annex 2).

In fig. 4.7 resulting costs and benefits for the plant's life time (15 years) are shown. Starting points were:

* fixed-dome BORDA-type installation (see annex 2);
* input dung valued on nutrient composition (see fig. 4.3);
* biogas used for cooking purposes;
* firewood transport distance: 10 km;
* discount factor: 4%/ year;
* no bank credits.

plant size:	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
present value of:					
total costs	221	343	411	512	615
total benefits	213	425	638	851	1286
Net Present Value (NPV)	- 8	118	227	339	671
benefit/cost ratio	0.96	1.2	1.6	1.7	2.1
pay-back period (years)	15	10	7	7	5
internal rate of return	4%	8%	10%	13%	18%

prices: * C$ 1,000.-

fig. 4.7: results financial analysis for average biogas systems

It appears that the family-sized biogas tanks (≤ 10 m^3) are hardly economically feasible, and that the benefit/cost ratio inclinnes with increasing plant size (economy of scale).

For plants > 10 m^3 digester volume, investment in biogas seems to be profitable. The larger digesters give better i.r.r.'s than the smaller ones (economy of scale).

Application of effluent slurry

In fig. 4.8 the influence of effluent application on the economic feasibility of a plant iis shown: In this table the three different cases of page 4-133 are compared:

1. Analysis for a farmer who already used a coompost pile, and now uses a biogas installation;
2. Case when dung is used for the first time; Before biogas- application no compost pile was used. The influent dung is valued zero;
3. Case when the effluent slurry is not used, and therefore is valued zero. The only benefit from the installation is fuel (substituting firewood).

plant size:	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
valuation of effluent: (benefit/cost ratio)					
1. in- and effluent on nutrient composition	0.96	1.2	1.6	1.7	2.1
2. influent = zero	1.6	2.0	2.3	2.4	2.8
3. effluent = zero	0.4	0.5	0.5	0.6	0.6

fig. 4.8: costs and benefits for different effluent conditions

From the study appeared that valoorization of the effluent slurry is a condition for economic feasibility of the plant: **The bio-fertilizer is (economically) a more important ooutput product than the produced biogas.**

Thiis is an extremely important conclusion for Nicaragua, since bbiogas is always considered the most important product of the system. Many farmers who do use biogas, waste the fertilizer without realizing what they throw away.

During the planning phase of a biogas project, when farmer, planner and designer ddiscuss the most appropriate application form of biogas for thhe specific situation, much attention should be paid to informming the farmer about the value of the produced fertilizer, annd the choice of crops to apply it to.

Distance to firewood-supply

To calculate the opportunity costs of firewood (and with it, the value of the produced biogas) the distance from the applierr to the firewood-supply is an important parameter, since transport costs form a substantial part of firewood costs.
Fig. 4.9 shows the effect of the increasing distance to the overall benefit/cost ratio:

plant size:	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
distance to firewood: (benefit/cost ratio)					
1. 0 km	0.83	1.1	1.3	1.4	1.8
2. 5 km	0.89	1.2	1.5	1.6	1.9
3. 10 km	0.96	1.2	1.6	1.7	2.1
4. 15 km	1.0	1.3	1.7	1.8	2.2
5. 20 km	1.1	1.4	1.8	1.9	2.4

fig. 4.9: costs and benefits, related to the distance to the fuel supply.

It should be remarked that these calculations are based on the officially fixed transport prices. In practice, these costs may be substantially higher where black rates are charged, or when own transportation meaans are used. Calculations indicated that the real costs of trransport may be much higher (2-5 times) than the officially seet prices for the high costs and the scarcity of spare parts ffor automobiles.

From these figures it appears that a shortt firewood supply is <u>not</u> a pre-condition to make a bbiogas plant economically feasible in Nicaragua. Most immportant is (as has been stated before) the use of the effluennt slurry as a fertilizer.

Calculations for a distance of 10--20 km may seem an exaggeration but in reality there are many areas where deforestation has striked so hard that no tree can be found in the far surroundings. Many farmers don't use their own woods, and buy firewood from the closest salesman, for fear of total deforestation of their land, with all its consequences such as worsening water supply and groundwater level, and increasing top-soil erosion.

The value of the discount factor

In § 4.3.1 the problems were described that are related to the valuation of capital costs in Nicaragua; There was stated that a low disccount factor should be counted with.
Fig 4.10 shows the influence of the value of the discount rate on the overall conclusion of economic feasibility; It will be clear that with decreasing discount rates the plant will become economically more attractive (investments are done in year 0, next years benefits prevail, so that high valuation in these years is favorable).
This figure is meant, in the first place, to show the influence of the value of the discount factor and to determine the internal

rate of return. In my opinion applying a low discount factor is justified to have an indication of the real economic consequences of this investment nowadays in Nicaragua.

plant size:	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
discount factor: (benefit/cost ratio)					
1. 0 %	1.3	1.7	2.1	2.2	2.7
2. 4 %	0.96	1.2	1.6	1.7	2.1
3. 10 %	0.66	0.85	1.1	1.2	1.4
4. 15 %	0.51	0.66	0.83	0.89	1.1

fig. 4.10: Influence of the value of the discount factor.

The influence of financing

In § 4.3.1 a form of government subsidies on productive investment was mentioned: Loans with a negative actual interest rate (i=30% with an inflation p=350% (1985)).

In case a farmer will obtain a one yearr credit on his biogas plant on these conditions, pay back rattes are extremely low (see fig. 4.11).
Especially wwhere national economy benefits much with the plants (see 4.5)) a loan of this form may encourage small farmers to build a ssmall-size plant. This existing form of financing could be used to make those small plants economically feasible.

plant size:	5mcu	10 mcu	15 mcu	20 mcu	30 mcu
economic feasibility in case of cheap credits (disc. rate = 4%)					
benefit/cost ratio	2.5	3.2	3.9	4.1	5.1
pay back period (years)	4	2½	2	2	1
internal rate of return	28%	41%	63%	67%	97%

fig 4.11: Influence of cheap credits on economic feasibility

4.3.3 Industrial plants

Results

If the produced biogas is to be used for other purposes than domestic use (stationary engine driving) some technical constraints should be kept in mind:

1. There must be a sufficient gas supply, i.e. ≥ 10 m^3/d. For that reason, only large-sized installations (≥ 20 m^3) are to be considered;
2. The gas-pressure must have a constant, low value (10-20 cm water pressure), so that fixed-dome installations can not be applied in these situations.

Results of costs and benefits for these types of installations are shown in fig. 4.12. In this table:

* Costs of investment do not include equipment for biogas application: It is supposed that existing engines (or generators) are used, and biogas is a mere substitute for fossile (or fossile-derived) fuels;
* Conversion costs of the engines are generally low, but hard to estimate: For a diesel engine the motor needs adjustment, while for gasoline engines some further conversion measures are needed. These conversion costs are not included either.
  They should be considered for every specific situation, and will influence the benefit-cost ratios in a negative way.
* Prices of the fuels shown are the official market prices of april 1986.

	present value of costs	benefits*	B/C-ratio	pay-back period (y)	rate of return(%)
plant:20m^3					
- firewood	889	851	0.95	≥ 15	4
- diesel	889	708	0.79	> 15	0
- gasoline	889	796	0.89	> 15	- 2
- electr.	889	737	0.82	> 15	1
plant:30m^3					
- firewood	1167	1276	1.1	13	5½
- diesel	1167	1063	0.91	> 15	3
- gasoline	1167	1194	1.0	15	4
- electr.	1167	1106	0.94	≥ 15	3

* prices * C$ 1000.-

fig. 4.12: costs and beneffits with industrial application

It may be concluded that the costs of investment are very high for this kind of application, while the actual benefits, for the applier, are even lower then when substituting firewood (transport distance = 10 km). See alsso fig. 4.5.

When compared with fig. 4.7 it may be concluded that the extra investment for a metal gasholder digester (30 m^3: = 1167 - 615 = 552 * 1,000 C$) is not repaid by extra benefits (0 in case of firewood application; negative in case of oil-derived fuel substitution).

The influence of fertilizer use

In this paragraph the question of the influence of effluent slurry use on the overall economic feasibility of an industrial biogas plant is treated.
The data in fig. 4.12 are based on the same average assumption as in fig. 4.3. Influent dung is valued on its nutrients composition.
In fig. 4.13 the following cases are investigated:

* biogas as a substitute for gasoline;
* discount factor: 4%;
* metal gasholder design, etc (see page 4.19)

plant size:	20 m^3	30 m^3
valuation of effluent: (benefit/cost ratio)		
1. in- and effluent on nutrient composition	0.89	1.0
2. influent = zero	1.56	1.7
3. effluent = zero	0.32	0.4

fig. 4.13: influence of effluent application with industrial plants

From the results it appears that investment in large-scale biogas plants for industrial application of the generated fuel is economically not feasible with the current energy prices in Nicaragua.

Capital costs: Discount rate and financing

The influence of the discount rate on this type of digesters is shown in fig. 14. The results are much alike the result from fig. 4.10.

plant size:	20 m^3	30 m^3
discount factor: (benefit/cost ratio)		
1. 0 %	1.2	1.4
2. 4 %	0.89	1.0
3. 10 %	0.61	0.70

fig. 4.14: Influence of the discount factor

The effect of a "subsidizing loan" for 1 year is shown in fig. 4.15.

plant size:	20 m^3	30 m^3
economic feasibility in case of cheap credits (disc. rate = 4%)		
benefit/cost ratio	2.4	2.7
pay back period (years)	4½	4
internal rate of return	24%	28%

fig 4.15: Influence of cheap credits on economic feasibility

It will be clear that, if Nicaraguan government is interested in biogas as an alternative energy supply, **subsidies of this kind will be needed to encourage the application of this technique.** This topic will be more extensively discussed in the conclusions of this chapter.

4.4 Social analysis

4.4.1 Justification of social costs and benefits

Introduction

To compare the social costs and benefits of a project it is necessary to value both the resources (factors of production) used and the goods and services produced in shadow prices, reflecting the "real costs or benefits" of a commodity to society.
The underlying principles are:
1. Factor costs should measure the output that society must sacrifice when the factors of production - land, labor, capital and foreign exchange - are moved from their best alternative use into the project being analyzed;
2. Intermediate goods prices should rreflect the cost of the resources needed to produce them;
3. Final goods prices should measure the resulting utility enjoyed by the consumers if the goods increase consumption or the equivalent resource cost (usually foreign exchange) if they substitute one source for another without markedly changing total consumption.[21]

The prices actually observed in an economy - whether a market economy or a centrally controlled one - may not measure social values correctly. Whenever there are controls, monopoly power, administered or legislated prices, external economies or other market distortions, market prices will diverge from social opportunity costs and cannot be used in social analysis.
Also, taxes and subsidies will introduce a spread between the prices consumers pay and those producers receive, either of which may reflect social values, depending on the situation. In all these cases, observed market prices must be adjusted or the correct market price must be selected to reflect social values. These adjusted (or selected) prices are called **shadow or social prices.**

In principle, every factor or good used in production and every good or service produced should be assigned a shadow price for social cost benefit analysis. However, the measurement of shadow prices is, in some cases, very difficult and complicated.

In Nicaragua, government has a policy of price control, wage restrictions, legislated prices, multiple exchange rates for imported commodities, subsidized goods to promote economic activity, etc. For example, cement and energy (fuels, electricity) have very low prices to promote economic activity. "Real" costs to society, may be 10-50 times higher than the actual market price.

Another major point of discussion is the price of foreign exchange. Nicaragua applied, in 1985, 10-15 different exchange rates depending on the buyer of local currency and the products he exchanged. Official rates were between C$ 70 and C$ 900 per US$ in april 1986, while the black market rates in the streets of Managua could be as high as C$ 2200.- per US$!

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[21] Roemer and Stern, 1975, p. 43

A study performed in 1985 compared cost-prices of various goods in the central american region. Based on these investigations a shadow exchange rate of 650-700 C$ / US$ was proposed. At this moment the official parallel exchange rate of the nicaraguan bank was 1:685.

It will be clear that every estimate of the price of foreign exchange is arbitrary in this situation.
A solution to this problem, which is applied in this analysis, is to divide every price in two components: One in local currency, to reflect the added value in the country, and one in foreign currency, reflecting the fraction of costs (or benefits) that is to be paid (or substitutes, resp) in foreign currency.

In this way, two separate analyses are made: One in Cordobas, and one in US-Dollars. From the resulting overall costs and benefits it can be concluded:

- the actual costs or benefits in foreign currency of an investment;
- the ultimate exchange rate that still makes an investment pay.

In order to make a comparison between the cordoba- and the dollar result possible, in first instance a change rate of 1:900 is assumed, which was the official parallel exchange rate for tourists in Nicaragua at that time.

In this paragraph a justification will be given of the assumed social costs and benefits for each of the commodities, whereas in § 4.4.2 the consequences of these assumptions for the overall social-economic feasibility will be presented.

Capital costs

In social analysis the costs of capital should be valued as if capital should be obtained from the international market. Therefore, as opposed to the financial analysis, real interest of capital can not be valued zero in social analysis.

For reasons of uniformity, however, this analysis counts with a standard discount factor of 4%, as in financial analysis.
In the sensitivity analysis, however, the effect of higher discount rates are investigated, which may be very important for acquisition of capital for biogas project outside Nicaragua.
(E.g: World Bank has managed a discount factor of 10% for years).

Labor

The valuation of social labor costs always has been a point of discussion: According to the principles presented at the top of this paragraph, social costs should be valued according to the social opportunity costs, i.e. to the costs of labor if would be worked on the best productive alternative.
In case of the valuation of labor in a rural setting this is a rather delicate question: Often unskilled labor is abundantly present, while skilled labor is scarce. Especially in Nicaragua, where many farmers keep more workers than they actually need during

periods of little activity, the opportunity costs of "unskilled" labor during this period are very low.
During the coffee harvest, however, high wages are paid for the unskilled job of coffee picking, so that during this period the opportunity costs will be considerably higher.

For that reason, two classes of labor are distinguished in this analysis:

1. Unskilled labor:
   In this analysis it is assumed that the construction of a biogas plant will occur during periods of little work for the concerned farmer.
   For building a biogas plant in rural setting the social costs of unskilled labor therefore are valued zero. This applies to the helpers of a craftsman (mason), and to the unskilled workers of a farm, responsible for plant operation.
2. Skilled labor:
   Local technicians (constructors, carpenters, masons) and managers are clearly in limited supply. Besides, the supply of skilled workers will not improve in the near future, because of the defence policy of the nicaraguan government.
   Therefore actual market prices for skilled labor will be a good reflection of the social costs of skilled labor.

Building materials

In Nicaragua, market prices of many commodities are subject to legislative limitations: Prices are fixed at a low value, to promote economic activity, or for reasons of social policy (poverty elevation).
In many cases government realizes this policy through management of exchange rates: If the production of a certain good needs imported resources, the exchange rate government counts to the buyer (an industry e.g) may be very low.

E.g. , Nicaragua bought her oil from the Soviet Union in 1986 for a price of US$ 18.-/bbl. Estimations of the costs of diesel production lead to a cost price of $0.83/gal.
The actual market price on that moment was C$ 120./gal, reflecting an imaginary exchange rate of 1 US$ for C$145.-, which is very low.

All materials used for the construction of a biogas plant are produced in Nicaragua.
However, during production in some cases imported resources are used, which have to be accounted for.
To determine social costs of these materials, an analysis should be made of the cost price of each item, considering the foreign utilities used for it's production.

In fig. 4.16 results are shown of this analysis for the materials needed for the construction of biogas plants. The items that needed most correction were:

1. energy:
   Some industries (cement, steel) need large amounts of energy for their production process.
   The following correction prices have been handled:
   * oil price: $18.-/bbl;

* diesel: $0.826/gal; gasoline: $0.798/gal; bunker: $13.8/bbl;
* electricity: $0.065 /kWh (28% of diesel conversion eff.);

2. transport:
   The resources need to be transported to the building site. It has been assumed that all materials are transported to Matagalpa in bulk (10-20 ton trucks), from there on to the building site in smaller (8 ton) trucks.
   The social costs used for transport of materials are calculated by a simple cost-price calculation. The following assumptions were done:
   * trucks: 1, 8, or 20 tonnes, or 24 m³ tank trucks, , cost price (resp) 13.5, 60, 120 and 100 thousand dollars.
   * yearly costs: 20% depreciation, 12% reparation, 10% interest + assurance = 42% of new price;
   * fuel consumption: resp. 4, 2, 1 and 1 km/liter fuel;
   * oil and other small maintenance: 50% of fuel costs.

   Transport costs until Matagalpa are corrected for in the social costs of the materials.
3. steel:
   Market price of plate steel (metal gasholders) in Nicaragua was C$60.32/lb (or C$133.-/kg), in april 1986. The price in Holland in that period was US$0.83/kg plate steel. This price is used as the shadow price of steel for Nicaragua.

item	amount	market price (april '86,C$)	shadow price (US$)		(C$)
bricks	1000	C$ 25,000	$ 1.44	+	C$ 24,609
cement	45.4 kg	500	3.94	+	115
lime	45.4 kg	1,000	0.32	+	925
sand	m³	4,000	3.38	+	3,355
river stones	m³	6,000	3.69	+	5,077
paint	lt	556	3.70		
steel plate	kg	133	1.00		
pvc tube, 1"	20 ft	1,200	1.30		
pvc tube, ½"	20 ft	600	0.65		
family burner	1 2 b.	50,000	42	+	12,500
ind. burner	1, 2 b.	70,000	58	+	17,500
ind. burnerr	1, 3 b.	100,000	83	+	25,000

fig. 4.16: Estimated social costs for construction materials

Programme costs

In many cost benefit analyses on biogas costs of the introduction and promotion of the programme are not accounted for, although they are real costs to society.[22]

In Matagalpa a project proposal has been drawn for the start of a biogas implemenntation programme in that region. The estimated budget for the fiirst three years of that programme, which planned the constructioon of 48 plants with a total volume of 720 m³, are

[22] E. Kijne, 1984

used for the estimation of the average (minimal) programme costs for biogas extension.

This budget included:
- Local engineers for the planning annd design of the plants;
- Resources to carry out the programme (transport, tools);
- Some basic field analysis equipment for a first service to biogas users.

Total budget of this programme for three years was US$ 31,500.- + C$ 7128,000, signifying an average amount of US$ 43.75 + C$ 9900.- per m^3 biogas plant.

Social benefits: output valuation

1. Biogas

For outputs, the same technical parameters as in § 4.3 will be assumed. Valuation will be based on the prices as have been presented so far. They are resumed in fig. 17.

	amount/m^3gas	amount/m^3_{dig}.y)	value (C$)	(US$)
domestic - firewood	7.3 kg	905 kg	1436.-	transport
industrial - diesel	0.36 l	44.5 l		9.72
- gasoline	0.29 l	36.0 l		7.60
- electricity	1.4 kWh	177 kWh		11.52

fig. 4.17: Value of biogas as a fuel, when substituting conventional sources. Shadow pricing.

2. Plant effluent

The same three cases of effluent re-use will be considered as in § 4.3.
Nutrients will be valued at a shadow rate of $0.43/kg (N,P or K). This price is based on the price paid in Holland. This seems justified, since Nicaragua imports all her chemical fertilizers.

4.4.2 Results for family and community plants

Results

Fig. 4.18 shows the results of the social analysis using shadow prices for the various plant sizes (fixed dome type) in local and foreign currency.

plant size:	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
present value in 1000 C$					
total costs	141	236	320	412	567
total benefits	80	160	240	319	479
Net present value:	- 61	- 76	- 80	- 93	- 88
present value in US$					
total costs	344	617	869	1143	1634
total benefits	825	1650	2475	3300	4950
Net present value:	+481	1033	1606	2157	3316
total NPV (1$ = 900C$) in 1000C$	372	854	1365	1848	28996
B/C ratio (idem)	1.8	2.1	2.2	2.3	22.4

fig 4.18: results social analysis for average biogas syystems (4% discount rate, firewood substituting, 10 kmm transport distance)

It appears that these simple biogas systems can be vary profitable from tthe "national interest's" point of view: Even the smaller faamily-size plants show a good cost/benefit ratio, when the biogas substitutes firewood.
Pay back periods of 6½ year can bee realized for the small plants, up to 4½ years for the 30 m3 plants. Internal rates of return were 15 and 24%, resp.

Social effects, such as environmental protection and health eeffects, were not included in this analysis.

Beneffits come in the very first place from the foreign-currency souurce: Chemical fertilizers are very expensive, and are sold very cheap in Nicaragua. Saving chemical fertilizers will cause considerable savings on the national bill.

The influence of exchange rate valuation

As has been stated in § 4.4.1 it is rather difficult to make a just estimation of the exchange rate for foreign currency. Nicaraguan government manages 10-20 different rates, and black market rate in the streets of Managua is as much as 2.5 * higher than the highest of the official rates.
In fig. 4.19 the influence of the official exchange rate on the overall effect of costs and benefits is shown. The chosen values represent the official exchange rate of the cordoba (1:70), exchange rates for non-governmental aid-organizations (1:450), the official parallel rate (1:900) and the black market rate (1:2400) in april 1986.

plant size:	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
exchange rate:					
1 US$ = C$ 70.-	0.83	0.99	1.1	1.1	1.2
450.-	1.5	1.8	1.9	1.9	2.1
900.-	1.8	2.1	2.2	2.3	2.4
2400.-	2.1	2.4	2.5	2.6	2.7

fig 4.19: Influence of exchange rate valuation on the overall social benefit/cost ratio

Because of the fact that the application of biogas technology leads to savings of foreign currency (input < output), a higher exchange rate leads to better benefit/cost ratios.
In the following paragraph the major source of this production of foreign currency will be identified.

The influence of fertilizer use

In fig. 4.20 the influence of effluent application on the socio-economic feasibility of a plant is shown. In this table the three different cases of page 4-13 are compared:

1. Analysis for a farmer who already used a compost pile, and now uses a biogas installation;
2. Case when dung is used for the first time; Before biogas-application no compost pile was used. The influent dung is valued zero;
3. Case when the effluent slurry is not used, and therefore is valued zero. The only benefit from the installation is fuel (substituting firewood).

plant size:	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
valuation of effluent: (benefit/cost ratio) (1 US$ = C$ 900)					
1. in- and effluent on nutrient composition	1.8	2.1	2.2	2.3	2.4
2. influent = zero	5.4	6.1	6.6	6.7	7.2
3. effluent = zero	0.33	0.38	0.41	0.41	0.44

fig 4.20: social costs and benefits for different effluent conditions

It appears that applying biogas technology in Nicaragua, without use of the plant effluent as a fertilizer, is an economic des-investment: **Use of the produced bio-fertilizer is a condition to make biogas feasible, also from a social point of view.**

Discount rate

In the previous tables discount factors of 4% were applied. In fig. 4.21 the influence is shown of the various discount rates on the overall benefitt/cost ratio of the plants:

plant size:	5 mcu	10 mcu	15 mcu	20 mcu	30 mcu
discount rate: (benefit/cost ratio) (1 US$ = C$ 900)					
1. 0%	2.5	2.8	2.9	3.1	3.3
2. 4%	1.8	2.1	2.2	2.3	2.4
3. 10%	1.4	1.6	1.7	1.8	1.9
4. 15%	1.1	1.3	1.4	1.4	1.5

fig 4.21: social costs and benefits for different discount rates

On page 4.23 it has been remarked that, to international standards, the discount rate should be valued higher than 4%. From fig. 4.20 (but also from page 4.27) it can be derived that with an internal rate of return, higher than 15%, biogas technology is economically feasible under the present conditions of Nicaragua.

4.4.3 Results for industrial plants

Results

In the case of industrial application of the generated biogas the cost-benefit analysis may become quite different.
Main differences with the analysis in the former paragraph are:

* On the costs side: Investment must be done in a metal gasholder, which implicates a further investment in foreign materials, and considerable extra investment in cordoba's;
* On the other side: The produced biogas can be valuated in foreign currency, since it is used to replace oil derived fuels such as gasoline, diesel and/or electricity. From the analysis should become clear whether these benefits are sufficient to pay back the extra investment to be done in the metal gasholder.

In fig. 4.22 the main results of the analysis are shown:

	present value of costs C$	present value of costs US$	benefits* C$	benefits* US$	B/C-ratio (1 : 900)**	pay-back period (years)	rate of return (%)
plant: $20 m^3$							
- firewood	1102	3602	321	3318	0.76	> 20	< 0
- diesel			0	5183	1.1	13	5½
- gasoline			0	4709	0.98	15½	3½
- electr.			0	5586	1.2	11½	7
plant: $30 m^3$							
- firewood	1480	4858	482	4977	0.85	18	1½
- diesel			0	7775	1.2	12	7
- gasoline			0	7064	1.1	13	5
- electr.			0	8377	1.3	10½	8

* local C$ prices: * C$ 1000.- ** discount factor: 4%

fig. 4.22: Social costs and benefits with industrial application

Although the situation is somewhat better than in the financial analysis, it should be concluded that **the use of biogas for substitution of imported energy sources is hardly economically interesting regarding the high investment to be done.**
Comparing figs. 17 and 21 it may be concluded that the extra investment to be done for this application (for the $30 m^3$ plant: US$ 3224 and C$ 913,000.-) is not earned back by extra production of local or foreign currency (US$ 2114.-).
Only in case of replacement of electricity with a $30 m^3$ plant (total extra benefits: US$ 8377 - 4950 = 3427.-) the foreign investment is earned back.

It should be realized, however, that investments to be done to apply the biogas for electricity generation are not included. It therefore will only be feasible in cases where electricity already was applied **and** produced, i.e. where a diesel generator was used to generate electricity.
These cases, however, are exceptional in Nicaragua.

The influence of fertilizer use

The results shown in fig. 4.23 confirm the statements made in the former paragraph: They show that **effluent re-use has a decisive influence on the overall social benefit/costs ratio of the systems**.

plant size:	20 m^3	30 m^3
valuation of effluent: (benefit/cost ratio)		
1. in- and effluent on nutrient composition	0.98	1.1
2. influent = zero	2.5	2.7
3. effluent = zero	0.35	0.39

fig 4.23: influence of effluent application with industrial plants, substituting gasoline

From the results shown in figs 4.22 and 4.23 it should be concluded that with the investigated plants, and on the investigated scale, the industrial application of biogas is not socio-economically feasible in Nicaragua.

Discount rate

The influence of the discount rate on the social benefit/costs ratio is shown in fig. 4.24. The results are much alike the results from fig. 4.20.

plant size:	20 m^3	30 m^3
discount factor: (benefit/cost ratio)		
1. 0 %	1.2	1.4
2. 4 %	0.98	1.1
3. 10 %	0.81	0.90

fig 4.24: The influence of discount factor, gasoline substituting.

Applying the international standards for a required internal rates of return (± 10%) for a project, it should be concluded that proposing the promotion of industrial biogas plants in Nicaragua, to be financed by international institutions, does not make a chance.

4.5 Conclusions

The most important conclusions from the socio-economic cost-benefit analysis of biogas technology in Nicaragua, presented in this chapter, can be summarized as follows:

1. Cost benefit analyses in Nicaragua are of limited reliability, because of the economic situation. The irregular increase of inflation and the lack of data make that every analysis of this kind has a rather limited period of applicability in the future;

A. Financial cost-benefit analysis

domestic applications

2. Application of biogas technology for domestic purposes, is economically feasible at a scale > 10 m^3 digester volume, from the point of view of the user (see § 4.3.2);
3. The economically most important benefit of the biogas process is the produced bio-fertilizer, i.e. the plant effluent. The anaerobic fermentation process yields 80-100% extra ammonium-nitrogen (fig. 4.3), producing 60% of total economic benefits;
4. Without using the bio-fertilizer as a substitute for chemical fertilizer, the biogas process will never be economically feasible;
5. Provision of credits at the official bank rate of 30% may be a necessary incentive for farmers to invest in biogas technology, especially for application on family scale (≤ 10 m^3 plant volume).
   Recommendations to virtually provide these credits depend on the results of social cost-benefit analysis;
6. In other cost-benefit analyses on biogas technology one of the major factors influencing the economic feasibility appeared to be the distance of the user to other energy sources. This did not play a decisive role in Nicaragua.

industrial applications

7. Industrial application of biogas technology, i.e. using biogas for driving stationary engines, requires investment in a metal gasholder for technical reasons;
8. Industrial application of biogas is economically not feasible, since the extra investments to be made cannot be earned back because of the low, subsidized energy prices in Nicaragua;
9. Internal rates of return for industrial plants remain below 4%, signifying that the investment is less than marginal;
10. If, with industrial applications, the produced bio-fertilizer is not used, the plant will have a negative rate of return;
11. Provision of subsidizing credits, as under note 4, will lead to a substantial improvement of the value of the internal rate of return. However, similar restrictions as under note 4 should be taken into account.

B. social analysis

12. The economic situation in Nicaragua, and the application of multiple exchange rates, make a social analysis of biogas technology in this country rather difficult. However, the value of the exchange rate does not appear to be of decisive importance to the overall feasibility of the technology;

domestic applications

13. Biogas systems for domestic applications can be very profitable from the "national interest's" point of view: Even the smaller family-sized plants show a good internal rate of return (> 15%). This is also sufficient when standards for credits from international organizations, such as the World Bank, are applied;
14. Benefits come in the very first place from the production of bio-fertilizer, as a substitute for chemical fertilizers. If the plant effluent is not used, biogas technology can not be socially feasible;
15. Subsidizing credits, as provided by the National Development Bank BND are recommended for the small family plants (< 10 m^3), because of the limited financial feasibility at this scale of application (see fig. 4.7).
    In case the applier has insufficient investment capital credit possibilities should also be created for bigger installations;

industrial applications

16. From a social point of view, the application of biogas technology for industrial applications is not feasible, because of the necessary investment in a more expensive digester design (see note 5);
17. The provision of subsidizing credits is not recommended at the investigated scale of application ($\leq$ 30 m^3 digester volume).

Chapter 5: Organization and management of biogas projects

contents:

Chapter 5: Organization and management of biogas projects

5.1. Introduction

As a third major analysis, after the technical and socio-economic ones in the previous chapters, organizational and management aspects will be discussed in the following three chapters.

Where technical and socio-economic feasibility may be seen as pre-conditions for the introduction of biogas and aspects that can be influenced by the projects only to a marginal extent, project organization and management will determine the eventual failure or success of an extension programme.

Let us define an organization as the system of human and other resources to achieve the project's goals[1].
Project management may be defined as the process of organizing, planning, leading and controlling needed to make the organization achieve her goals[2].

My objective in this chapter is to discover in which way biogas projects may try to achieve their goals. In other words: it should

be indicated in which way the employment of personnel, material resources and management techniques will result in a successful extension of biogas technology. Why plants often do not function, and in which cases this should be blamed to failing management.

In 5.2 more attention is paid to the theoretical aspects of projects as means to achieve development goals, and the contemporary discussion on this subject;
Next issues will be discussed:
- what is a project;
- the project cycle;
- criticisms on project planning and implementation;
- learning and uncertainty in development planning;
- participation and development projects.

In 5.3 a detailed survey will be given of the contents and structure or a biogas extension programme, using organization analysis models and literature reviews.

This analytical framework will be used for:
* an analysis of existing biogas programmes in Nicaragua, i.e. the INE and the ENPRA/GTZ programme (chapter 6 and 7);
* an outline for future activities, such as the proposed biogas extension project of MIDINRA Reg. VI (Chapter 8).

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[1] See Hulshof (1981) and Krijken (1983)
[2] Hellriegel and Slocum, 1986

5.2. Projects as a tool to manage development

Regarding the world of "development assistance", "aid" and "international solidarity" **projects** are a phenomenon that are, for many people, a synonym for "development activity".
Projects have become the primary means through which governments of developing countries, and also non-governmental organizations, attempt to translate their plans and policies into programs of action. No matter how comprehensive and detailed development plans seem to be, they are of little or no importance unless they can be translated into projects or programs that can be carried out. Thus, projects have become important channels through which governments and international assistance organization invest their resources.

For this reason, projects have come to play a central role in the political economy of developing countries. They can influence the processes through which economic changes occur by integrating markets, linking productive activities in the public and private sectors, providing the technology for transforming raw materials into economically and socially useful products, and creating the physical infrastructure needed to increase trade and exchange[3].

In many countries projects also stimulate social change: education, health, family planning and social service projects help to satisfy basic human needs and provide new skills required in traditional societies to initiate and sustain modernization.

But what really are projects?

A project is, according to van Doorn "a complexity of activities, limited in time and place, aimed at the realization of a specific set of objectives"[4].
Most important characteristics of projects are, that

* they are unique, so a-cyclic. The tasks, as well as the specific work relations are new;
* they should provide certain degrees of freedom for the involved fellow-workers to make a creative task-fulfillment possible[5].

As such, successful projects can generate new resources for further investment, creating a momentum for continued and widespread economic progress. In this sense, Hirschman calls development projects a special kind of investment:

> " the term connotes purposefulness, some minimum size, a specific location, the introduction of something new, and the expectation that a sequence of further development moves will be set in motion."[6]

One of the main reasons of the projects popularity as a development tool is, that it is considered by their sponsors to be a manageable sets of activities, that is likely to remain the primary means of translating development policies and aid

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[3] Uphof and Ilchman, 1972; See also Rondinelli, 1981, p. 4
[4] J.J.A. van Doorn, in id (ed), 1971
[5] K.T.A. Halbertsma, 1978, p. 7
[6] Hirschman, 1967, p.1

strategies into programs of action: Before being granted for finance, the proposed project usually is to be analyzed and appraised into detail, to convince the sponsor of the usefulness and potential feasibility and to provide a tool to control and evaluate the obtained results.
Projects are extremely manageable in this sense since, being limited in time and strictly objective oriented, they can be divided into phases in which a well-defined part of the project is executed. Evaluation at the end of each project phase makes progress control possible and offers the financing organization the possibility for a "go-ahead decision", or to cancel further activities.

It may be useful, at this point, to make a distinction between programmes and projects.
A programme is an organization in the true sense of the word: A system of human and material resources trying to achieve a set of objectives. Projects may form a part of the programme, but the programme may contain more activities.
Projects, on the contrary, are activities trying to achieve a limited objective (or 'task objective[7]') in a limited period of time.

- the project cycle

Each project passes through a cycle that, with some variations, is common to all. The project cycle consists of a series of successive phases, each phase leading to the next. The last phase in turn produces new project approaches and leads to the identification of new projects or improvements to be introduced in current projects, making the cycle self-renewing[8].

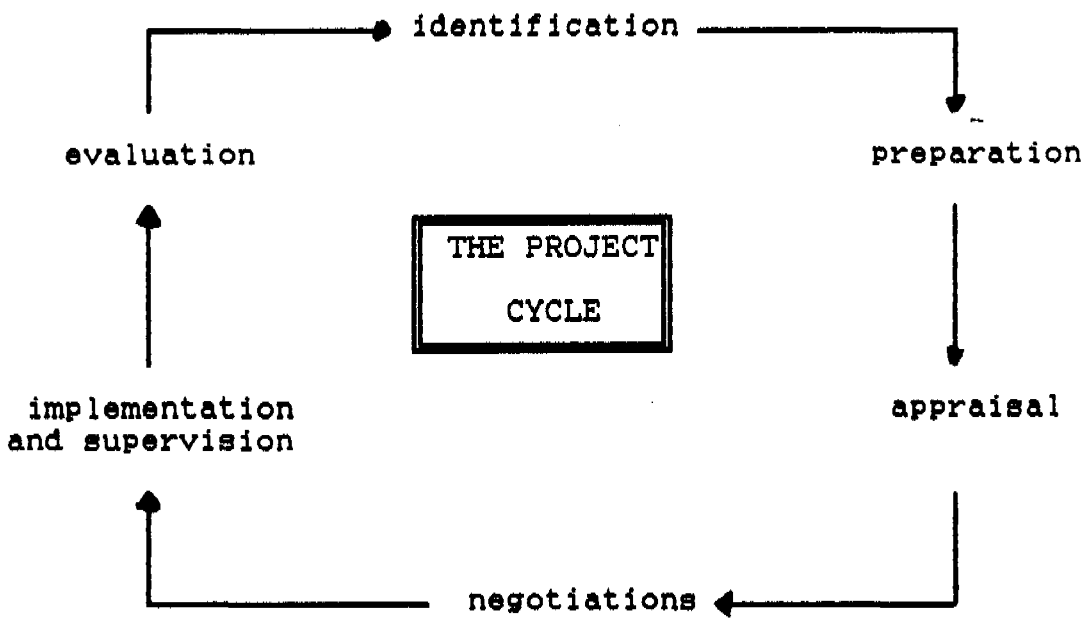

fig. 5.1: The project cycle (after Baum, 1978)

[7] D. Newman, 1973, p. 9
[8] W. Baum, 1978

Various models of the project cycle have been developed, of which the World Bank's is the most well known one. In this model, 6 phases are distinguished: identification, preparation, appraisal, negotiations, implementation and supervision and evaluation. The same model, adjusted slightly to some marginal points, is used by several other institutions.

An analysis of a project through the project cycle may be helpful for two reasons:

1. Since different organizations and individuals commonly assume responsibility for different aspects of project planning and execution, the cycle provides an overview of tasks preformed by a diversity of organizations or departments, each considered essential to a project's success.
2. A second reason for using the cycle as an ordering framework is the potential value or seeing the complexity of the entire process from the point of view of a developing nation when all of the international assistance agencies' prescriptions are combines. To support this concept, Rondinelli presents a detailed checklist of planning and management, consisting a 9 project phases and 130 (composite) items that, prescribed by most international assistance organizations, should lead development planners and project managers through the details of a project[9].
   In the same way, the World Bank publishes "project preparation handbooks" that blueprint which items should be of the planner's or manager's concern, during each phase of the project[10].

In this analysis the project cycle is used to evaluate the biogas extension programs so far executed in Nicaragua. It is used to analyze the different aspects of project planning and management. Therefore, the cycle as presented by Blankenberg is adapted, which consists of 5 phases (project identification, formulation, appraisal (and negotiations), implementation and operation). This model refers to the World bank version and Van den Toorn's model[11].

- criticisms of project planning and implementation

The operations of major financial assistance organizations - the World Bank, the United Nations Development Programme (UNDP), and others - have been the subject of substantial criticism over the past decade from both outside observers and internal study groups. Most of the major criticisms focus on aid administration - project planning within funding organizations and execution within developing countries.

The administrative procedures have strong bureaucratic and technocratic tendencies, not in the least through the wish of financiers to obtain maximum guarantees for a project's success. Where creativity, flexibility and innovation, combined with a major process of learning, should be the major characteristics of finding solutions to the complexity and unexperiencedness of development

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[9] Rondinelli, 1977, p. 7-9

[10] See, e.g. B. Grover, 1983

[11] W. Van den Toorn, 1983 (see Blankenberg)

problems, the existing procedures of administration have created an atmosphere of bureaucracy and technocracy.

Management literature shows that creativity and bureaucracy, or adhocracy and bureaucracy, do not cope and will lead to a situation where one has to budge for the other[12].

Others come to the conclusion that administration should correspond to the needs of a project, i.e. administration should leave freedom in cases where complexity and unacquaintedness with the situation call for a flexible and creative project approach. Whereas, in cases of low uncertainty and risk (e.g. massive dissemination projects) administrative control may be a useful tool to reach efficient management[13].

- learning and uncertainty in development planning

Korten states, that projects may pass through a learning process, in which, successively
* learning to be effective,
* learning to be efficient, and
* learning to expand the application are the phases through which many activities go[14].

These stages of the learning process all call for a different management approach, in which the emphasis should be moved from flexibility to control, from adhocracy to bureaucracy.

This approach, in essence, is also found with Rondinelli:
In order to cope with complexity and uncertainty in developing project he proposes a "framework for adaptive administration of development projects". This approach seeks to "recognize that all development projects are policy experiments and [he proposes] to plan them incrementally and addaptively by desegregating problems and formulating responses through a process of decision making that joins learning with action."[15]

He describes a four-stage process of project planning and implementation that seeks to cope with problems in an experimental, incremental and adaptive fashion (see fig. 2).
At the same time it gives a classification of projects, and reflects the importance of a gradual implementation, i.e. a gradual scaling-up of projects in time, to take away uncertainties and ignorance in implementation projects[16].

It will be clear that experimental, pilot, demonstration and dissemination projects each call for a different management approach. Therefore, the projects will be discussed in the pages to come, with some emphasis on the general management approach that is needed for the specific project.

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[12] see e.g. Mintzberg, 1981
[13] see Rondinelli, 1981
[14] Korten, 1981
[15] R, 1981, p 89
[16] See, e.g., the cases Blankenberg presents in his work (1985)

Project type or stage:

	Experimental	Pilot	Demonstration	Dissemination
unknowns or design problems	problem or objective			
	possible alternative solutions			
	methods of analysis or implementation	methods of analysis or implementation		
	appropriate technology	appropriate technology		
	required inputs or resources			
	adaptability to local conditions	adaptability to local conditions		
	transferability or replicability	transferability or replicability	replicability	
	acceptability by local populations	acceptability by local populations	acceptability by local populations	
	dissemination or delivery systems	dissemination or delivery systems	dissemination or delivery systems	dissemination or delivery systems
	large-scale production technology	large-scale production technology	large-scale production technology	large-scale production technology

<u>Characteristics</u>

higher ←→ lower

- ← — — Uncertainty and risk — — — →
- ← — — Political vulnerability — — — →
- ← — — Innovativeness — — — →
- ← — — Addition to existing knowledge — — — →
- ← — — Need for creative management — — — →
- ← — — Need for flexibility of organizational structure — →
- ← — — Need for rare or specialized technical skills — — →

fig. 5.2: A framework for adaptive administration of development projects
source: Rondinelli (1981)

experimental projects

Experimental projects are generally small-scale, highly exploratory, risky ventures that do not always provide immediate or direct economic returns or yield quick and visible results. Their benefits are derived from the acquisition of knowledge. They are needed when problems have not been clearly identified, alternative courses of action have not been widely explored and their impacts cannot be easily anticipated.

Under these conditions effective management methods and techniques cannot be confidently prescribed. Little is known about the appropriate types, amounts and combinations of resources or about the most effective sequence and timing of interventions.

By formulating development projects through a phased, experimental approach information can be gathered from a few places before embarking on a demonstration or full-fledged national program.

Experimental projects can be used
- to assess alternative courses of action and to allocate to those that seem most feasible during early phases of testing and observation;
- to test the applicability of methods and techniques that are transferred from other countries or sectors;
- to search alternative courses of action if problems arise from unique cultural, social or ecological conditions;
- to lower the risk of introduction of (technical) innovations.

Experimental projects need some protection in their early stages from political pressures to terminate them because of mistakes or to replicate them too quickly when they show signs of success. Political pressures to transform them prematurely into pilot, demonstration or dissemination projects are equally dangerous.

pilot projects

Pilot projects can perform a number of important functions:
- they can test the applicability of innovations in places with conditions similar to those under which experiments were performed;
- they can test the feasibility and acceptability of innovations in new environments;
- they can extend an innovation's range of proven feasibility beyond the experimental stage;
- they may serve as small-scale prototypes of larger-scale facilities, and
- test markets for goods and services to be produced by proposed projects.

Because they must be adapted to many different environments, pilot projects may require more financial investment than experiments. As with experiments, it is useful to provide pilot schemes with a stable and secure source of financing to protect them from the political vagaries of the budgeting process, especially if some initial trials prove unsuccessful.

In the pilot stages, project planning must be flexible and responsive.
Cuca and Pierce found that in pilot family planning projects

> " a more fluid design is an asset since it permits modification in response to environmental changes and freedom to manipulate inputs."[17]

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[17] Cuca and Pierce, 1977, p. 77

demonstration projects

The purpose of a demonstration project is to show that new technologies, methods or programs are better than traditional ones because they increase productivity, lower production costs, raise income or deliver social services more efficiently. Their major objective is to show potential adopters the benefits of employing innovations.

Even as the third phase of an experimental and pilot sequence, high levels of risk attend demonstration projects. At this stage, however, the risk is more evenly shared between project sponsors and intended beneficiaries.
For this reason, Morris (1981) derived a number of principles from his review of integrated rural development projects in Africa, of which the following may be of interest to us:

- demonstration projects must offer low risk for participants;
- they must provide **visible** and **substantial** benefits at the farm level;
- they must offer participants regular access to cash incomes;
- they must use innovations that are not dependent for their adoption on loan financing in the initial phases;
- they must consider the long-term effects of technology transfer because they may be quite different from immediate effects;
- they should not be implemented in a way that by-passes local officials, who will remain long after technicians and managers who initiated the project have moved;
- they should build administrative capacity on small and incremental rather than on large-scale and complex activities that have a higher probability of succeeding[18].

Demonstration projects operate with much more certainty and knowledge of the situation than experimental or pilot projects. Therefore, project planning and management can be fixed more, although some flexibility and freedom for corrective measures should be left open: Conditions that have not been forseen in experimental or pilot phases may make corrections necessary.

replication, dissemination and service delivery projects

The dissemination of tested methods, techniques or programs through replication, full-scale production or service delivery projects is the final stage in an experimental series. The major contribution of these projects is to expand productive and administrative capacity.

Basic design problems of these projects include those of testing full-scale production processes and technology, developing appropriate and effective delivery and distribution systems, up- scaling of those processes, and maintaining an adaptive and responsive approach after they are transferred.

The most difficult problem at this stage is transferring experimental, pilot or demonstration projects to large-scale bureaucracies.

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[18] Morris, 1981, p. 123

Many examples exist of dissemination projects that failed because earlier phases had been skipped or because factors were overseen. They include world-wide projects, such as the "Green Revolution" of the sixties and numerous examples on a national or regional scale. Blankenberg (1985), e.g. presents examples of the implementation of rural technology in India, but I am sure that every country has its own examples of the "too fast, too much" kind[19].

In chapter 6 this classification of development projects will be useful in analyzing the design and realization of the biogas projects in Nicaragua. It will appear, that both projects showed substantial lacks concerning their approach, and the way they executed their tasks.

It is of my concern to identify these lacks, and their consequences, and find a more appropriate approach that is needed to realize the goals of these biogas projects.

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[19] See especially the chapters 3,6 and 7 (B., 1985)

- participation and development projects

One of the major issues in development theory today is the aspect of participation of the beneficiary group in development projects. Where planned activities, such as projects, aim at important change in the life of a group of people (the beneficiary group), these activities are bound to fail if this beneficiary group is not involved in the concerned decision.

Galjart defines participation as "exercising of upward influence on the decision-making process" [20]. In other words, the essence of participation is that the beneficiary group exercises influence on decisions that affect their daily life.
This pleads for a bottom-up approach of the development process, in which the beneficiary is a fellow-decision maker in each of the phases of the project cycle. From the starting-point of project identification (in which e.g. the needs of the beneficiary are assessed), through project-formulation, execution, operation and evaluation the beneficiary group should be involved in the decisions that influence the eventual result of the project.

Considering the typology of development projects made in the former paragraph it can not be stated that participation is more important for one project type or for another: In experimental projects involvement of the beneficiary group may be just as important as in projects of the demonstration type. Participation of the beneficiary is more a general attitude in the planning of projects, needed to make an activity succeed [21].

As a consequence, project planning should be executed in a flexible and responsive way: On indication of the beneficiary it should be possible to adapt the project, or even change the project's goals.

It should be emphasized that this participation theory is not a mere ideology of democratic decision making.
Participation is a **necessity** to make projects successful, to make it possible that the project will not collapse during the operation phase, i.e. after the "experts" will be gone.

Participation is one of the most difficult aspects of development projects. It does not cope with the technocratic and centralistic approach of many institutions in developing countries, and causes, as such, problems with the mother- organizations.
One may encounter a lot of distrust between the project organization and the beneficiary group: Earlier experiences of the beneficiary-group towards government officials, as well as old biases of officials to the poorer groups of society, cause tensions within the project, which may be hard to overcome.

In the coming analyses of biogas projects in Nicaragua emphasis will be put on the aspect of involvement of the various parties in the decision processes that lead to the project. Consequences of this approach will underline the numerous examples described in literature.

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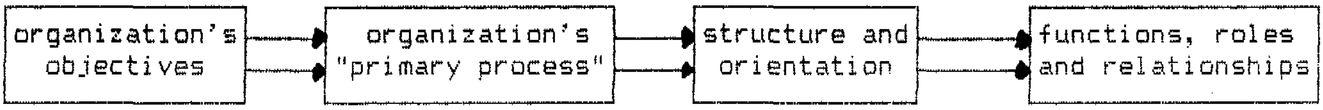
[20] Galjart, 1982, p 4
[21] See also Rondinelli, 1983, pp 77-78

5.3 Organization and management of biogas programmes

5.3.1 The analysis of biogas extension programmes

After the more general and theoretical discussion on development projects in the former paragraph, practical aspects of the analysis of biogas projects will be examined here. This, to make a foundation for the analysis of the biogas programmes that have taken place, so far, in Nicaragua.

The main practical issues in an organization design (but also in its analysis) are:
a. the recognition of the organization's objectives;
b. the identification of the ways or processes through which the organization is trying to achieve her objectives (or the 'primary process');
c. the general structure and orientation of the organization;
d. the specific roles and relationships within it[22].



To us, at this moment, items a-c are of most interest for analyzing the biogas programmes:

a. The **objectives** of biogas programmes may differ a little, but in general the main objective will be:
   Dissemination and promotion of biogas technology.
   This may be for various underlying reasons, such as:
   - saving or replacement of traditional fuels, saving of chemical fertilizer, from a point of view of "national interest";
   - health arguments;
   - improvement of a target group's economic position or diminishing its economic or political dependence, and
   - for reasons of environmental protection.

b. The way to achieve this objective, or the "**primary process**" may be described as developing and/or supporting initiatives that promote the objective of the programme (dissemination of biogas technology). These activities include promotion and support of initiatives of farmers who want to use biogas technology, through the provision of information, finance (subsidies), materials, equipment, human resources or technical support.

   Next to the "primary process" an organization usually consists of one or more secondary or "**maintenance processes**".
   These processes are intended to supply the primary processes with sufficient (i.e. quantitative and qualitative) human resources, means and information to assure its continuation for the shorter and longer run.[23]
   These processes are not <u>directly</u> aimed at the achievement of the organizational goals, but support and maintain the primary process for now and in the future.

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[22] D. Newman, 1973, p. 64
[23] A.H.Hulshof, 1982, p.28

These "maintenance activities" may include, in the case of a biogas programme:

- supply of human, financial and material resources for the programme;
- research and development activities;
- provision of information, publicity, and other marketing activities;
- training, education and transfer of knowledge to local staff, other organizations or to beneficiaries;
- supporting initiatives from outside the organization that support the organizational goals;

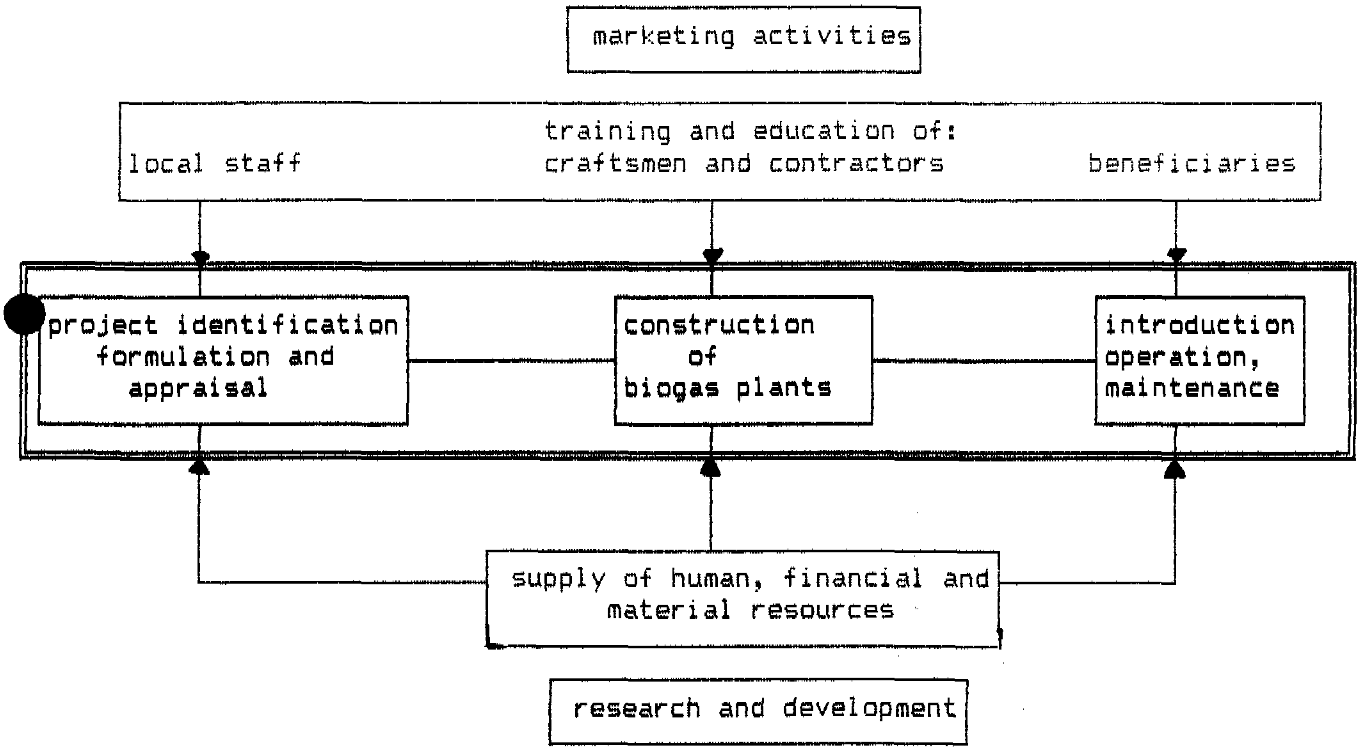

fig. 5.3: Primary and secondary processes in a biogas extension programme

c. The basic organizational structure needed to achieve the oorganizational goals depend strongly on the mix of activities performed. It will be clear that building a plant requires a different management approach than doing an information campaign, servicing operating plants, doing technical research or giving advise to farmers with individual questions.
For that reason it is not possible to make a general statement on the precise organizational form of a random biogas programme. In the analysis of Nicaraguan biogas programmes I will restrict myself to examining on how a certain organizational structure may have conflicted with the performance of the programme, i.e. with the achievement of organizational goals.

In this stage it may be useful to make an overview of the contents of a (rather complete) biogas programme, and give an indication of the need or usefulness to include certain activities in a biogas programme. This, to be able to make a more concise analysis of the INE and ENPRA projects in Nicaragua.

5.3.2. The primary process of a biogas extension programme

The primary process, defined as "those processes directly aimed at the achievement of the organization's goals", determine in the very first place the character of the set of activities developed in the biogas programme.
When the process of implementing biogas plants is recognized as the primary process, a division in sub-processes can be made. This analysis is closely related to the analytical instrument of the project cycle, since the implementation of biogas plants is mostly executed in a project-form.

As far as project-alike ventures are concerned the project-cycle, as presented in fig. 5.1, may be used. When more than one project are at stake, the organization of these projects is a process in itself.

For our purposes it is convenient to divide this process into three sub-processes:
- project identification, formulation and appraisal (the pre-investment phase);
- construction of the plant (implementation);
- the introduction, operation and maintenance process (after-care, see also fig. 5.3).

In the next three sub-paragraphs these sub-processes will be examined in more detail.

5.3.2.1 The pre-investment process

The pre-investment phase of projects should be regarded as a preparation for project implementation and -operation.
During this phase studies are made which form the foundation of the eventual project execution.
The studies are needed for the following reasons:
- to identify the needs or problems to be solved in the project;
- to formulate the most feasible solution to those identified needs;
- to anticipate at problems which may occur in the execution- or operation phase of the project.

During this period three main project phases may be distinguished:

1. Project identification:
   Based on a problem-identification and/or need-assessment study it is systematically determined which of the beneficiary's problems, or needs, are to be solved.
   If this identification is carried out seriously, the organization will be able to form a rather precise idea about the problems in a particular society and to adjust their perception to the needs and priorities of other parties. As a result it is possible to formulate objectives that reflect the opinion of various interest groups.
   Although this phase may seem to be a first logical step in bringing about a project, this stage is often skipped or performed insufficiently. Decision makers or bureaucrats often think they know the problems of a certain target group, and

"forget" to systematically determine them[24].

2. Project formulation:
   The purpose of project formulation is to develop a set of possible project proposals which fit in the systems of various interest groups.
   In this phase an inventory is made of various alternative solutions for the problems which were identified, and of the parties to be involved in each of those options; The specific objectives and resource constraints of these parties are analyzed; Available technological solutions, their economic costs and benefits, as well as particular constraints for their introduction are reviewed. In the case of the application of biogas technology this means that attention should be paid to:
   - the availability of primary matter (dung);
   - the (constant) availability of water;
   - the availability of firewood, or other alternative fuels;
   - the need of manure and/or fertilizers, and the value of the bio-fertilizer as compared to (e.g.) chemical fertilizers;
   - the need of infra-structural adaption at the farm, needed for a smooth introduction of biogas technology (e.g: adaption of the stable, need of gutters for influent supply and/or fertilizer removal, kitchen adaption, etc.).

   Output of this phase is one or more alternative project proposals which meet, to a more or lesser extent, the beneficiary's needs, and fit within the objectives of the other involved parties. During this phase management tools, such as investment analysis (= financial analysis) and a socio-cultural sensitivity analysis may be used to assess the feasibility of the proposed options.

3. Project appraisal:
   In this phase valuation of the findings of identification and formulation takes place in order to make a deliberate choice for one specific project proposal.
   The first action to be taken is the development of measurable criteria for the selection. In general these criteria refer to the extent in which the objectives of the project can be achieved and the constraints against its implementation can be removed. This process may be called "operationalizing of objectives".
   The second step is the actual measuring of the sets of alternatives against the criteria as developed previously. For that purpose comparisons between various options are required in order to get a clear idea of the best solution available. Aspects that are studied in this comparison are: the degree in which the problems can be solved and the objectives be achieved, the feasibility of the various options (economic, social, cultural and organizational)and the chace that constraints in implementation can be removed.
   It should be emphasized that not only quantitative data are to be considered, but that also qualitative information (e.g. improvement of job-satisfaction for farm-workers; improvement of the hygienic situation in the kitchen) should play a role in this process of valuation.
   The next step is to take a decision about the best solution

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[24] See i.e. F. Blankenberg, 1985, chapters 3 and 4

available and finally it is decided whether it should be introduced or not.

Quite often only one option as selected in an early phase by central level policy makers (or project objectives!) is considered, while in many cases no additional information is gathered about its specific characteristics.
Under such circumstances a comparison between options and even a valuation of the only option that was selected is not possible. If, nevertheless, the decision is taken to pursue its introduction, there is a good chace that it will be unacceptable for implementors and users and that problems will arise during implementation and operation.

SUB PROCESSES	NEEDED STUDIES
▪ PROJECT IDENTIFICATION - perception of the situation - setting and demarcation of problem area - output: problems to be solved and objectives to be achieved	- need assessment - problem assessment - monitoring and evaluation
▪ PROJECT FORMULATION - inventory of alternative options and parties involved * potential constraints of options * financial costs/benefits of options * specific objectives of parties * resource constraints of parties - output: set of project proposals	- technology assessment and - global design - financial Cost Benefit Analysis - sensitivity analysis - monitoring and evaluation
▪ PROJECT APPRAISAL - valuation of project proposals * development of criteria * measuring of proposals * comparison between alternatives - output: best option available	- feasibility studies - social CBA - assessment of best option - monitoring and evaluation
▪ INVESTMENT DECISION: YES OR NO - if yes: ——— project implementation	

fig. 5.4: The pre-investment process (after Blankenberg, 1985, p. 37)

During the pre-investment phase of the project the **participation** of the beneficiary in decision processes is of major importance. All too often the involvement of the "target-group" is restricted to the choice of the location of the biogas plant:

* During the phase of project identification need- and problem assessment studies should include at least a form of social analysis that tries to measure the (real) needs of a target population. Especially when a project is directed to a special kind of technology the risk exists that solutions are only found within the "product-mix" of the project.
  This leads to the suggestion that biogas-extension programme should have at least good contacts with other programmes that promote other forms of rural energy supply, small-scale manure production and/or sanitation.

* During the phase of project formulation it is very important that the budget the farmer is willing to spend is determined together with the beneficiary. He should be informed as precise as possible about the consequences of each option. As well as financially as concerning the costs and savings of labor time during the operation phase of his investment project.
  The beneficiary should also have an idea of the structure of costs and benefits of his investment: Financial analyses are always based on numerous assumptions, and after some years of operation it may appear that variations in prices have caused the investment to become a des-investment!
  Closely related to this is the problem of financing: The project should be able to inform the beneficiary about possibilities to obtain credits for his new investment. In case that bank loans are hard to obtain for a certain group of farmers the project may find a task in negotiation, or (if needed) warrant the credit.

  The choice of technology that is to be made during this phase should be discussed extensively with the beneficiary: The idea of the new technology must be supported, while on the other hand it should be avoided that the beneficiary has unrealistic expectations of his investment.
  Demonstrations, or working during some days with a demonstration plant may be useful in this stage of the project.
  However, the demonstrations should not be restricted to the owner or manager of the concerning farm; It is at least as important to workers who will have to operate the plant or use the gas (the cook!) to understand the consequences of the technology for their daily work.
  (In case of a (often horizontally structured) cooperative it may be recommendable to divide the tasks during the operation phase before the investment decision is taken!)

* Concerning the appraisal of the project it may be noted that it is not the task of the project to vote for some solution or another: The farmer is to decide, and his decision should be based on his (rationally or irrationally based) opinion and expectations of the options and his developed criteria.

5.3.2.2 The implementation process (plant construction)

Project implementation is the phase in which the project proposal as formulated and selected in the foregoing three phases is carried out. This process may be divided into (see fig. 5.5 and 5.6):

1. Making a detailed design, including plant allocation and kitchen specifications, to make the implementation process advance as efficiently as possible. This detailed design will consist of:
   - Site-selection, which depends on:
     * general farm lay-out, referring to the distance from the plant to stables or coral, kitchen, effluent compost pit and/or field where the bio-fertilizer is applied;
     * physical soil properties;
     * groundwater level;
     * next to this it may be desirable to construct the plant in such a place that the user of the gas can have it in sight.
   - Precise specifications and sizes of the plant, as far as these have not already been done in the project formulation phase;
   - The same for the kitchen, and the connecting (gas-) pipes;
   - Resulting from this: detailed material lists, inventory of needed human resources, needed equipment and transport;
   - Possibly selection of implementing organizations, based on a well-founded capability analysis of those organizations, and on consensus about the basic approach of the project and its implementation (especially with regard of participation of the beneficiary);
   - Detailed (network-) planning for the construction phase, also with respect to the need of (human and material) resources in time (together with implementing organizations);
   - Acquisition of materials; Contracting of personnel; Reservation of equipment.

2. The construction process itself, which can be divided into:
   - excavation of the basin in which the plant is built;
   - construction of the digester, storage tanks, and other works in which masonry is the prime specialty;
   - construction and installation of the pipework, the kitchen and other works in which plumbing is the main occupation.

   Figs. 5.5 and 5.6 summarize the aspects of importance in this phase.

   The implementation phase of a project is a part which can easily be board out to other organizations: local building institutions, e.g, who have more regular work for the building craftsmen, may be contracted to do the construction job. Another example is self-work of the beneficiary (-community): Especially the excavation work and other unschooled jobs can be taken care of, in order to reduce labor costs.
   It may be clear that contracting local institutions needs close coordination between the project organization and the contractor.
   - In the first place the contractors capacity (quantity and quality) must be examined, and some cases courses must be organized to tech needed, special building techniques (e.g. the chinese digesters!);
   - Next to this agreement must exist about the general approach of the project, especially concerning participation of the target group in the building process;

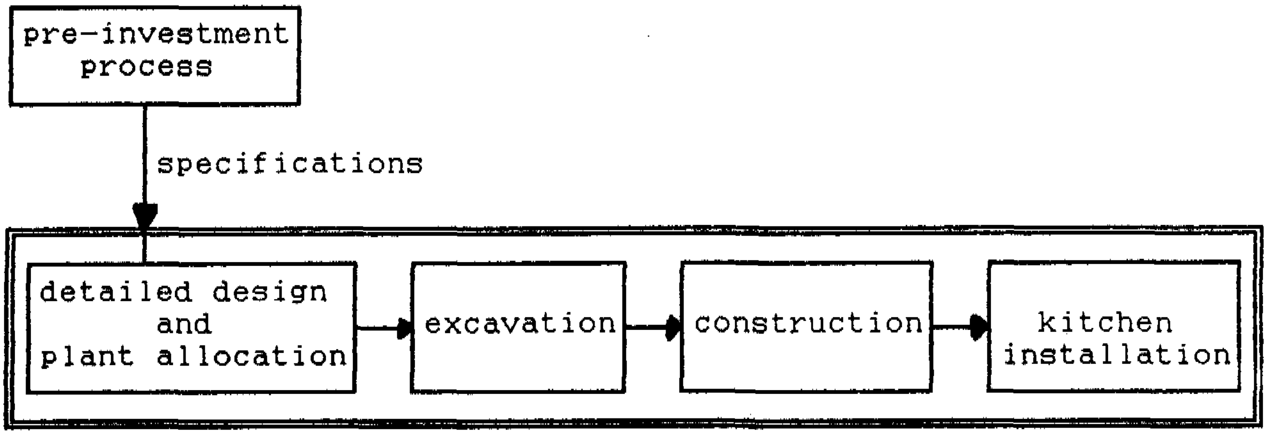


fig. 5.5: The implementation process

element \ phase	PRE-INVESTMENT	DESIGN	EXCAVATION	CONSTRUCTION	KITCHEN
FINANCES	- contract between project, bank & beneficiary	- reservation and allocation - capital planning	- budget control	- budget control	- budget control
PERSONNEL	- provisional planning	personnel planning contracting implementing org.	unspecialized personnel	development (construction techniques)	development knowledge transfer
EQUIPMENT	- provisional planning	- selection - reservation - planning	- transport - maintenance	- transport - maintenance	- transport - maintenance
MATERIALS	- provisional planning	- selection - acquisition - planning		- construction - transport - management	- construction - transport - management
INFORMATION	- plant specifications	- specifications of plant and kitchen - planning		- information and education of beneficiary	- informing farm-workers

fig. 5.6: Activity-matrix of the implementation phase

5.3.2.3 Introduction, operation and maintenance

Project operation is the phase after completing construction. It should be divided into an introduction phase, and the period beyond.

1. Introduction

Purpose of the introduction phase is to incorporate biogas technology in the existing working routine of the beneficiary. In most cases an information and training programme is a suitable means for that purpose. Attention must be paid to all sub-systems of the biogas system: supply of organic matter, water supply, gas use, the treatment and application of produced bio-fertilizer and the digester itself (see also fig. 2.3).

Organic matter supply:
The introduction of biogas technology usually leads to changing routines of cleaning of stables, corals, chicken-run or (in some cases) the fields. Aspects that needs attention in this respect are:

- dung treatment: Biogas technology puts requirements to the composition of the organic matter (water contents, C/N-ratio). This can be achieved by mixing certain additions, such as straw or rice hulls (with chicken dung);
  In those cases where dung previously was used in a composting process the habit may exist to mix too much addition to the dung. E.g, cow- and pig-manure need additions in composting processes, whereas they do not in biogas technology.
- cleaning frequency: the digester needs regular and frequent loading (usually at least once in 2-3 days) for optimal results;
- cleaning methods: Especially in those cases where cleaning was performed with abundant water (e.g. with hosepipe) dryer cleaning methods (e.g. with wheel barrow) must be introduced in order to avoid excessive dilution of the organic matter;

Water supply:
Water contents of the effluent is a very important factor for plant performance: Total Solid contents should be within the range of 8-15% for optimal gas production. In case to little water is added the digestion process may even come to a standstill. Points of interest for the introduction phase are:

- cleaning methods: see above;
- quantity of water added: The importance of the amount of added water should be emphasized and explained clearly. Often water supply is no problem during the rainy season, but in periods of water scarcity, when the liquid mostly is to be brought from a greater distance, mixing enough water is considered too much trouble. Acidification of the fermentation process may be a consequence.
- water quality: In cases where the water is chemically polluted (with insecticides, anti-biotics, heavy metals from small scale industries) the digestion process may be damaged to a fatal extent. In those cases alternative water sources (if present) should be used.

Gas use:
The introduction of biogas technology will bring about substantial changes in daily energy using practices, such as cooking, lighting and running engines. Here I will restrict myself to the use of gas for cooking.

Cooking habits are dramatically changed by the introduction of biogas. Most of these changes are improvements. They need, however, good attention when being introduced.
Aspects that need most attention are the following:

- Use of cooking equipment:
  A furnace is an apparatus that is (with her pipes, hoses and handles) quite different from the traditional wood-burning places or stoves. Next to this, mostly different pans need to be introduced, that give better heat transfer efficiency. Those things make that the woman of the house, or the cook of the community, is often forced to work with completely new technology, with all sorts of attending problems of accustoming and adaption.
  In Nicaragua many women had problems with this transition: The habit of keeping the woodfire burning during the day was very strong, and did not end with the introduction of the gas. Several reasons can be given for this:
  * The gas furnaces sometimes are not suited to heat big pans in a fast way. Stoking firewood may give a considerably faster result;
  * The smoke of firewood may cause a lot of irritation at the eyes, or even inflammations, but it is also said to keep all kinds of vermin (mosquitos, scorpions) away. Therefore, other weapons should be used to fight them.

- Economic gas use:
  One of the most difficult points of the use of gas is the regulation of the gas flow, which has a considerable impact on the heating efficiency of the fuel. Most people are inclined to open the gas-handle as far as possible, in order to speed up the cooking process. This leads to spoiling gas, which may become short in supply.

- Changing cooking schemes:
  In the biogas digestion process gas is produced 24 hours per day. Part of this can be stored in the (separate or built-in) gas storage. A consequence of this is, that there is only a limited amount of gas available to be used, and energy consuming activities should be spread over the day.
  This may conflict with the existing cooking schemes, and therefore be a source of irritation.
  During the introduction it is recommendable to review together with the cook the existing cooking schemes. If necessary a new planning should be made, so that the present gas stock is sufficient during the day.

- Safety aspects:
  Biogas is a mixture of explosive gases, such as methane, hydrogen, sulphur-hydrogen and carbon-monoxide. Instructions are necessary to avoid accidents, which may occur through leaking pipes, hoses or handles. Also instruction should be given how

to detect leaks: Some people would be inclined to use a candle or a match to find the source of evil-smelling gas.
Another point is the question whether biogas should be purified from sulphur-hydrogen before use. The latter causes a bad smell, and may therefore irritate. When the gas is used for cooking purposes, this must not be done: other components of biogas are smell-less; Leaks are only perceptible through the presence of H_2S.

- Trouble shooting:
  In case of no gas reaching the kitchen the cook should be able to identify the most regular technical troubles, such as:
  * gas being out of supply, caused by excessive water use;
  * blocking gas production caused by lack of reactor feed;
  * gas pipe blocking caused by the presence of water in the pipe;
  * an empty water trap, causing the gas to escape from the system;

Training and instruction may be given on the spot, or at a demonstration plant. In the best case the introduction is provided by a woman, preferably a cook from another farm, who daily works with biogas.

Treatment and use of bio-fertilizer:
The value of this economically most important product of the biogas process is mostly under-estimated: In Nicaragua little farmers make effective use of it, which may have several causes:
- unacquaintedness with the use of organic matter for fertilizing ends. This is especially the case with farmers who recently started agricultural activities (transition from extensive husbandry).
- Also farmers who recently started their independent farm, under the new land reform laws, often only partially know the value of organic manures. Chemical fertilizers, which have to be imported, have a modern look and are cheap.
- The same problem is found in some state-farms, which-have a relatively easy access to chemical fertilizers, and hardly bother promoting the use of organic manures.

Since the use of the bio-fertilizer is a pre-requisite to make a digester economically feasible it is extremely important that during the introduction phase attention is paid to training on the good use of manures. Aspects that should be treated are:
- Value of bio-fertilizer: advantages over chemical fertilizers, importance of organic matter for the fighting of top-soil erosion, presence of pathogens, etc;
- Treatment of bio-fertilizer: the effect of composting and storage on nutrient value and pathogen contents;
- Practical aspects: periods for application, techniques for dry and wet application, needed quantities, nutrient demand for different crops, etc.

It will be clear that this part of the introduction can best be provided by professional agricultural advisors, eventually after being informed themselves.

Use of the digester:
Instructions regarding the use of the digester must contain the following aspects:

- Daily use, with respect to loading and effluent removal:
  * Manure is best loaded daily, immediately after collecting. Drying causes the matter to become insoluble, and causes the loss of nitrogen.
  * attention should be paid to the importance of mixing organic matter and water before loading it into the digester.
- Maintenance:
  Most biogas digesters need very little maintenance. Only once in 2-3 years the digester needs to be emptied completely; The project organization might find herself a task in assisting with equipment, such as an adequate pump.
  Digesters of the chinese type need maintenance to keep gas storage gas-tight; After emptying the digester (once in 2-3 years) the gas-holder part should be plastered with a new concrete layer, and painted with tar.
  Digesters with a metal gas-holder needs annual painting, to fight corrosion. After 5-8 years the metal gas-holder needs to be renewed.
- Trouble shooting:
  In case of no functioning of the digester the beneficiary should be able to recognize and remedy some basic problems, such as:
  * obstruction of the gas-pipe by water or slurry;
  * removal of floating layers in the digester;
  * signalize leakage of the digester;
  * establish process problems, such as acidification and toxification.

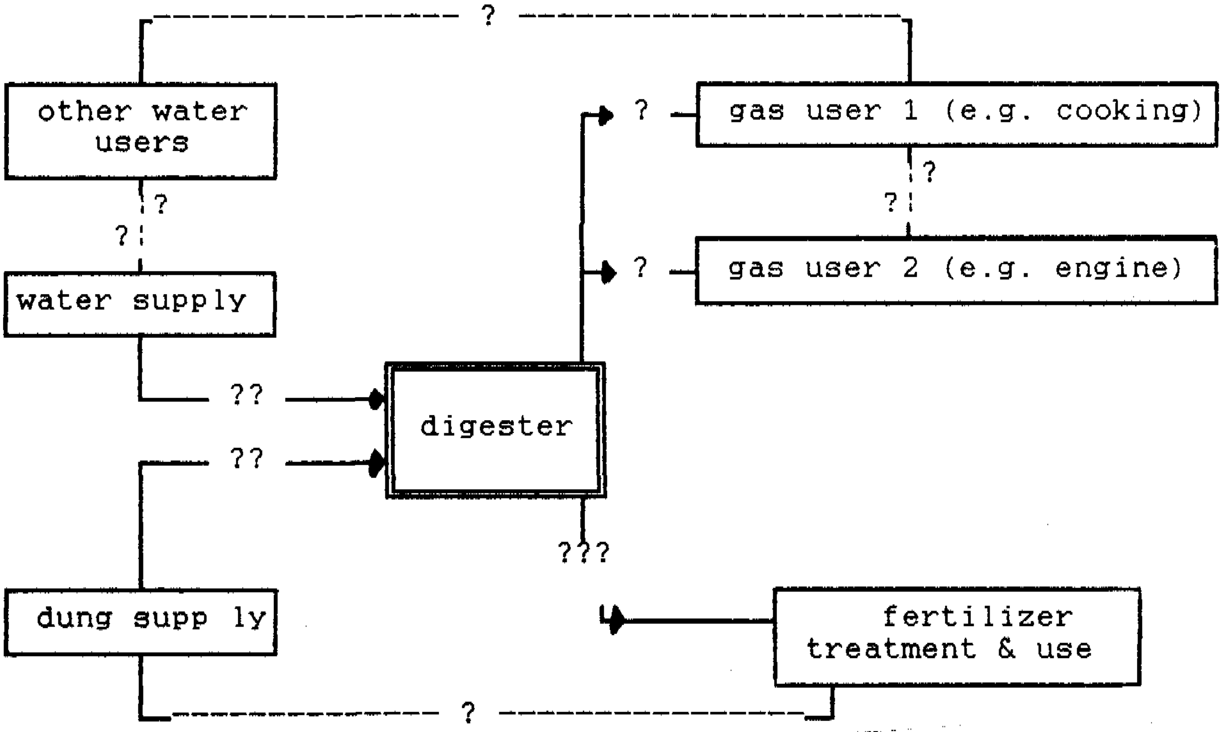
2. Operation and monitoring

After the introduction phase the longest project stage commences: The operation, maintenance, monitoring and servicing phase.
Most aspects of the operation already passed when discussing the introduction.
Some more attention should be paid, however, to the organization of the work at farm level.
Aspects on the involvement of other organizations, especially of interest for servicing and monitoring, are treated in a separate paragraph (see 5.3.2.4).

The introduction of biogas is always a source of much excitement and tensions in a community. Reason for this will be that the biogas system takes a very central place in the community: It finds itself in a position, in which it influences as well the working, as the private situation.

In many situations the implementation of biogas technology in a farm gave problems in the internal organization. For that reason this aspect will be examined in more detail.

The separation of tasks and responsibilities at farm level can again be made using the system approach of the biogas system (see fig. 2.3). In fig. 5.7 a sociogramme is presented which indicates some potential (functional) conflict lines around the biogas plant.



* —— ? —— = direct contact and potential conflict line
* -- ? -- = potential conflict line

fig. 5..7: Biogas system: Sociogramme

In fig. 5.7 a distinction is made between the direct contact lines, which may have a conflicting character, and indirect lines.

* The direct contact lines show the relations between the various sub-systems. That those relations are also potentially conflicting will be clear when it is considered that the users of gas and fertilizer are dependent on the preceding steps iin the process for their resources: When the installation is not regularly loaded the cook may not have sufficient fuel to prrepare the meals.
* Next to these their are also ppossibly conflicting relations in cases where competition for resources exist: In the dry period competition between the various water users may exist about the distribution; When more gas-users depend on the produced gas allocation problems may arise, etc.

These relations should be taken into consideration when tasks are divided, in order to avoid too stormy or even violent conflicts.

A general remark concerning the division of tasks and responsibilities within the beneficiary-community is, that this division should in the very first place be **clear**. There should be a clear definition of all responsibilities, tasks and planning within the community. Problems can be expected in communities that have a very informal structure. In those cases it is e.g. possible that biogas as a technology is wanted, but that nobody wants to perform the necessary, but low-status-tasks of loading the digester. Therefore consensus about the division of responsibilities must exist, eventually it may be necessary to reach it before starting the construction phase.

Monitoring should be done on the technical as well as the social performance of the applied biogas technology: Next to the collection of data on gas-production, loading of primary matter and water, it is very important to know how the target population **experiences** the newly introduced technology.

Technical data to be recorded are:

- daily load of primary matter and water
- daily production of gas
- daily production of bio-fertilizer

These data are useful for the judgement of the technical performance of the system. They may offer a better grip on the design process, and are a base for economic evaluations.

Next to this the following social aspects should be evaluated:

- how are the products of the plant (gas and fertilizer) used?
- how is daily operation and control managed and organized within the community?
- how do people experience biogas in their daily life?
- what are the actual costs and benefits for the community?
- does the plant meet the expectations of the target group?

5.3.3 Secondary processes in the biogas programme

Next to the primary process 5 secondary processes are needed to facilitate the primary process resources and information in order to achieve the organizations objectives: Research and Development, Supply of resources, Training and education, Marketing, and Administration (see fig. 5.3).

5.3.3.1 Research and Development

R&D activities in a biogas extension programme should be performed to such an extent that they support the primary process in solving certain technical, practical problems. These problems should have a direct relation to the main project activities. Fundamental research on biogas will, in general, <u>not</u> be a take of a biogas extension programme.[25]
As a result, R&D activities may, e.g, be aimed at solving the following problems:

* the fermentation of certain materials, with which little or no experience exists. Gained knowledge can directly be applied in a practical situation;[26]
* standardization of design in a specific local situation.[27]
* enhancement of gas- or fertilizer- production through experiments after the optimal mix of water and organic matter;
* treatment and application of bio-fertilizer, with regard to storage, treatment, crop choose, soil characteristics and other locally depending parameters;
* the use of biogas in various types of burners, lamps, engines, etc.

R&D may be done on lab-scale or on pilot scale. In both cases it may be cooperated with local institutions, such as research institutions, universities, schools and laboratories. Participation of the beneficiary-owner of the pilot plant- should be pursued.

5.3.3.2 Supply of resources

The programme organization may play a promoting role through the organization and coordination of acquisition of financial, material or human resources:

<u>Financial resources:</u>
For financing, various alternatives exist, in which the programme may play an important role:

* Finance through **own money**: In Nicaragua many enterprises and big farms have much money in local currency, and many of them lack potentially profitable investments for inflational reasons. Biogas may be such an investment.
* Finance through **bank loans**: The National Development Bank (BND) provides credites on productive investment, on very attractive conditions (± 30%/year for a one-year credit; inflation: 350% in 1985). The programme may play a role in negotiations with

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[25] see U. Werner, Stöhr and Hees, 1986, p 161
[26] see, e.g, Sofia Bonilla Garcia, Georg, Hoffmann, Ullrich, 1985
[27] see, e.g, A. Schlusser, 1985

the bank through the provision of information on feasibility and economic profitability of the investment. For small farmers the project might bail for return of credits.

* Credits from the **project budget**: In case banks do not give credits the project may provide, for individual cases, credits. In case of pilot- or demonstration plants the project may give financial support to encourage participation.

Material resources:
In an economy that suffers from scarcity it may be very useful to perform the acquisition of material in a centralized way: The project should have good contacts with local producers or wholesalers of materials; In case of foreign goods the programme organization may take care of imports, through direct contact with importers, foreign suppliers, or a foreign contact organization.
Certain equipment, needed for construction or servicing (e.g. a pump) should be within the organization and at the disposal to be put on at the beneficiaries or contractors request.
The programme organization should have a good overview of the supplier-market and know where needed material resources can be obtained.

Human resources:
The programme organization should have a good overview on the local labor market: Local craftsmen or contractors should be registered and their capacities and specialties should be known, regarding all necessary activities: Design, construction or servicing of plants, burners, stoves, etc.
Best is to have the disposition of a regular set of craftsmen and/or contractors, and keep a pool for replacement and/or completion.

5.3.3.3 Training and education

Training and education of the various related groups is a very important task within the programme, that introduces a new technology into a society.

Target groups for training and education programmes for biogas may be:

* engineers, and local counterparts
* local craftsmen and contractors
* owners, institutions, etc
* operators and users, with as a special group
* cooks and housewives.

It will be clear that all these target-groups have a different need of information and require a different training approach.
Fig. 5.8 gives an overview of possibly needed courses with target-groups and possible trainers.

Target group	Method	Subjects of instruction	Training periods	Instructors
House-wives	On-the-spot training on their own biogas systems and biogas-fueled stoves (if possible), visits to other house-holds, performance of repair work under supervision, cooking tests on stoves of various type and make with different burner settings.	System function, operation and optimum utilization, troubleshooting, minor repairs, optimum flame adjustment, most appropriate stoves, cooking prac-tices, recipes, safety aspects	if possible: repeatedly	servicing staff, women with biogas experience.
Farmers	On-the-spot training on their own biogas systems and fields, visits to other farmers, laying out of small test fields for experimenting with different kinds of fertilizer, instal-lation and use of compost pits.	System function, operation and optimum utilization, safety aspects, fertilizer value of digested sludge, fermentation.	if possible: repeatedly	servicing staff, agricultural advisors
Servicing staff	Seminars and training courses (local), (model-)tests, tours.	System function, various systems, types of construction, materials, effects of temperature/ feedstock/ retention time/ consistency, trouble shooting, utilization of gas and fer-tilizer, safety aspects	annual courses, refresher courses, supervised prac-tical work	Senior servicing staff, agricul-tural advisers, engineers.
Craftsmen and con tractors	Seminars and local training, system construction, tours.	System function, various systems, material/construction know-how, produc-tion methods, performance of repairs	introduction course, plus prac-tical proficiency training	Engineers, senior craftsmen
Organizers	Seminars and tours, visits to various institutions (banks, authorities, government agencies)	Correlations between social and finan-cial cost-efficiency analyses, plant function, advantages and drawbacks of different systems, household vs. commu-nity systems, use of local materials, social correlations, administration (bookkeeping, planning, promotion, application, approval procedures)	two-weeks intro-duction course, plus excursions	Biogas experts, engineers, agri-cultural experts, sociologists, business admini-strators with farm management training
All of the above	Workshops, seminars	Individual subjects	Revolving	Experts and specialists

fig. 5.8: Typical aspects of biogas training programmes.
source: J. Hohlfeld, 1985

5.3.3.4 Marketing aspects

The task of the marketing sub-process is to facilitate and expedite exchanges within the (dynamic) environment[28].
Within a biogas programme marketing activities contain the following aspects:

- Determination of and successful operation in the market of renewable energy sources. Need for various technologies (biogas and others), and adapt the product mix to the markets needs. Indicators which can be used to determine the eventual product mix may be obtained through:
  * direct contacts with clients;
  * market research;
  * observing economic indicators, market prices, etc of other (traditional and renewable) energy sources, and of fertilizing. Use can be made of financial and social cost-benefit analyses.
  * Contacts with institutions which are active in the same field of renewable energy sources and fertilizer provision;
- Promotion aspects, of which the most suited to elevate the targets of a biogas extension programme are:
  * Personal contacts with the beneficiary.
    Directly, through visiting farms in concentration areas, or indirectly, through visiting supporting organizations of those farmers (UNAG, MIDINRA) or participation at specialized congresses or trade fairs.
    As an important source of working capital good contacts should be kept with foreign financiers; Individual projects, research and development activities, information campaigns, etc. may financially be supported by them.
    Use can be made of demonstrations, visits to other plants and informative and promotional material (folders, brochures, etc).
  * publicity:
    Promotion via local newspapers, radio stations and television, and via more specialized media such as information bulletins of agricultural institutions. It will be clear that keeping good contacts with them is of crucial importance.

5.3.3.5 Administration and bookkeeping

Next to regular bookkeeping it is important to administrate project-wise regarding planning and after-calculations.
In this way project planning and control may be improved, as well as costs calculations.

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[28] Pride and Ferrell, 1983

5.3.4 The environment of the programme organization

5.3.4.1 The mother organization

The relation between the (often temporary) programme- and the mother organization may be of major importance to the quality and functioning: It is within this organizations that activities are to be developed, projects have to be initiated, and supporting processes should function.

The position of the programme within the mother organization may be as a regular part of an organization of which the goals correspond to the programme goals. In that case, a biogas programme may be a department next to other renewable energy - or appropriate technology diffusion programmes.
In another case biogas may have only slightly to do with the primary objectives of the mother organization. Such is the case when the programme is fit in, e.g, regional departments of an energy institute (whose main target is urban electricity provision) or of an independent farming organization (e.g. ENPRA).

In the first case will be fit in (if it doesn't already origin from) an existing organization with it's own culture, rules, procedures and with centralized supporting departments (administration, project preparation, construction-workshop, etc). The programme will be largely dependent on the mother organization, at it may be difficult to shape an own course of action.

In the latter case (for which goods reasons may be at stake) the biogas programme will likely be an exceptional part, in which other rules may be needed than in the rest of the organization. It may be necessary to set up separate supporting organizations, and it is likely that a different sub-culture will develop in this part of the organization. The programme will have the opportunity to develop more independently from the mother.

This may be important since the programme, at least in the start-up period, may need a certain independence to develop her strategy. When implemented into an institute with existing, corresponding activities an existing bureaucracy may disturb or inhibit the own development of the programme. On the other hand: In a corresponding organization use can be made of the experience the other programme had, and the culture will be formed to the needs of the (to biogas-dissemination similar) programmes.

As a result of this no general or optimal structure can be given of a biogas programme. Processes, as outlined in 5.3, should be present (and above all:function!) in one form or another, but how they are structured does not seem of vital importance.

Regarding to power relations with the mother organization, and the independence in strategy, it may be remarked that the needed liberty depends on:

- the character of the programme (experimental, pilot-, demonstration- or dispersion);
- the goals, task-objectives and culture of the mother.

5.3.4.2 Other organizations

The number of executing organizations involved in the various stages and the division of tasks between them depend on a number of factors, of which the most important are:

* the size of the biogas programme;
* the (geographical) concentration of activities;
* the existence, capacity and experience of local craftsmen and/or organizations.

As a consequence no blueprint can be presented for the organization of a biogas programme and the relations with its environment. However, some statements can be made:

1. From the point of view of integration of new technology in society and transfer of knowledge it is important to involve various local organizations in the control-phase of biogas projects;
2. Especially in an expanding programme practical tasks should be pushed off to local craftsmen, so that the programme organization can occupy herself with more stimulating and coordinating activities. In this way a decentralization and a dispersion of knowledge and experience can take place;
3. For the quality of the project it may not be so important how the various tasks are divided between involved organizations. More important is, that all necessary tasks are performed in a regular and qualitatively good way.

An example of the division of tasks within a biogas extension programme is presented in figs. 5.9.[29]

Figs. 5.10 and 5.11 summarize the relation between the various sub-processes and other organizations (except for the mother-organization).[30]

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[29] From: Werner, Stöhr and Hees, 1986

[30] Derived from E.J. de Bruijn and B. van Bronckhorst, 1982

activity	local craftsmen	beneficiary	project/ government
- programme planning; R&D; strategic dissemination concept;	* participating	* participating	* leading
- planning of single plants; standardization of design;	* leading	* participating	* leading
- information and beneficiary advisory;	* leading		* supporting
- financing		* own capital	* credit, subsidies
- construction of plants:	execution	help	
o excavation	*	*	
o construction	*		
o installation of piping and equipment;	*		
o adaption of the stables	*		*
- acquisition of materials and equipment	* local available		* import & rationed
- introduction	* techn. advisory	*	* supporting, mangement advisory
- maintenance	*	*	
- repairs	*		
- training of craftsmen	*		* execution
- marketing	* needs		* leading
- legal aspects			* leading

fig. 5.9: Example of the involvement of contractors

organ \ process	PRE-INVESTMENT	EXCAVATION	CONSTRUCTION	INSTALLATION	AFTER-CARE
BENEFICIARY	- participation in all elements (see 5.3.1.1)	- participation with unschooled labor	- idem	- idem	- introduction (see 5.3.1.3)
FINANCIERS	- contacts about loans for specific projects.	- budget control	- budget control	- budget control	- financing major repairs
LABOR MARKET AND CONTRACTORS	- orientation - contractors for specific projects	- contracts (see 5.4)	- contracts - execution	- contracts - delivery & installation	- servicing & reparation
SUPPLIERS	- orientation	- ordering	- delivery materials & equipment	- delivery materials & equipment	- ordering & delivery
RELATED ORGANIZATIONS	- advisory on specific projects	- advisory in specific projects			- advisory, exchange of results, monitoring

fig. 5.10: Environment matrix for the primary process

organ \ process	ADMINISTRATION	R&D	ACQUISITION	TRAINING & ED.	MARKETING
BENEFICIARY	- planning - budget control	- participation in pilot projects		- introduction phase - workshops	- contacting & information - publicity
FINANCIERS	- budget control	- financing of R&D activities	- acqu. of project capital	- financing of T&E activities	- overview financing institutions (local and foreign)
LABOR MARKET AND CONTRACTORS	- budget control - labor contracts & conditions		- acqu. of personnel and contractors	- involvement of craftsmen & contractors	- overview labor market - overview local contractors
SUPPLIERS	- budget control	- delivery of materials and equipment	- ordering & delivery of materials and equipment	- information and presentation of (local) materials	- overview of available products
RELATED ORGANIZATIONS		- participation - exchange of results		- participation - exchange of experience	- overview/importance of other techniques; - promotion & publicity

fig. 5.11: Environment matrix of the secondary processes

Chapter 6: The programme of the Instituto Nacional de Energía (INE)

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Chapter 6: The programme of the Instituto Nacional de Energía (INE)

6.1 Introduction and goals

This programme started in 1982 with a subsidy of the FAO to the Latin American Organization for Energy (OLADE) to develop biogas technology in a number of latin american countries. In these years, the oil crisis still had a considerable impact on the national economy (For Nicaragua: ± 20% of national expenditures in 1978 -'82,[1] while obtaining oil became more and more problematical for Nicaragua) which, in combination with heavy foreign debts, stressed the need to save foreign currency.
For the execution of the programme, OLADE cooperated with the national energy institutions of the countries concerned, in this case the National Institute of Energy (INE).

Objective of the INE-programme was the introduction, dissemination and promotion of biogas technology in most general terms.
Underlying reasons (or 'raison d'être'[2]) for this were:
1. to save energy that otherwise had to be imported from outside the country;
2. to save (imported) chemical fertilizers;
3. to fight unacceptable contamination of the environment by certain agro-industries, such as coffee and cheese factories;
4. to save firewood in the rural areas, in order to fight deforestation and erosion problems.

In my opinion the INE biogas programme was more justified out of macro-economic considerations than out of motivations from the point of view of the (less well-to-do) farmer.
This opinion, however, is based on a personal impression after some months working with the INE department, and from interviews with co-workers[3].
Written statements on the programme's objectives could not be exposed.
The same statement can be made on the rest of the analysis in this chapter.

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[1] Lunes Socio-Economico de Barricada, 1983-'84, and see chapter 3
[2] after D.Newman, 1973, p.68
[3] Cándido Tablada, Guadalupe B. and Reynaldo Vegas should be mentioned here

6.2 Task objectives and primary process

The task-objectives that were put to the programme were the following[4]:

1. the selection of an optimal reactor design for biogas plants for the specific applications in the local situation;
2. At the same time the installations were to serve demonstration ends, to promote dissemination of the technology at a larger scale.

For that purpose, experiments were set-up with 6 different reactor designs, using 3 different substrates. During 1980-'81 12 biogas plants were constructed, to ferment the various organic materials (see fig. 6.1).

project	year of constr.	prop.	target group	prime matter	type	volume of plant (m³)	use of plant
1. Nagarote (León)	1981	coop*	rural community	cow dung	China	12	not in use
2. La Borgoña (Masaya)	1981	coop	rural community	cow dung	China	12	not in use
3. El Tamagas (Xiloa/Chiltepe)	1981	APP**	farm community	cow dung	PF-Xoch.-Mex.	16	not in use
4. El Escobillal (Chiltepe)	1981	APP	farm community	cow dung	PF-IIE-Mex.	30	in reactivation
5. Marcell Pallais (Tipitapa)	1981	?	farm community	cow dung	PF-IIE-Mex.	2*20	not in use
6. La Revolución (El Crucero)	1981	APP	farm community	coffee pulp	BT, OLADE	2*9	not in use
7. Los Alpes (Matagalpa)	1981	APP	farm community	coffee pulp	BT,OLADE	2*9	experimental
8. El Trabajo (El Crucero)	1981	APP	farm community	coffee pulp	BT, OLADE	2*9	not in use
9. Cacho (Juigalpa)	1982(?)	APP	cheese factory	cheese wastes	Red mud	20	destroyed
10. ENAMARA (Condega)	1985	APP	slaughter house	slaughter waste	PF	130	in reactivation

* = cooperative ** = state farm (Area Propriedad del Pueblo)

fig. 6.1: List of installations built by INE[5]

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[4] R. Vegas, C. Tablada: pers. comm.

[5] Composed from data of N. Bobulesco, G. Ortolano, 1986; INE, pers. comm., own observations

They were located at various places all over the Pacific and Central Zone of Nicaragua, with the idea that in this way the technology would be used at the locations were it would be needed. and where the conditions were right for biogas applications. It was chosen for a scattered implementation to come to a widespread implementation of the technology (fig. 6.2).
Furthermore, it was thought that direct rural implementation of biogas technology would have a promotional effect for an eventual more massive dissemination of the technology in Nicaragua.

The implemented plants were regarded as pilot-plants, and were mostly located at state-owned farms, that were being developed at that time in Nicaragua.

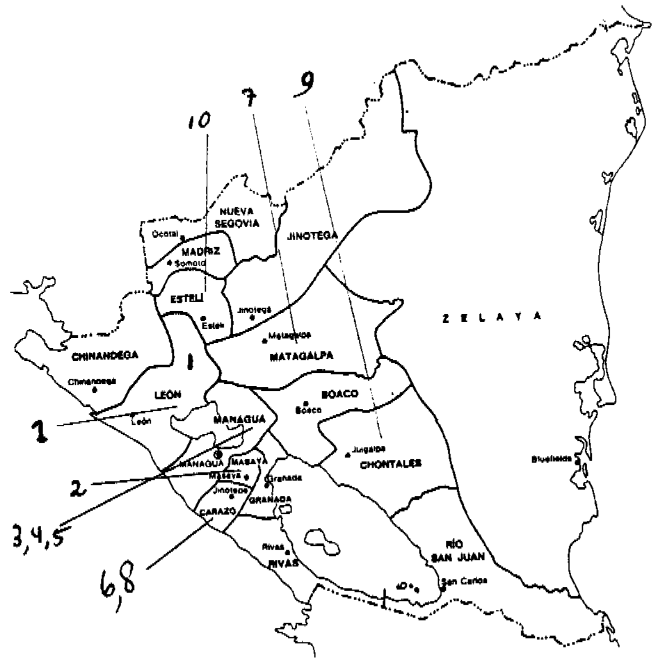

fig. 2: Map of Nicaragua, with locations of INE's plants

Operation and maintenance of the plants were supposed to be performed by the local people, who were to enjoy the use of the produced gas as well. Operation would be attended by the Office for Alternative Energy of INE, where a division of Biogas had been founded with some personnel (2-3 technicians, 1-2 constructors) and facilities (transport, field laboratory equipment, construction workshop).

In 1983 all constructed plants were out of work: Technical, environmental and social circumstances caused the plants, one by one, to cease functioning, and the fresh biogas-team from Managua was insufficiently equipped to overcome the plant break-downs.

During the following four years the managuan biogas team tried to repair and re-activate the plants. For that purpose the team did several technical repairs to the various plants, sometimes in cooperation with other institutions (the UNI/DINOT- and CITA-INRA/GTZ programme).

Occasionly some experiments were done with the installations, but none of them ever really functioned for a substantial period (say, more than a year).

In 1986 the year budget of the biogas team, that up to that point was financed by INE, was refused by the National Investment Fund (FNI).
During 1986 it was unofficially, but plurally announced that the biogas office would be closed[♠].

[♠] INE, pers. comm.

6.3 The basic organizational structure

6.3.1 INE's renewable energy programme

As such the biogas programme fitted in what is now the alternative energy programme of the institute, which has its residence in the Oficina de Fuentas Alternas de Energía (OFAE), and resorts under the vice-minister of Planificación (see fig. 6.3).

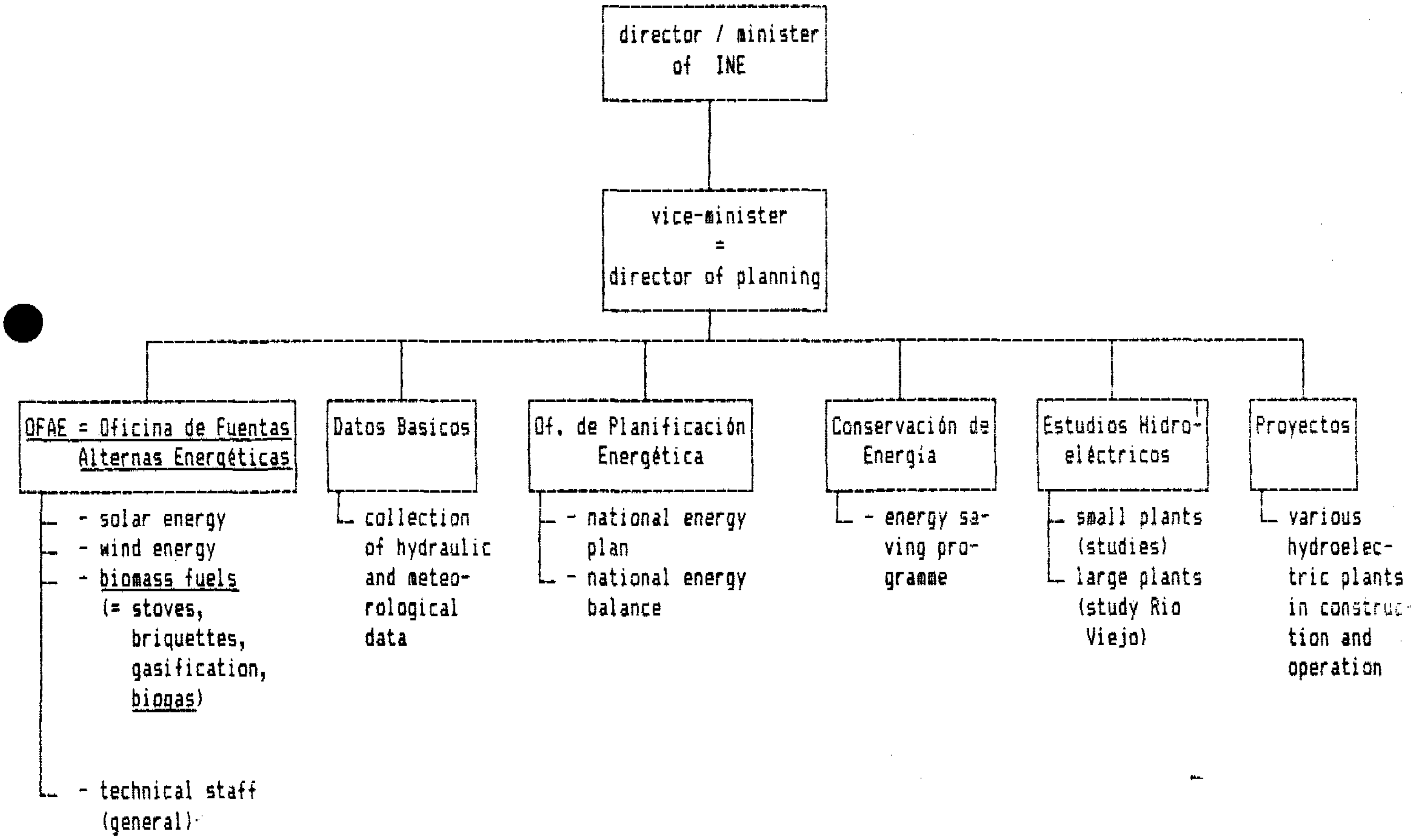

fig. 6.3: Organization scheme of the planning division, with the place of the biogas (approximative, april 1986)

The scheme of fig. 6.3 should not be considered as the absolute truth; It is only one way of analyzing the institute, and more opinions on "how INE is structured" do exist.

Although the various (sub-)departments in OFAE surely differ considerably in their approach, in general the objectives of the departments are realized through the following activities:

1. studies
2. applied research and experimental projects
3. pilot and demonstration projects
4. information and education campaigns,

all in the field of (mostly rural) alternative energy production and conservation.

As such the activities have a rather experimental character, and concern only with energy-technologies that are (at least in Nicaragua) still in development.

At the moment of writing it is not very clear whether the stoves, the gasification and the biogas projects of the biomass-office still exist; During 1986 some considerable changes have taken place in OFAE, among which a re-organization and the termination of one or more (sub-) departments.

6.3.2 Internal organization of the programme

The programme itself is organized as a small project team, with 2 permanent co-workers (a senior agricultural engineer and an agricultural technician).
Next to these two one technicial (as well constructor as metal worker) is at a more or less permanent disposition of the programme. (Some years ago the programme had substantially more co-workers at her disposition, but since a few years the programme seems "depriorizado".)
The senior-engineer is responsible for the programme and therefore occupies himself more with contact with management of OFAE and with other the other renewable energy programmes within INE, or outside the organization.
In practice the agricultural technician performs more administrative tasks.

Field visits and technical jobs are mostly done together.

If necessary extra manpower is recruited from staff personnel within the OFAE, or from other renewable energy programmes.
Next to this some functions are executed by central organs, such as administration, planning of transport and drawing (of designs)).
For a more detailed division of tasks between the programme and the mother-organization is referred to § 6.4.4.1.

6.4 Programme analysis

In this paragraph the programme will be analyzed in detail. Since the objectives of the INE programme, identified in § 6.1, correspond to the pre-supposed objectives of a biogas programme in § 5.3.1 the evaluation is performed according to the analytical framework derived in chapter 5.

Therefore the objectives of the programme will be considered in detail first, after which the primary process and the secondary processes will be analyzed and, por fin, the relations of the programme with its environment.

Each process-step will be evaluated for <u>completeness</u> (whether it was carried out at all) and for <u>quality</u>.

6.4.1 Objectives, task objectives and project classification

Because of the novelty of biogas technology in Nicaragua and the in-experience of the new biogas team it was decided to set up the programme with task-objectives which, in Rondinelli's classification (see 5.2) are characteristic to the following project types:

1. **Experimental projects:**
   The plants were to serve research purposes.
   The idea behind this was that although biogas technology seemed sufficiently technically developed, specific local circumstances would put constraints to the applicability.
   These constraints were regarded as **technical** factors: Because of the overwhelming amount of existing (and propagated) reactor designs it was decided to use the experiments to identify the most suitable reactor design for the digestion of several locally available reactor feeds.
   This task-setting, based on technical arguments, leads to the strategy to test several reactor types for different types of primary organic material.
   The designs were obtained from other latin-american institutions, experienced in biogas (Mexico (IIE and Xochicalli) and Guatemala (OLADE). The chinese reactor designs may have been obtained through the same organizations)[7].
2. **Pilot projects:**
   The experiments were to be executed on a pilot-scale. This seemed justified since they already had been tested and applied by the designers.
   In practice this meant that the plants were built **in situ**, (i.e. at farms where the application of biogas seemed useful), and on a scale at which they could contribute, to a more or lesser extent, to the energy and fertilizer needs of the farm.
3. **demonstration projects:**
   The division of the plants over Nicaragua (see fig. 6.2) can only be explained for if demonstration objectives played a role. The same design- and prime matter- combinations were applied at various locations, far from each other.

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[7] C. Tablada, pers. comm.

In the case of the coffee-pulp digesters, for example, two different major coffee producing areas were selected for building exactly the same type of process and plant design: El Crucero (south of Managua) and Matagalpa. For experimental -or pilot- project objectives this would not have been necessary in the first place.
Only if the plants were to fulfill a spear-point function in the demonstration and dissemination of biogas technology such a strategy can be explained for.

This multi-task setting may be explained for from the conditions on which the financial support of OLADE was given: All expenditures were to be done before a certain date at which the project was to be terminated (dead line).
As a consequence of this, more projects were applied for than actually could be overseen, which lead to the known fatal consequences.

Next to this it may have played a role that the international OLADE/FAO project aimed to finance demonstration, rather than experimental projects. In order to stay within the term of reference demonstration ends were to be included into the programmes objectives.
If this actually was the case, it should be concluded that the FAO/OLADE programme did not correspond to the needs of the nicaraguan situation.

6.4.2. Primary process analysis

In § 5.3.2 (page 5.13, and fig. 5.3) the primary process was divided into three sub-processes, which (more or less) correspond to the phases of a project cycle for implementing biogas plants(pre-investment, implementation and after-care).

Within the INE programme these sub-processes correspond to the logical phases of the INE-OLADE implementation project of 1981-'82, in which 8 out of 10 INE plant locations had been constructed. The other plants (Cacho, 1982 and Condega, 1985) can be evaluated, as individual projects, within the same framework.

6.4.2.1 Pre-investment

In the pre-investment stage a most feasible solution to an identified need should be formulated, and it should be anticipated to problems which may occur in the implementation- or operation phase.

The fact that none of the INE plants functioned in the period 1983-'86 for a substantial period already suggests the need of a critical look at the pre-investment phases of the projects.

6.4.2.1.1 project identification

The purpose of the identification stage of a project is to identify the needs of a certain target group, or to assess the problems to which the project should offer a solution.

* The INE project was initiated after suggestions from the Latin American Organization of Energy Development (OLADE), who had obtained financial support from the Food Organization of the United Nations (FAO) to initiate the dissemination of biogas in several latin-american countries.
  So the project was initiated <u>from above</u>, rather than after an estimation of the most urgent needs in rural Nicaragua, and without receiving requests of support from the agrarian population.
* After the suggestion from OLADE that financial support may be available for activities of this kind INE set up an organization to prepare the programme. The offered support would be composed of financial resources to implement a certain **quantity** of biogas plants, and equipment for the construction and after-care of the plants (a vehicle, tools, pump, workshop-equipment for gas-users equipment, etc).

Based on the task objectives locations were selected for the construction of the plants.
But in which way took this selection of locations place?

Looking at the division of the plants over the agricultural tenure-sectors in fig. 6.1 it can be concluded that 2 of the selected enterprises were cooperatives (La Nagarote, La Borgoña) and that the other 5 were state owned. The 2 plants that were build after the OLADE project were also state-owned.

This indicates that the plants were located at the spear-points of the agricultural policy in young revolutionary Nicaragua. At the time of planning the digesters of the OLADE programme, land reform was still in her first turbulent phase, in which ex-Somoza-properties were transformed to (principally) state-enterprises (see 3.3.3).

In 1981 the Law on the Land Reform was denounced, which gave rise to the formation of new cooperatives and private farms.
Although not officially the sanidinist policy of those days preferred state-farms and cooperatives over the private sector, so from a political point of view it was logical that the selected locations were in the preferred sectors. This opinion is reinforced when it is considered that the needed investments in the plants were donated from the FAO-funds.

The top-down approach in the selection of locations can be painted into detail, when the hierarchical structure of the state-farm organizations is also involved in the picture (see fig. 6.5): INE contacted the management board of selected state enterprises, who in turn, after deciding to participate in the project, ordered the farms (UPE's, or production units) to participated in the biogas activities.
It must be assumed that the managuan programme did not have any contact with the population of the UPE's about their needs, at this stage of action.

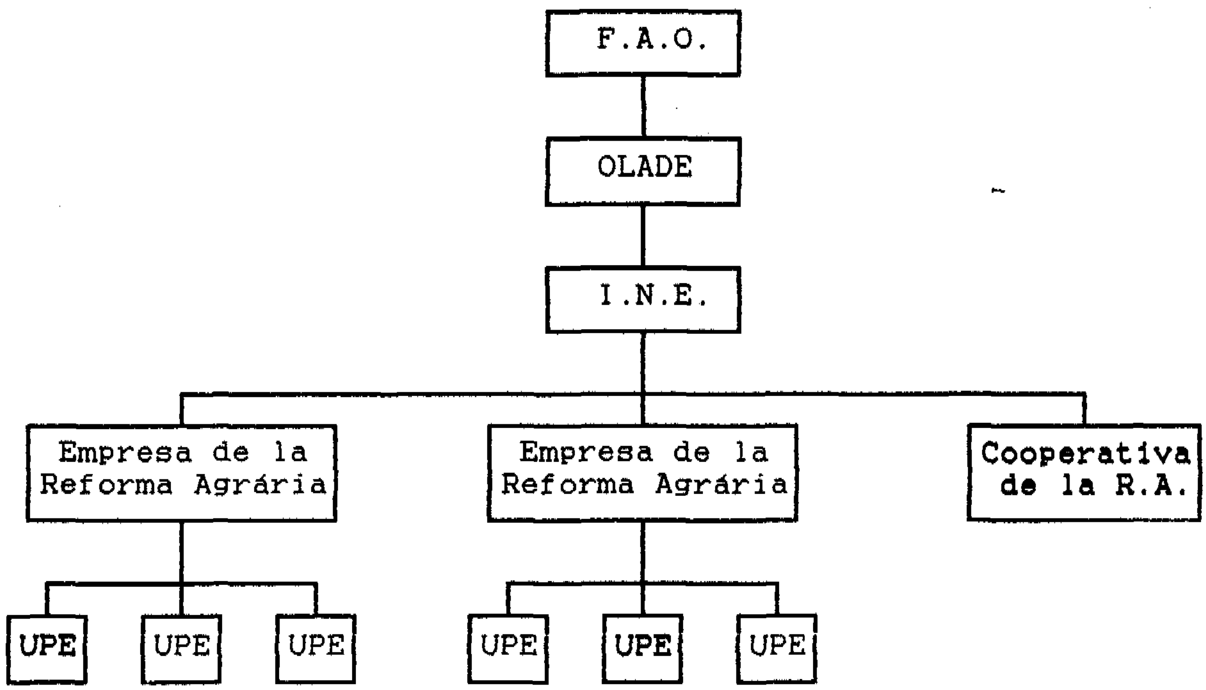

fig. 6.5 : Selection structure of plant locations

Another argument that supports the supposition that too little attention was paid to project identification is the simple fact that the project concerned itself with only one technology. In other words: With the solution in mmind problems were sought. This reverse application of tthe problem-solution-cycle lead to situation where non-optimal solutionss were applied to non-prioritary problems.

For example: The fermentation of coffee pulp is often justified as a solution to environmental pollution problems: Coffee processing industries produce a lot of wastes (4 tonnes of pulp and 10 m^3 of wastewaters per 10 tonnes of berries). These wastes are often inappropriately disposed, with heavy environmental pollution as a result.
In Matagalpa and El Crucero the urban population is troubled with the effects of this pollution: Contamination of the drinking-water supply is the consequence of careless waste management.
Digestion of coffee pulp was proposed as an (at least partial) solution to this problem. If the pulp would be processed and used for energy production, people would be motivated to better waste disposal. Annoying effects of the processes would be taken away.
This may be right.
However, the way the biogas programme approached the situation gives rise to questionable priorities and wrong solutions: With fermentation of coffee pulp as a solution in mind the problem of environmental pollution by coffee wastes was attacked. With as a logical solution: Fermentation of coffee pulp.
It should be mentioned here that process technology of fermenting coffee by-products was not readily developed yet: Several research institutes in the world (also central-american!) had several problems executing the process. It should have been known to INE that digestion of coffee by-products was still in an experimental stage in other countries, and that application at pilot scale would require substantial input of expertise.

Another approach would have been to take the environmental problem as a starting point. In that case it would have been concluded that:

* during the coffee harvest it is not the coffee pulp, but the irresponsible disposal of <u>wastewater</u> that causes 80% of the contamination to the drinking water supply*;
* more methods of coffee pulp re-use exist. One of them is composting, and use as a fertilizer for the coffee crops.
  This process is applied by many (**private**) coffee farmers in Nicaragua, but not in state farms.
  These other (and more obvious) solutions, and their problems at implementation, were not considered. An investigation at the causes of the difference of approach between private and state-enterprises seemed a logical step before looking for <u>technical</u> alternatives for pulp re-use.

Concluding, it is my opinion that this approach lead to an (at least) disputable solution to a problems which should not have had priority.

6.4.2.1.2 Project formulation

Purpose of the formulation stage of a project is to develop a set of possible project proposals as a solution to the identified problems or needs, that fit into the systems of various interest groups (see § 5.3.2.1).

Regarding this objective with respect to the INE programme it may be remarked that there are no indications that within the INE biogas programme more than one proposals were developed. Technology assessment was not carried out, since from the start the solution was set.
Within INE, however, other rural energy development programmes had been started that purposed to promote the dissemination of other technologies.

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* Wasser, 1986

I never noticed something of a more integrated approach towards rural energy problems, or other forms of co-operation between de various departments. In my opinion it was more that the various programmes aimed at a specific user group for which, in general, that programme's technology seemed most appropriate.
The biogas programme concerned itself in the first place with larger agrarian, or semi-agro-industrial cattle-farms and communities with communal cooking, whereas, e.g. the woodstove programme aimed more at larger rural communities with individual cooking tradition.

A very important element of the formulation phase in a project is the identification of particular constraints for the application of a certain solution in the local situation. Economic costs and benefits of the various solution should be considered in order to make a global statement on the economic feasibility of the involved options, and financing possibilities should be investigated. Indications can be found that these tasks were performed to an insufficient extent:

* Particular constraints for the introduction of biogas were not identified, or severely underestimated. Basic technical constraints for the application of biogas technology, such as the presence of organic matter and water, were not considered enough, witnessing the fact that 6 out of (all) 10 plants had problems with organic matter supply, and at least one out of 10 plant locations did not have the disposition of sufficient water throughout the year (see also § 2.2.2 and -3).

* For some reasons the programme paid too little attention to the aspect of the use of biogas by the beneficiary:

  For example: After repairing the installation in "El Escobillal" the plant was started up without the introduction of gas user equipment. The Empresa, owner of the farm, and INE disputed on the question who's task it would be to install a kitchen. As a consequence the furnaces were not placed until more than 6 months after producing biogas again.
  The produced fuel could not be used, and vanished into the air.
  As a consequence, workers of "El Escobillal" were even less motivated to operate the plant, and the formal structures of hierarchy had to be applied more and more to have the plant filled regularly.
  After this period, just at the moment that agreement could be used on the division of responsibilities between the involved parties, the plant collapsed again and new major repairs had to be carried out.

  Reasons for this conduct may be found in the fact of lack of self confidence of the INE crew: Considering the past it was the question whether biogas would ever be produced. Therefore the programme was pre-occupied with the mere process-technical aspects of producing biogas. Using the gas was too far away.

* Also the application of the other biogas product, fertilizer, was hardly paid attention to.
  For fertilizer application the programme crew may not have had enough experience and knowledge on the agricultural aspects. Besides this, the value of bio-fertilizer was heavily underestimated. Biogas was regarded as the primary product, fertilizer as a side effect.
  Therefore fertilizer use was often overseen.

* Economic cost-benefic analyses on biogas technology, neither financially or socially, have ever been made in Nicaragua. This implies that these investment decisions have been made blindly, without knowing, for sure, whether the investment ever would pay back.
  This is the more surprising since, at the end of the seventies, several cost-benefit analyses were published on application of biogas technology in India. From these studies it was concluded that the economic feasibility of the technology was at least questionable[9].

* Regarding the identification of possible financiers it should be remarked that:
  - During the OLADE project FAO was prepared to pay the investment-costs of the plants. Therefore, the financing question did not have any priority at that stage;
  - However, FAO would not pay for future beneficiaries who would be interested in biogas technology;
    It is striking that after the OLADE activities only two more projects were initiated, of both state enterprises with enough financial resources. In these cases, no credits were needed.

  If INE would have perceived the problem of finance for small farmers, and if she would have been interested in this group as a potential beneficiary group, they would better have:
  o contacted financing organizations to convince them of the importance of biogas for the farmers and for the nicaraguan society, as well as of the fact that investment in biogas was profitable;
  o performed constant monitoring and detailed administration of the executed projects, in post-calculations, cost-benefit studies and reports.

  It should be remarked, however, that INE was saddled with 10 non-working plant locations (14 biogas ruins). In such a situation it would be rather ambiguous to try to convince anybody of the advantages of biogas technology!

6.4.2.1.3 Project appraisal

The purpose of project appraisal is to select the most appropriate solution of a set of options formulated in the former phase.
Although it already has been mentioned that in the INE projects only one alternative "solution" has been considered, and that therefore no relative valuation of the projects against criteria can take place, this phase may still be of interest to us.
It is also in this phase that an estimation should be made of the solvability of problems, which can be expected to occur during later phases.
Problems in the economic, social, cultural or organizational respect.

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[9] See for a survey of the cost-benefit analysis on biogas e.g. A. Barnett a.o, 1978, or the discussions of chapter 4.

These problems have insufficiently been identified, or severely been underestimated in the INE programme. Two plants do not function at this moment because of social and/or organizational problems:

- In "La Borgoña" the community still quarrels about the division of tasks, (see page 2.12) whereas
- in "La Nagarote" the conflicts about task-division and gas use raise to such a height that personal accidents occurred.

The identification of problems of this kind is, of course, a matter of experience, which the INE programme did not have.

What strikes me more is that after having these experiences, the INE organization does not seem to have learned from them, and did not change her attitude towards these kind of problems.
The approach remained a very technical one, and I encountered very little notion within the INE crew for social aspects of the introduction of biogas.

6.4.2.1.4 Participation in the pre-investment phase

From the description in the former paragraphs it may be clear that not much attention was spent to the problems, needs or opinions of the population of the farms. Although it was the farm-population who would have to operate the plant, and use the produced gas and fertilizer.

During my investigation I never got the impression that the local population of the concerned cooperative or UPE was involved in the decision processes that lead to the construction of plants. Not during identification, nor during formulation or appraisal.

Concerning the state farms questions may be raised on the identification of the target group by the INE programme. INE may have seen only two involved parties: The farm and INE.
The farms as such was not regarded as a sub-system with at least two involved, but entirely different interest groups: Management and the farms workers. This would have been more logical, since those two groups have entirely different interests in biogas technology:

* For the management economic profitability of the process will be the most important decision factor for the adoption of biogas;
* For the workers core, however, economic considerations will not count. For this group acquaintedness, reliability and comfort in their working and living conditions are much more important factors. It is these factors which will determine their attitude towards biogas.

Within the project little or no attention was paid to the operating personnel and users of the biogas products. To their wishes and suggestions regarding the use of organic matter, their attitude towards handling excreta or manure, and wishes regarding gas-use. Farm workers were always supposed to be happy with the changes the project brought to them, so they should, at least, be so grateful to perform their duties of operation and maintenance well.
This was, of course, not the case.

Further critical notes concerning participation in the pre-investment stage of the INE activities are:

* no problem identification or need-assessment studies have been performed, resulting in some cases in the approach of wrong (= non-prioritary) problems (see, e.g, 6.4.2.1.1);
* the beneficiary, whether the population of the farm or the management of the empresa, were informed about technology characteristics or eventual alternatives for energy supply or fertilizer production;

This lack of room for participation of the beneficiary had its impact at the operation stage of the projects.

6.4.2.2 The implementation process

In the implementation process the eventually formulated and accepted project will be executed. In the case of biogas projects this can be described as construction of the biogas plant and installation of the user equipment.

As outlined in § 5.3.2.2 the implementation process for biogas projects can be divided into **detailed design** and **construction stages**.

These tasks were not executed completely within the project organization: Designs of the plants were obtained from abroad, and at most slightly adapted. Construction was executed by the biogas team, which had the disposition of two masons.

It is not possible to give in this paragraph a detailed description of the construction process in the INE projects. The latest plant was built in 1985 (in Condega), so I did not have the opportunity to experience the construction of an INE plant.
However, some remarks can be made on the design procedures which were followed in the programme.

From the 10 plant series built 6 had more or less serious technical imperfections. These imperfections concerned the technical design (IIE plant type), used material (Red-mud reactor, Cacho) and ergonomic aspects (OLADE batch type, used for coffee pulp digestion).

problems in technical plant design

Starting point of the design of plants was usually an existing, already applied plant-type. The detailed design was directly obtained from the foreign organization which had made it.

So also was the case with the IIE plug flow reactor, which was designed in Mexico.
The IIE design is a V-shaped, oblong canal out of bricks, plastered with a cement layer. The canal is covered with a concrete curved hood to make the reactor gas-tight (see fig. 6.6).

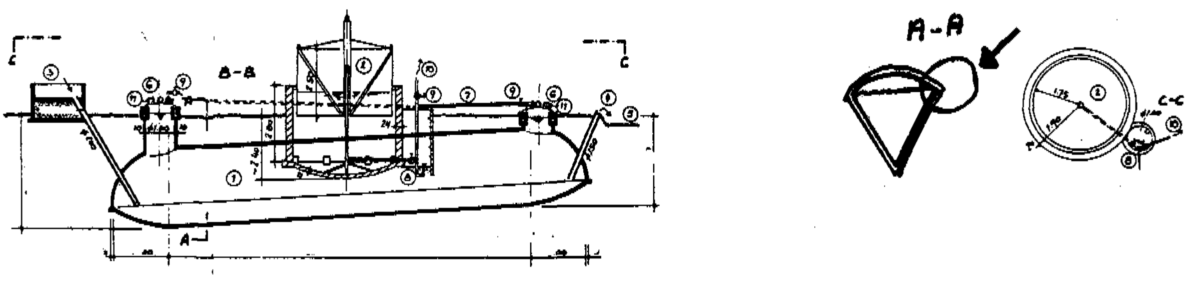

fig. 6.6: IIE-Mexico reactor design

Examining the design it was vague where the walls and cap should be armoured.
Since INE did not have architectural expertise to check the designs, the drawings were straightly copied and brought into practice.
Needed reinforcement in the connection between walls and gas cap were overseen, with as a consequence that shortly after taking the digester in use the tank showed numerous cracks through which gas leaked.
Three of these tanks were built: Two in the community of Marcell Pallais Checa in Tipitapa, where in the summer of 1982 the digester was flooded after heavy rainfall, and remained below the water level of the nearby lake[10] (which was a next design failure: Ground water level in the various seasons and/or soil characteristics were not checked).
The other, in El Escobillal, was repaired several times. After the first repair, in 1985, the plant functioned for less than 6 months, after which the same problems occurred again.

<u>problems with construction material</u>

The reactor in Cacho, Juigalpa was intended to ferment residues from a cheese factory. It was decided to do an experiment with a red-mud plastic reactor. This reactor is an egg-shaped plastic bag, made of a mixture of "Red Mud" (a waste product left after aluminum oxide is extracted from bauxite), waste PVC and used engine oil. The bag is used as digester as well as gasholder, or with a separate gasholder. (see fig. 6.7).

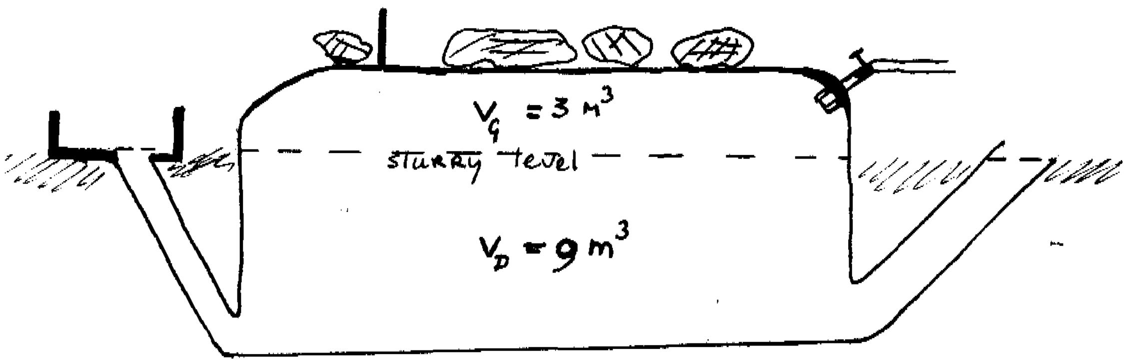

fig. 6.7: Red-Mud reactor with separate gasholder

Red Mud Plastic is very resistant to chemicals and its characteristics are very similar to rubber. It is not damaged by U.V. rays which is contrary to ordinary PVC which becomes hard and cracks.

It has advantages over reactors of the conventional type through costs-reduction (± 10-50% in India) and transportability.

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[10] Bobulesco and Ortolano, 1986

Within little months after installation the installation revealed cracks and tears; gas leaked away. The problems occurred at the seams where the plastic sheet is glued together with solution. It is a known problem with Red Mud Plastic that the patches and solution are not U.V. ray resistant and become porous[11].

Several reparations were tried, but failed: Good solution was not available in Nicaragua, whereas foreign glues were not purchased for the lack of foreign currency, and lack of confidence in the quality of these glues.

<u>ergonomic aspects</u>

Of the implemented plants the OLADE batch reactor, which was used for the fermentation of coffee pulp, distinguished herself negatively by a rather unfriendly design (see fig. 6.8).

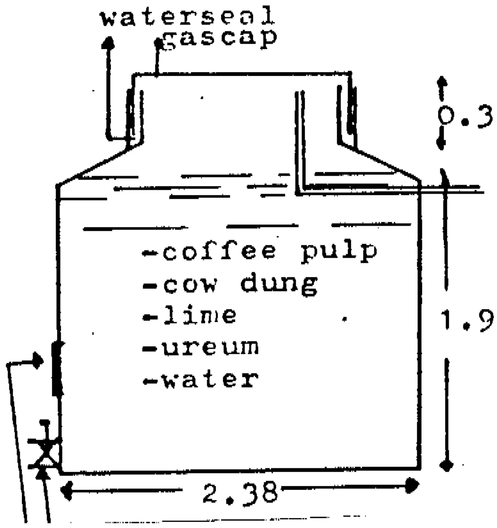

fig. 6.8: OLADE batch reactor for digestion of vegetal wastes

The reactor was built aboveground, and was rather unfriendly to use because of the fact that primary matter was to be loaded **from above** into the reactor. It may be clear that it is rather laborous task to regularly fill the tank with **tonnes** of organic matter.

In "Los Alpes" the tank was even built above the level of pulp disposal.
This position was chosen because of the needed space for the supply of construction materials.
It was not considered, however, that farm workers had to lift the organic matter for 3-5 meters for operating the plant. Sufficient dislevel would have been available to make the plant at a location 10 meters below.
The programme preferred ease of construction above ease of plant operation.
"Los Alpes" workers were not very motivated to fill the tank with organic matter, and never felt called upon to load the reactor when needed. This had to be ordered by the farm manager, and was not a very popular job.

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[11] See e.g. E. Kijne, 1984

concluding

It may be concluded that in plant design technical mistakes were made that could easily have been prevented if some experience with the technology would have been present.

In the case of the coffee pulp digesters site-selection mistakes could have been prevented by input of foreign expertise and better information form the OLADE organization to INE.
Although taking the point of view of the plant user would already be enough to perceive these kind of mistakes.

The IIE-plug flow reactor design should not simply have been copied. Therefore the designs were not detailed enough. Problems could have been avoided by having the designs checked by an architect or a civil engineer.

In the case of the Cacho Red Mud reactor the programme staff should have known better. The staff did have access to foreign literature material and followed courses abroad. The problem of U.V. rays attacking glue in plastic-bag digesters is well known.

6.4.2.3 Introduction, operation and maintenance

After plant construction the period begins in which the consequences of decisions, made in earlier phases will declare themselves.
In biogas technology this declaration may be in a scale from little technical errors (e.g. leaking gas pipes) up to severe technical breakdowns or disuse of the plant for not being accepted by the community.

The after implementation phase has been divided into two stages in § 5.3.2.3 : Introduction of the plant to the local community, and aftercare. In the introduction period the local community is to be prepared as such that she can perform plant operation and simple maintenance. Attention should be paid to items of all sub-systems of the biogas system as outlined in fig. 2.3 and § 5.3.2.3.

introduction

The activities in the introduction phase can be summarized to the fact that although reasonable attention was paid to technical aspects of plant operation and -maintenance, the aspects of the use of gas and bio-fertilizer were underlighted: Gas use was regarded as something that came after gas production.
Since gas was rarely produced, people forgot what it is used for. The relation between the biogas tank and the use of the produced gas was lost out of sight.

The same counts for the use of bio fertilizer: This aspect of biogas technology got little, if any attention within the project. Within the programme personnel little expertise existed in the field of fertilizing, so that the technical possibilities , but also the economic value of the digested dung were severely underestimated.

Concerning the use and maintenance of the digester it may simply be remarked that the INE crew was not master of the technology, so that the master couldn't teach his pupils.

operation and monitoring

In § 6.4.2.1.4 the lack of participation of the target population has already been discussed. This lead to a situaion in shich little or no motivation existed to do daily operating routines.

Next to this, a general problem in INE projects was that it was not clear in many cases who was to perform plant operation: The population of the farm or community, or the INE team. Especially when technical problems began to occur in most of the plants, the INE crew took over, more and more, the daily operating routines. This caused some obscurity with the beneficiary about who was supposed to perform these tasks. A consequence was that after some time most plants were only operated by the INE crew.

About this operation may be remarked that it occured rather irregularly: The undermanned biogas office could not take care of all crashed plants, so that only some got attention. This, next to the problems of cutting budgets for the office, which caused more and more trouble in planning material resources, extra labor and, above all, transport. Many plants were therefore left unattended, and never functioned again (see also fig. 6.9).

Concerning monitoring mostly only technical aspects were monitored: Gas production, in some cases in relation to process pH and the quantity of primary matter supplied to the reactor.
Data on user aspects, such as the frequency and amount of gas used, or the application of reactor effluent were not recorded, let alone the opinion of the population of the new technology, the extent to which it satisfied the populations needs.

6.4.2.4 Conclusions regarding the primary process

In fig. 6.9 (next page) the implemented plants in the programme, with their main problems, are outlined.

Regarding all problems outlined above, and in § 6.4.2.1-3 it may be concluded that most causes of the fact that none of the INE plants function at this moment can be found in the stage preceding the construction of the plants:

* In those cases where "technical problems" occurred insufficient attention was paid to the formulation phase (technology assessmen, i.e. adaption of the choise of technology to the available resources) and to technical design.
  Also the use of not readily developed techniques and designs lead to disappointment and much wasted efforts, since these processes (digestion of coffee pulp, cheese- and slaughter-residues) were never controlled by the INE technicians.
* In those cases where "social" or "organizational" problems caused the plant to cease producing gas, this has been caused by:
  - insufficient agreement between the programme and the beneficiary, or within the target community (La Borgoña, La Nagarote);
  - the complete lack of possibilities for the target group to participate in preparing decisions. It was not recognized in the programme that biogas technology would determine the future energy- and fertilizer-supply in the community, and that the populations could have had own ideas on this theme. In practice the target communities showed little or no interest in the biogas tank, and continued living in their traditional way.

Next to this, the lack of attention for economic aspects of biogas technology, and for the application of the produced bio-fertilizer are severe structural shortcomings in the programme.

project	year of constr.	sector	identified problems and (phase in which caused)	reperation attempts	operation by INE
1. Nagarote (León)	1981	coop*	social, organizational, (identification, formulation)	-	-
2. La Borgoña (Masaya)	1981	coop	organizational (formulation, introduction)	-	-
3. El Tamagas (Xiloa/Chiltepe	1981	APP**	technical (prime matter), org. (identification, formulation)	-	transport of dung from Chiltepe
4. El Escobillal (Chiltepe)	1981	APP	technical, social, organiz. (ident., form., design, oper.)	reparation at gas-holder, in- and out-let of slurry	substantial, operation maintenance and reparation by INE
5. Marcell Pallais (Tipitapa)	1981	?	technical (formulation, design)	-	-
6. La Revolución (El Crucero)	1981	APP	technical, social (indent. form., design, oper.)	-	INE only party who performed operation
7. Los Alpes (Matagalpa)	1981	APP	idem "La Revolución"		
8. El Trabajo (El Crucero)	1981	APP	idem "La Revolución"		
9. Cacho (Juigalpa)	1982(?)	APP	technical	attempts, failed for lack of materials (glue)	
10. ENAMARA (Condega)	1985	APP	technical, ?	various reparations since construction	? -

* = cooperative ** = state farm (Area Propriedad del Pueblo)

fig. 6.9: Summary of problems at INE plants.[12]

[12] Own observations, N. Bobulesco and G. Ortolano, 1986

6.4.3 Secondary processes

In § 5.3.3 five secondary processes were identified, relevant to biogas extension programmes: Research and development, supply of resources, training and education, marketing and administration. The presence and performance of these processes in the INE programme will be described in the following sub-paragraphs.

6.4.3.1 Research and Development

It has already been indicated that, within the INE programme, attention was paid to R&D. Albeit because of the fact that the planned processes did not lead to the desired results.

Especially in the field of digestion of coffee sub-products experiments were developed: Various mixtures of primary matter were tried out in order to obtain acceptable digestion results and high gas productions.

In 1985-'86 INE took part in experiments of the regional Ministry of Agriculture in Matagalpa for purification of coffee wastewaters. In this activity it was tried to treat the wastewaters using the anaerobic process, producing biogas.

Next to this the INE programme was involved in experiments at the preparation of briquettes from coffee pulp, in order to valorize by-products of the coffee process.

Also the construction of the last two plants (Cacho, for the digestion of cheese wastes, and ENAMARA for slaughterhouse-wastes, should be mentioned here.

Considering all these activities, together with the objectives of the programme and the failed projects in mind, the question should be raised whether these R&D activities should have been carried out at all: In the first place, R&D activities within the framework of a biogas extension programme, should support directly the activities of the main process. This means that research should only be done at problems, directly aimed at finding solution to practical problems, occurring in other projects.
Only in the case of the coffee-pulp digestion, where mixtures of coffee-pulp and other other organic materials were tested, will fit in this description, although questions may be raised on the priority of these investigations. See also § 6.4.2.1.1.

In my opinion it would have been more logical to put priority to problems occurring at the digestion of cow-dung. After all, 5 out of eight plants constructed within the INE/OLADE programme, used cow dung as a primary matter, and **none** of them functioned.
The digestion of cow dung is known as the technically most simple application of biogas technology. Still these plants did not function in Nicaragua. A good evaluation of these programmes (which would have to incorporate all social, economic and organizational aspects) should have taken place.
Such an extended investigation was not carried out.

In stead, the programme aimed at the technical improvement of a process variant which is at least disputable: It is known that anaerobic digestion of coffee pulp produces relatively little gas and requires good process control [13] and theresore: Technical insight in the anaerobic digestion process.
This needed knowledge and experience lacked in the INE team.

The same statement counts for the Cacho and ENAMARA projects, which were initiated after the OLADE programme.
The digestion of whey (from chess production) and the fat residues from slaughterhouses are known to give technical problems.[14] Special process control measures and even different reactor designs are needed for acceptable process performance.
The INE team, however, did not seem to be hampered by her lack of knowledge.

Because of the technical problems that required attention in these experiments no time was left to perform the other, more urgent tasks, such as reactivation of the run-down plants or consultancy services to the despondent and quarreling "beneficiaries" of other projects.
If a profound evaluation of all projects had taken place, regarding also social and organizational aspects, less mistakes would have been made in the new projects: Such a study would have stressed the importance of pre-investment studies as described in chapter 3, and would have forced to take away the attention from technical aspects.

6.4.3.2 Supply of resources

The second sub-process to be reviewed is the supply of financial, human and material resources. These supplies will subsequently be described for the INE programme.

supply of finance

Plants built within the framework of the OLADE programme were financed from the **project budget**, i.e. the FAO paid investments. The other two plants (Cacho and ENAMARA) were co-financed by the empresa, being the owner of the state-farm where the plant was located. It is not known whether the needed capital was borrowed, or available enterprise capital was used.

INE did, to my best knowing, not have contacts with the National Development Bank (BND) to promote subsidiary loans to the farmers who would start with biogas technology.
This seems reasonable, since INE wouldn't be able to proof the technical or economic feasibility of the process, which is required for obtaining the loans.

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[13] Bressani, 1979
[14] G. Lettinga, S. Sayed a.o: 1984

supply of human resources

Most activities were executed by the INE-team, in co-operation with the beneficiary, who put the unschooled labor.
Within the team 2-4 craftsmen (who were constructors as well as metal workers) could be involved in the construction or reparation of a plant. These people were at a permanent contract with INE, within the Office for Alternative Energy Sources (OFAE) (see fig. 6.3).
Unschooled labor was put by the empresa, based on formal orders.
In general it may be stated that the provision of human resources did not give substantial problems.

supply of materials

Materials were provided from INE stocks (centrally purchased), but in later phases the team usually bought on the regular consumer market. Especially after 1983-'84 provision of materials must have been very problematical because of the rapidly declining supply in the market (economic situation).
To my knowing no direct contacts with factories or wholesalers were maintained, although good contacts did exist with local small-scale suppliers.
It must be stressed that it is not known how this situation was when new plants were constructed.

6.4.3.3 Training and education

In § 5.3.3.3 various target groups for training and education programmes were indicated, such as engineers and local counterparts, local craftsmen and contractors, owners and institutions, operators and users, and cooks and housewives.
In fig. 6.10 these target groups, and the training programmes in which they were involved, are outlined.

target group	description of Training & Education
housewives and cooks	"on the job" -training
operators and users	"on the job" -training
owners and institutions	"Congreso Nacional de Biogás"; individual information
local craftsmen and contractors	"on the job" -training
engineers and local counterparts	"Congreso Nacional de Biogás"; courses abroad; "Grupo Nacional de Biogás"

fig. 6.10: Training and Education for various target groups

Sincee the INE team was rather small the regular fellow-workers were involved in all activities: Project preparation, construction, aftter-care, and most of the secondary processes.
They were also invollved in the training programmes, and performed the training "on thee job".

In practice this training limited itself to showing how a plant should be loaded with slurry, or how a tortilla should be frried on a biogas fire.
A consequence was that little or nno people at farm-level knew how the plant really worked, what took place inside the digester, and how technical problems could be overrcome.
In this respect, it may be concluded that too little attentiion was paid to training of the beneficiary (operators and housewives).

Own craftsmen from INE were instructed by the programmes' engineer. This meant that, after a certain period, they could work rather independently.
In practice this gave little problems: Technical troubles came from design mistakes, mostly not from mistakes made in the construction or reparation.

For owners of the plants there were no special training facilities. They were invited, however, on the "Congreso nacional de Biogás", an irregularly organized meeting of all organizations sideways involved in biogas.
In this meeting technical presentations were held of the results of all nicaraguan biogas programmes, and interested people could contact the engineers for information (see also 6.4.4.2 - involvement of other organizations).
Most of the information provided in this Congress seemed rather irrelevant for this target group.
In practice it appeared very difficult to reach the most important owners because of the fact that the congress was in Managua, far from most biogas plants.

One engineer of the INE programme could irregularly attend courses abroad. He was sent to a course in the People's Republic of China, and was sent to a biogas congress in Mexico.
The other involved fellow-workers were supposed to get training and education by this engineer.
In practice this did not work out very well:

* The engineer who was sent to China (where he got most of his information) spoke little English, and it should be doubted whether he was able to comprehend all information;
* It should also be doubted whether the information provided in this course was all that relevant to the actual problems in Nicaragua: The programme emphasized technical aspects, while management aspects, that gave more problems in Nicaragua, got little or no attention. Next to this, the situation in China is very different from the nicaraguan situation.
* The same engineer had problems explaining more complicated matters, because of the fact that he didn't understand it all too well, but also because of personal limitations regarding the transfer of knowledge to other people.

6.4.3.5 Bookkeeping and administration

Administration was kept by the central INE organization.
No project administration was kept, so that no direct information on the activities executed per project (materials, labor, transport, equipment) was available.
Therefore no post-calculations could be obtained, and there was only a global insight in the economic consequences of all executed activities.

Summarizing it may be concluded that the T&E facilities the INE programme offered:

* did not structurally provide the needed information to plant operators, gas- and fertilizer users;
* provided little, and mostly irrelevant information to plant owners, through the Congreso Nacional de Biogás;
* provided information that was hardly adapted to the local situation and to the own staff. This information, on its turn, was spread moderately among the other fellow workers.
* The training on the job of craftsmen did not appear to be a bottle neck problem in the actual situation.

6.4.3.4 Marketing aspects

In § 5.3.3.4 the task of marketing activities was described as "to facilitate and promote exchanges within the (dynamic) environment". Two major activities were identified:

1. determination of, and operation in the market of renewable energy sources;
2. promotion of biogas technology.

For a biogas extension programme it is necessary to have an overview of the needs and the supply of renewable energy sources, in order to be able to offer an appropriate product-mix to the customer.
Some remarks have already been made on the marketing approach of the INE programme:

* Customers were primarily canvassed among state enterprises, being the managing institutes of state farms.
  Reasons for this were, supposedly, primarily political.
* An opportunity to extend the offered product-mix could be found in a substantial co-operation with related offices within the OFAE department in INE.
  This opportunity was not taken. The market for renewable energy sources was, within INE, divided into segments in which a specific office (and with this: a specific technology) could operate.
  The biogas programme primarily operated with larger cattle and coffee farms.

Next to this the following remarks can be made regarding the marketing approach of the programme:

1. Market research, or attempts to extend the customer base, were hardly or not undertaken.
   A rather plausible explanation for this was the fact that the programmes' capacity was not sufficient to perform the existing activities satisfactory, let alone new projects.
   Only at the "Congreso Nacional de Biogás" new contacts could be made, but this Congreso was, in the very fist place, meant for exchanging data between the various biogas programmes. Next to this, future customers were hardly reached.
2. In the field of publicity it may be remarked that (positive) publicity for the programme was always welcome, but that there was not an active policy in this.
   To my best knowing the programme has never published folders or any other written information to promote biogas technology.
   Presumable for the same reason as mentioned before: There was hardly any, or no capacity to start new activities.

6.4.4 The programmes' environment

6.4.4.1 The mother organization

In § 6.3.1 the position of the biogas extension programme within INE was outlined (see also fig. 6.3).
Because of the small capacity of the biogas staff some tasks of the programme were obviously housed in other departments of the mother-organization, whether the office for alternative energy sources (e.g. the provision of human resources) or the central Department of Planning (e.g. administration).
When regarding the primary and secondary processes the involvement of the mother organization can be outlined as in fig. 6.11.

	responsibility	finance	personnel	equipment	materials	transport	information
Primary processes							
o project preparation							
* identification	M + P	M	P + M	P	P	M	P
* formulation	P	M	P	P	P	M	P
* appraisal	M + P	M	P + M	P + M	P + M	M	P
o project implementation							
* detailed design	P	M	P + M	P + M	P + M	M	P
* construction	P	M + B[1]	P+M+B	P + M	P + B	M	P
o after - care							
* introduction	P	M	P + B	P	P + B	M	P
* operation, maintenance, reparations	P	M	P + B	P	P	M	P
Secondary processes							
o research and development	P	M[3]	P	P[2]	P[2]	M	P
o supply of resources							
* financial	P	M+B[1,3]					M
* human	M + P	M + B	P + M				M (+P)
* material	P (+B)	M+B[1,3]	P			M	P
o training & education	P	M[3]	P	P	P	M	P
o marketing	M + P	M	P	P	P		M + P
o administration	M + P	M	M	M	M		M + P

[1] also: OLADE [2] also other institutions [3] also external financiers
P = Programme; M = Mother organization; B = Beneficiary

fig. 6.11 Division of tasks and responsibilities between Programme Organization (P), Mother organization (M) and Beneficiary (B) in the INE project.

From fig. 6.11 it appears that the mother organization is involved in, and responsible for:

1. All financing:
   The mother sets a yearly budget at which the programme has to develop her activities.
2. Personnel:
   Personnel which is not permanently staffed at the biogas office (technical staff, such as masons, draughtsmen, etc) can be borrowed from the central organization.
3. All transport:
   The programme does not have the disposition of own transport, which in practice leads to numerous little problems and bureaucratic quarrels.
4. Project identification:
   Projects were sometimes delegated within the OFAE to the various renewable energy programmes.
5. Administration and book-keeping: See also § 6.4.3.5.
6. Incidental tasks, such as detailed design and marketing activities were also centrally provided.

The relation between the programme and the OFAE, or the other hierarchical organs, was mainly problematical in the field of <u>planning</u>.
Partly because of the decreasing priority of the biogas programme it was more and more difficult to get the facilities which were centrally supplied.
Another reason for this is the generally increasing bureaucracy in nicaraguan institutes, which grows noticeably since a few years. A relation may be laid with the declining economic situation, cut budgets and increasing want of the government to get control of the institution's expenditures.

The biogas programme had to operate, more and more, within an organizational bureaucratic organization, which does not provide the flexibility needed to operate experimental- or pilot projects.

A key position in this was transport.
Without cars the staff couldn't visit the plants and do the necessary operations to get, or keep the plants going.
The cars were centrally supplied, and it took several days to get a car for a one-day's-visit to a plant location.
Visits for more than a week were only possible in vacation time.

Another problem which is more general for nicaraguan institutions is financing of expenditures: Co-workers spent a lot of their time to get their declarations paid since the institutions are always short of cash.
At a certain point staff does not want to pay advances for materials, meals or lodging, and programmes fall down.
Related to this is the relative decline of government salaries: They do not keep pass with inflation, whereas the free market wages do.
At this moment a real exodus of government personnel takes place, and more and more people try to find a job in the market-, or in the informal sector.
These are consequences of the overall economic situation that affects all government activities, so also the biogas team of INE.

6.4.4.2 Relations with other organizations

In § 5.4.2 it has been stated that the involvement of other organizations could be desirable for the reasons of dissemination of the technology in society. With the growing of the programme tasks should be left to other, civil organizations in order to promote dispersion of knowledge and experience.

In the INE biogas extension programme such a strategy was not followed: All tasks for the implementation of biogas tanks and all secondary processes were executed by the INE organization, to some extent together with the beneficiary (see figs. 6.12 and 6.13). This centralized strategy had also another negative effect on the performance of the programme: Beneficiaries which had problems with their biogas plant had to wait for the (overburdened) INE-team to come down from Managua. The geographic distance made, together with the bureaucratic problems that had to be overcome, that it would take weeks if not months, before attention could be paid to each individual problem.
In this way the little motivation for biogas the beneficiary still might have had, disappeared rapidly.

INE plays a co-ordinating role in the "Grupo Nacional de Biogás", the national biogas group.
This group is a platform of a great number of organizations directly or indirectly involved or interested in Biogas.
Organizations which are daily occupied with biogas, and which are member of the platform, are MIDINRA/ENPRA (of the GTZ/ENPRA programme) and the Universidad Nacional de Ingeniría (UNI) (see also § 1.2).
Members, interested in the activities in the field of biogas are MINSA (the Health ministry), INAA (the water institute) and (since 1986) ENAPLAST, a producer of PVC-plastic products.

The platform is meant as a co-ordinating and interests-defending organization, having it's connections in all related government institutions.
Tasks of the platform may be described as:

* Exchange and discussion of results of the various programmes;
* promotion of the interests of biogas technology, on a higher level;
* exploration of new potential activities for the connected organizations.

Up to june 1986 the platform has realized the following activities:

* It has been involved in the organization of the "Congreso Nacional de Biogás";
* It has initiated contacts with ENAPLAST, in order to promote the development of plastic (PVC) gasholders;
* It has promoted the interests of sideways related organizations in biogas.

In practice this organization functioned moderately well, not in the last place because of the problematical relation between the INE and MIDINRA/ENPRA programme.

organ \ process	PRE-INVESTMENT	EXCAVATION	CONSTRUCTION	INSTALLATION	AFTER-CARE
BENEFICIARY	- no substantial participation - go ahead dec.	- unschooled labor	- idem	- idem	- training "On the job" - unschooled labor with reparations
FINANCIERS	- go ahead decision (OLADE)				
LABOR MARKET AND CONTRACTORS		- via beneficiary	- own permanent personnel - administration	- own permanent personnel - administration	- own permanent personnel - administration
SUPPLIERS			- delivery via INE		- via consumer market
RELATED ORGANIZATIONS	- information to Grupo Nacional - advisory		- idem		- advisory - exchange of results

fig. 6.12: Environment matrix for the primary process, external organizations

organ \ process	ADMINISTRATION	R&D	ACQUISITION	TRAINING & ED.	MARKETING
BENEFICIARY		- offers locations for pilot projects		- "on the job" - Congreso Nacional de Biogás	
FINANCIERS					-
LABOR MARKET AND CONTRACTORS			- acquisition of personnel	- training "on the job" of own personnel	- insight in labor market
SUPPLIERS	- personnel administration	- sale of materials and equipment	- idem		- insight in local consumer market
RELATED ORGANIZATIONS	- budget control	- exchange of results - participation		- exchange of experience	

fig. 6.13: Environment matrix of the secondary processes, external organizations

6.5 Conclusions

Regarding all information outlined above the following conclusions with respect to the INE biogas extension programme seem justified:

1. The set of task objectives for the programme was too comprehensive. Too many goals had to be realized within the scope of one programme: Experimental-, pilot- and demonstration aspects were included, leading to a situation in which many expectations were raised and no reverses could be allowed (§ 6.4.1);
2. Within the programme the limited technical and organizational capacity of the INE organization was insufficiently taken into account. This limited capacity was in the very first place caused by the lack of experience of the nicaraguan staff at the beginning of the INE/OLADE project in 1980 (§ 6.4.2.2);
3. The selection of projects could not sufficiently be motivated: Priorities were presumably based on political rather than technical, economical or social arguments, which leaded to disputable choises of project locations (§ 6.4.2.1.1);
4. The choise of technology is also to be called "disputable": In this choise mostly technical arguments (of better process performance) must have prevailed (§ 6.4.2.2);
   It would have been perferable to make a technology selection based on need-assesment and an estimation of its functioning in the local situation (6.4.2.1.1);
5. In general the project preparation was far from sufficient: Apart from the technical aspects which were overlooked, no attention at all seems to have been spent to social, economic or organizational aspects (6.4.2.1.2);
   In project preparation participation of the target group was missed completely, giving rise to (at the best) a desinterested beneficiary group, which did not know what was going on in her community (6.4.2.1.4);
6. Regarding the secondary processes it may be remarked that research and development may have been overstressed, while training and education, marketing and project administration got too little attention (6.4.3);

During the operation stage (after 1983) a bureaucratizing INE organization, which arose from the rapidly worsening national-economic situation, opposed against the functioning of the biogas programme. Organizational freedom, needed to operate as an experimental- or pilot-project, were taken away. In this atmosphere it was hardly possible to get the heavily damaged programme in the rails again (6.4.4.1).

Chapter 7: The Programme of the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

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Chapter 7: The Programme of the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

7.1 Introduction and goals

In 1983 the German Institute for Technical Cooperation (GTZ) started to develop activities in the field of biogas implementation in Nicaragua. It was the first of a number of projects that were initiated in the "Biogas extension programme" of the German Appropriate Technology Exchange programme (GATE).

This "Biogas Extension Programme" was developed in 1980/81 on behalf of the German Ministry of Economic Cooperation within the framework of German development aid.
Starting point is a concept of "integral development", i.e. support is not limited to energy and fertilizer aspects, but equally takes account of other aspects, such as agricultural, craftsmanship, health as well as socio-economic structures.

The objectives of this biogas extension programme were:[1]
- Promotion of the rural development in selected areas through the extension of biogas plants on the basis of an integrated project approach;
- Development and extension of biogas plants adapted to local requirements, such effort focusing on small family farms;
- Development and application of extension strategies fitting into the particular situation;
- Promotion of extension through co-operation with local organizations and multi-disciplinary consulting teams (engineers, agricultural experts, sociologists/economists);
- Integration of the programme into the international biogas development.

The more general objective of a biogas extension programme, as formulated in § 5.3.1, "dissemination and promotion of biogas technology", forms a part of this set of objectives.
Next to this, the activities of the GTZ extension programmes are more specifically aimed at certain target groups (small family-farms) and a certain general approach is pre-supposed (integrated project approach).

The underlying justification of the programmes lies, in my opinion, in a believe in the possibilities of biogas technology as a source of alternative, renewable energy:[2]
- The programme was started at a moment that in the so-called A.T.-movement (Appropriate, or intermediate Technology) the application of biogas got abundant attention. This enthusiasm was based on results of biogas extension programmes in the Peoples Republic of China, and in India.
- GTZ as an organization occupies herself with the promotion and extension of so called "appropriate technology" in a broader sense of the terms (see also 7.3.1.1).
- Also at the moment of writing this report GTZ still has confidence in the potentials of biogas technology.

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[1] GTZ, 1986, p. 1-2
[2] pers. comm. with Mr. Uli Werner, Oecotop, december 1986

This, in spite of the more negative results, reported from above mentioned countries.[3] This certainly has to do with the own approach GTZ has developed since 1982 in the extension of biogas technology, which is not merely technology-orientated but takes the concept of integral development as a starting point.

Until now, the Biogas Extension Programme has delegated teams to 6 different countries, i.e. Nicaragua (1982-1985), Burkina Faso (1982-1983), Caribbean area (since 1983), Tanzania (1984-), Burundi (1984-)and Bolivia (1986-).

The german biogas programme started in Nicaragua in november 1982 in the Nicaraguan Center for Experimentation and Integrated Development CITA (Centro de Investigación de Tecnología Apropriada), which resorted under the Institute of Agricultural Land Reform INRA (INstituto de la Reforma Agraria).

For a number of reasons the programme was transferred to the Empresa Nacional de Porcinas (ENPRA) in march 1985.

At the end of 1985 the participation of the GTZ project team in Nicaragua was terminated by the german government: The augmentation for another year was refused by the CSU minister of International Cooperation.
Reasons for this may have been bureaucratic (the official project term had terminated) or political.

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[3] (see also page 1-3)

7.2 Task objectives and primary process

The programme may be divided into four stages, which are characterized by the following task-objectives:[4]

1. Inventory and evaluation of the biogas plants that already existed on the moment of project initiation (until june 1983);
2. Planning and construction of three pilot- and demonstration plants at agricultural schools (june 1983-june 1984);
3. From half 1984: Planning and construction of family plants, official education programmes, research on the quality of bio-fertilizer;
4. Planning, design and construction of biogas plants on a small and larger scale, especially for the treatment of wastes of the ENPRA farms (especially after the transfer to ENPRA, until december 1986).

In fig. 7.1 is shown, what installations had been build in december 1985, when the project officially was submitted:

project	year of constr.	prop.	target group	prime matter	type	volume of plant (m^3)	use of plant
1. EAG, Esteli	1983	?	agr. school	pig dung	BORDA	30	regular
2. EIA, Rivas	1983	?	agr. school	cow-pig-chicken	BORDA	2*15	regular
3. Valle Los Aburtos	1984	?	agr. school	chicken-cow-	BORDA	2*15	regular
4. ENPRA "El Repliege"	1985	APP**	pig farm,electr.	pig dung	BORDA	2*136	regular
5. Largaespada, Ticuante	1984	pr***	family	pig-cow-latrine	BORDA	4.5	regular
6. San Jacinto	1985?	pr	family	cow-latrine	BORDA	7.6	irregular
7. Buenos Aires	1985?	pr	family	cow-chicken	BORDA	10	irregular
8. El Rosario	1985	pr	family	cow dung	BORDA	10	regular
9. Los Zarzales	1984	coop*	co-operative	cow-latrine	BORDA	10+7.5	regular
10. Valle Los Aburtos	1985	pr	family	cow-pig-latrine	BORDA	10	regular
11. Don Juan	1985	pr	family	cow dung	BORDA	10	regular
12. Rudi(Quinta Werder)	1985	pr	farm community	pig dung	BORDA	21	regular
13. Las Piedrecitas	1986	APP	farm community	cow dung	BORDA	15	regular
14. Ticuantepe	1986	APP	insemination st.	cow dung	BORDA	15~	regular

fig. 7.1: Biogas plants built in the GTZ project

Furthermore, three installations were built at the CITA camp in Santa Cruz, near Esteli. From the information obtained it is not clear whether the GTZ project-organization was involved in the planning and construction of these plants (see further 7.3.1.2). Next to this, one plant was built at the camp of the ENPRA farm "Mauricio Duarte" in 1981, without the help of the Germans.
The Santa Cruz plants haven't functioned since the experimental camp was abandoned in 1985 because of closing CITA.
The ENPRA plant still functions.

During the CITA period, activities were aimed at pilot- and demonstration projects. The plants at the three agricultural schools were all effectuated within the CITA-INRA/GTZ framework.

The CITA organization was not familiar with the process of technology dissemination: As an experimental center, the general approach of this organization was rather experimental and technical.

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[4] W. Maennling, U. Werner, 1986

This situation became a major limitation for the biogas project, developing a dissemination strategy, and was one of the major reasons to transfer the programme from CITA to ENPRA.[5]

This transfer was motivated as follows:

- Developing activities within CITA-INRA was often rather laborious and time-consuming: The CITA organization got less and less financial and organizational support from the MIDINRA mother organization in those days. As a consequence, developing activities which were to be financed with local resources became increasingly problematical;
- ENPRA was very much interested in developing biogas activities, as well for own applications as for extension of the technology on a commercial base;
- In the course of 1985, after the departure of the biogas project, CITA-INRA was closed, and the activities adjourned. MIDINRA may have played a promoting role in the transfer of the programme in view of the future developments.

With the transfer of the programme to ENPRA emphasis changed from the pilot- and demonstration plants to dissemination of technology.
This dissemination was performed in a limited geographical area (see fig. 7.2). This regional concentration of activities avoided negative side-effects such as, e.g, the INE project had.

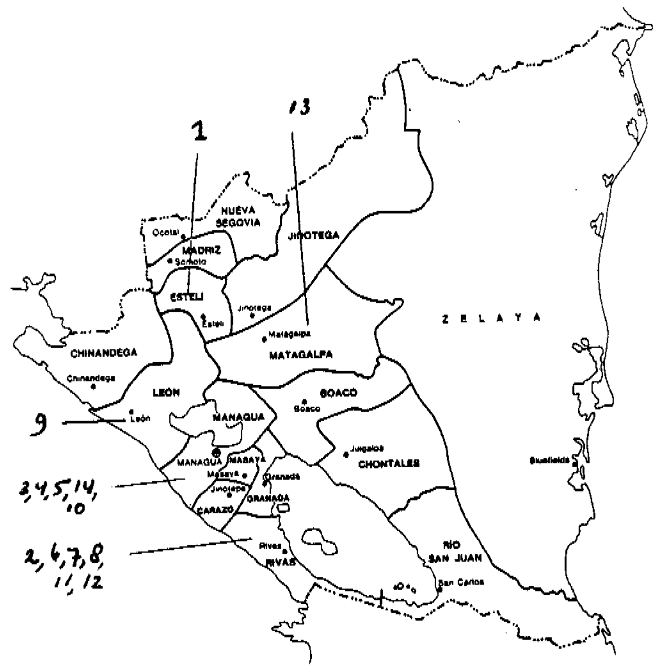

fig. 7.2 Map of Nicaragua with the location of the GTZ plants

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[5] Most of the statements made in this chapter are based on interviews with the GTZ co-operates and on personal impressions during visits I made to various projects.

As appears from fig. 7.1 the success-rate of the GTZ project was rather high, as compared to the INE project: Only two out of fourteen plants showed problems of irregular operation. The other twelve were operated by the beneficiaries, or the workers at the farm of the beneficiary.

Of the constructed plants 7 were family plants, 6 were community plants (with gas use for domestic purposes) and 1 (the El Repliege plant) was mainly used for industrial purposes.
The ENPRA plant at the "Mauricio Duarte"-farm, built without the help of the german engineers, was used for domestic (=community) purposes.

7.3 The basic organizational structure

7.3.1 The mother organizations

7.3.1.1 German Appropriate Technology Exchange (GATE)

Deutsches Zentrum für Entwicklungstechnologien - GATE - was founded in 1978 as a special division of the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, which resorts under the responsibility of the German ministry of economic Cooperation (BMZ) (see fig. 7.3).

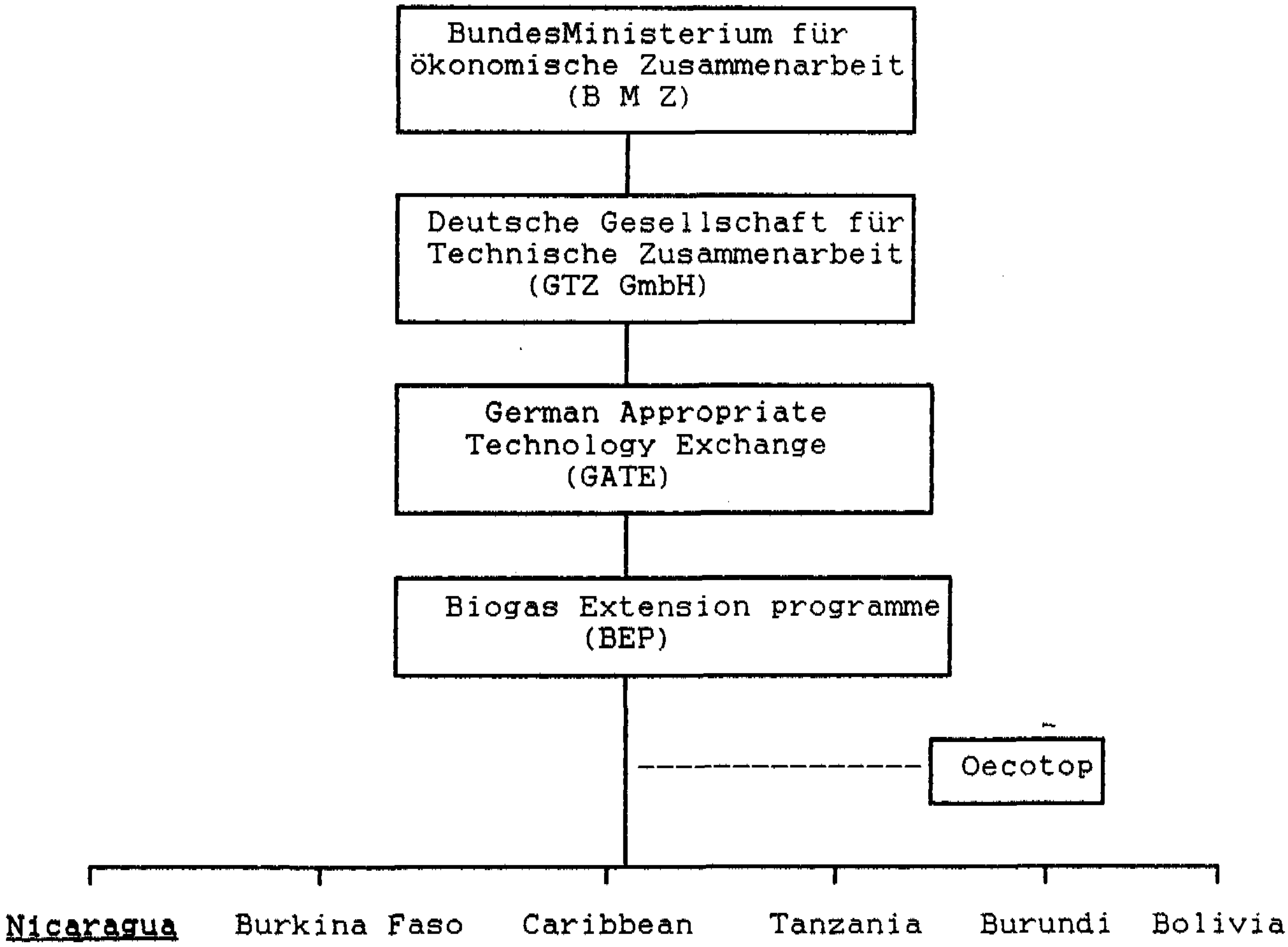

fig. 7.3: Place of the Biogas Extension Programmes in GATE, GTZ and the official german economic cooperation programme

GATE is a center for dissemination and promotion of appropriate technologies for developing countries.
GATE defines "Appropriate Technologies" as those which are suitable and acceptable in the light of economic, social and cultural criteria. They should contribute to socio-economic development whilst insuring optimal utilization of resources and minimal detriment to the environment. Depending on the case at hand a

hand a traditional, intermediate or highly-developed technology can be the "appropriate" one.[*]

GATE focusses its work on three key areas:

- **Technology Exchange:** Collecting, processing and disseminating information on technologies appropriate to the needs of the developing countries; ascertaining the technological requirements of Third World countries; support in the form of personnel, material and equipment in order to promote the development and adaptation of technologies for developing countries.
- **Research and Development:** Conducting and/or promoting research and development work in the field of appropriate technology.
- **Cooperation in Technical Development:** Cooperation in the form of joint projects with relevant institutions in developing countries and in the Federal Republic of Germany.

In § 7.1 it was described that the Biogas Extension Programme, as a body of joint projects with local counterpart organizations, was founded to promote biogas technology in developing countries.
The nicaraguan Biogas Extension Programme was the first within the BEP.

7.3.1.2 Centro de Investigación de Tecnología Apropriada (CITA)

The Nicaraguan Research Center for Appropriate Technology (CITA), was a part of the National Institute of Land Reform (INRA), which was later incorporated into the "super-ministry" of agrarian development MIDINRA (see fig. 7.4).

CITA-INRA concerned herself with the development of appropriate technologies, with the objective to overcome Nicaraguas economic foreign dependence. For that purpose they had the disposition of a research center at Santa Cruz (Esteli), where various forms of appropriate technology were tested. These were in the field of rural energy production and utilization, agriculture, sanitation and water supply.
Biogas technology would fit in the scope of their activities.

CITA-INRA started it's activities on biogas technology, as INE did, with support of the Latin American Organization for Energy Development (OLADE).

CITA-INRA wanted to experiment with biogas-technology in on-site situations, such as agricultural co-operatives.
Aim was to come to a diffusion of the technique in a smaller scale than the INE-programme aimed at.
In the period before the cooperation with the German programme, CITA-INRA built 6 installations, in locations of which two can be described as experimental (the installations in Santa Cruz (the research field of CITA-INRA) (CEID-1) and in the University of Central America (UCA) in Managua) (see fig. 7.5).

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[*] GATE, 1986

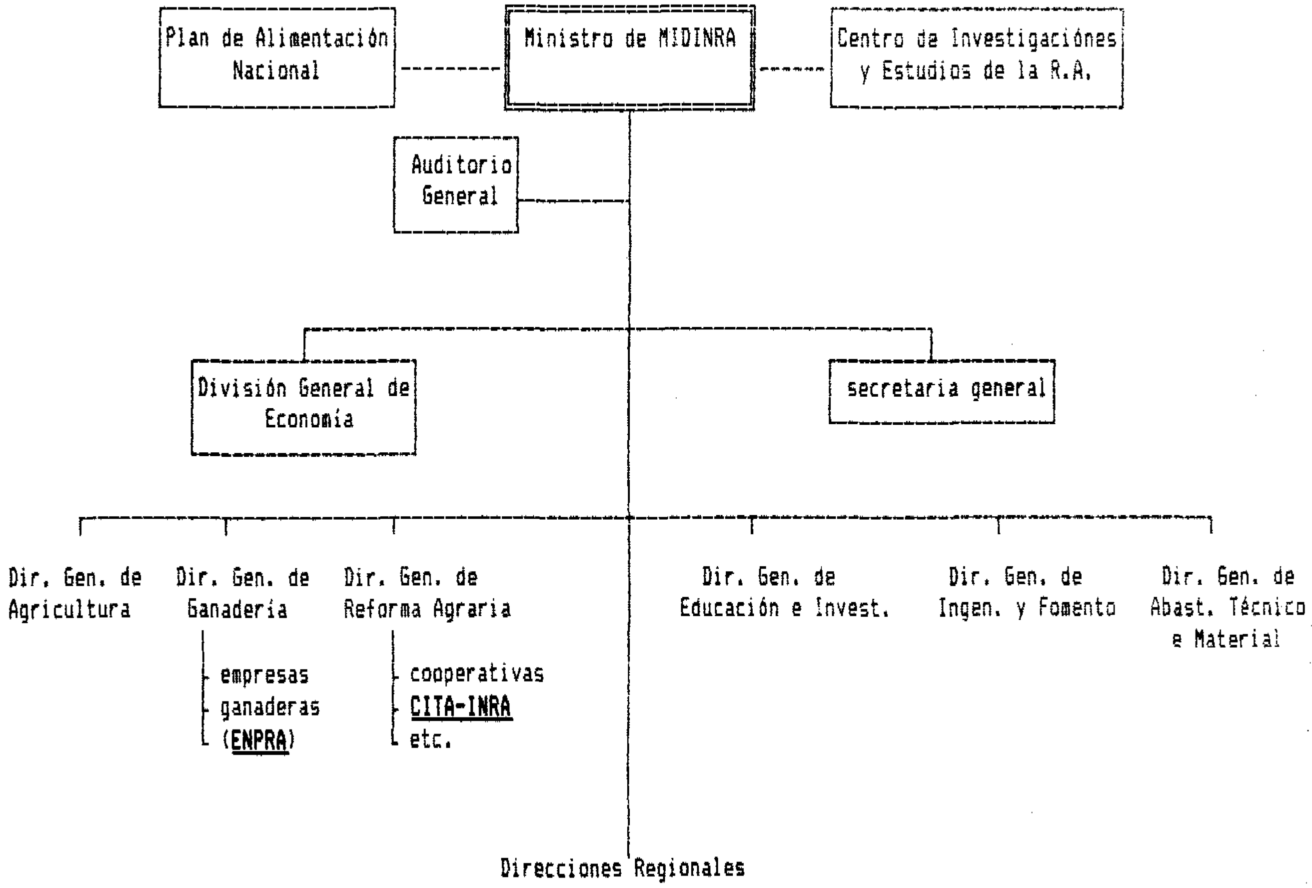

fig. 7.4: Location of CITA-INRA within MIDINRA

project	year of construction	target group	prime matter	type	volume of plant (m³)	use of plant
1. Los Laureles	1980	agr. co-operative	cow dung	BT,OLADE	6	not in use
2. Somotillo (Ch)	1981	agr. school	cow dung	China	6	abandoned
3. UCA-Managua	1981	experimental	cow dung	PF,OLADE	6	not in use
4. CEID-Sta Cruz	1980	experimental	cow dung + human excreta	India	2*6	abandoned
5. CEID-2	?	coop (pig farm)	pig dung	Nicarahuac	2*25	not finished
6. CEID-3	?	family	cow dung	ferrocement	6	abandoned

fig. 7.5: Biogas plants built in the CITA-INRA programme

From these data it appears that also CITA-INRA had various problems to keep the implemented biogas plants going: In 1984 all built installations were out of use, albeit that two of them were experimental installations.

In november 1982 the programme started a cooperation with the German Institute for Technical Cooperation (GTZ). This included the incorporation of two German engineers (from march 1984 on: Also one socio-economist) in the CITA-INRA organization.

During this period the first two stages of the GTZ programme (evaluation and construction of pilot- and demonstration plants), as described in 7.2, were executed.

In november 1984 it was decided to stop the programme, and replace the German biogas team to the National Pig Firm ENPRA, that already had shown her interests in biogas technology with the construction of a biogas plant at the Mauricio Duarte farm in Managua.

7.3.1.3 Empresa Nacional de Porcinas de la R.A.

The ENPRA was founded in the last months of 1979 to unite the 6 bigger Pacific pig farms in one state enterprise. Most of these farms were in very bad condition, with a poor technical level, a reduced number of animals, etc. The Institute of Land Reform (INRA) destined the production just for the internal consumption market.

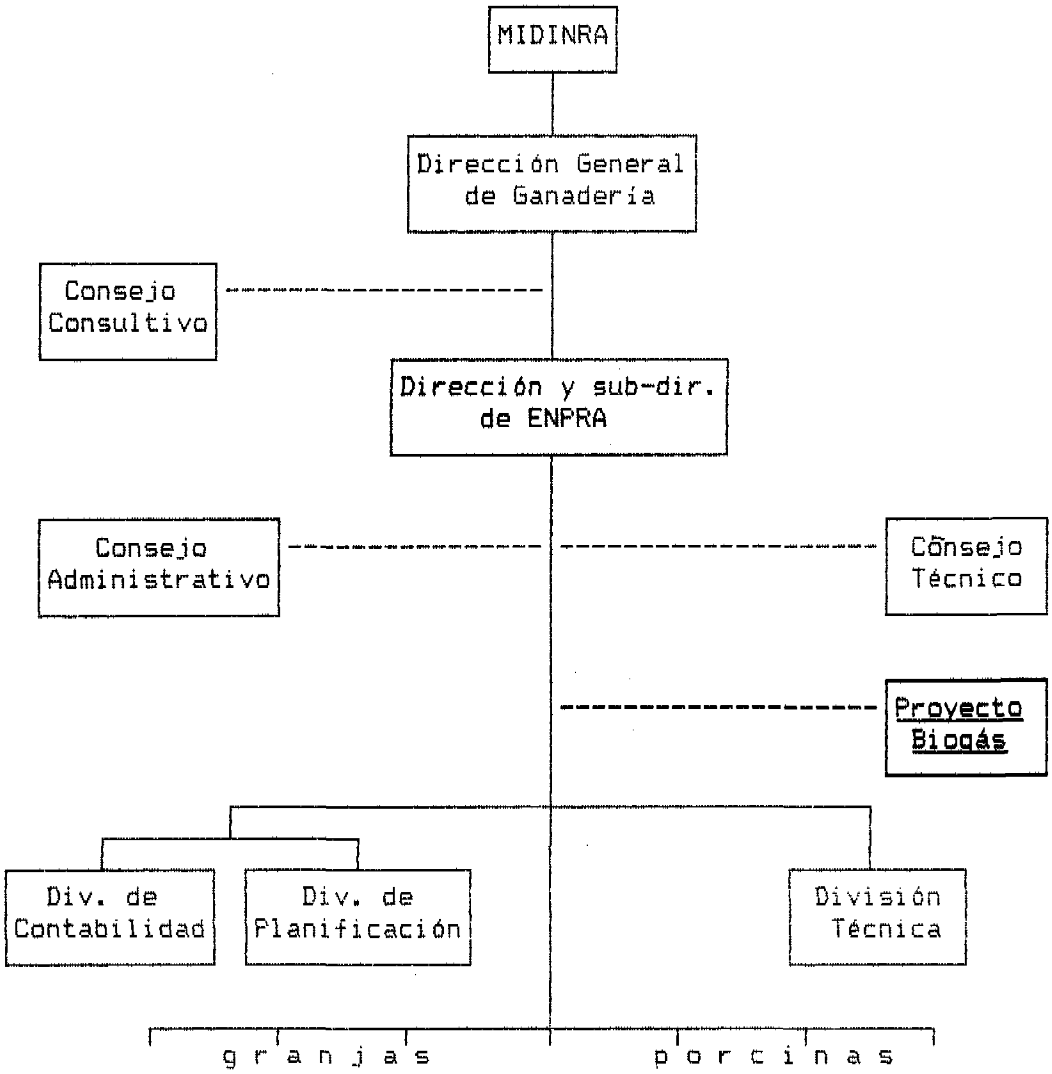

fig. 7.6: Location of the ENPRA in MIDINRA and the BEP within ENPRA

In the years ENPRA turned out to be one of the most profitable state enterprises. In 1985 a profit of 50 million Cordobas was made (in 1985: 1US$ = C$ 70.= (official rate), or 1US$ = C$650 (official parallel market)).
Profits are used for re-investment (1/12), taxes (1/3) and for the Ministry of Agriculture (7/12).

The Biogas programme is financed, to a large extent, from the profits.

ENPRA's activities in the field of biogas began with the personal initiative of one of her employees to construct a biogas plant for the provision of fuel for the kitchen. The plant was loaded with a very small fraction of the waste streams which were produced in the 5000 pigs counting farm.
This activity turned out to be very successful: In those days the Mauricio Duarte plant was the first really good functioning plant in Nicaragua, and still it is a plant that belongs to the most productive ones (gas production: $2m^3/m^3_{reactor}$.day).

ENPRA is pressed more and more to take care of her waste streams: The pig farms produce a huge amount of organic waste (1 pig produces the amount of organic waste that equals the amount produced by 1.7 persons), which in many cases molests the surrounding population for its smell and water pollution.
When the biogas project in CITA-INRA was stopped, ENPRA invited GTZ to continue their activities within ENPRA, with the objective to come to solutions of their environmental problems.
The treatment of waste streams should then be combined with biogas technology.

ENPRA and the GATE programme agreed on the following task-objectives for the biogas team while located at ENPRA:[7]

1. Training and education of ENPRA personnel in construction and operation of biogas plants in pig farms;
2. Idem, concerning cattle-farms, family plants and regional extension of biogas technology;
3. Technical and social-economic evaluation of biogas technology;
4. Development of a global programme for sanitation and waste treatment of intensive pig-farms in Nicaragua;
5. Optimization of the use of biogas in motor engines;
6. Introduction of biogas technology in sanitation (domestic refuses, latrines).

ENPRA staff would have to be trained to continue the activities after the Germans had gone.

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[7] W. Maennling, U. Werner, 1986

7.3.2 The internal organization

The programme started in CITA with a team of two german (agricultural engineers) and two nicaraguan technicians (one chemical engineer and an engineer/project leader).

In a later stage (in november 1982) a german socio-economic expert was included in the team, in order to coordinate a socio-economic evaluation of the application of biogas in Nicaragua.

Next to this the team had the disposition, during the ENPRA period, of draughtsmen, workshop constructor, local craftsmen and a secretary.

Officially one of the nicaraguan technicians was the project leader. In practice this lead to the situation that especially bureaucratic tasks were executed by this leader.
Technical decision were, in general, taken by the german project staff, mostly after consultation of, or in a learning situation with, the nicaraguan technicians.

It is good to mention the fact that during 3 of the 4 project years the german staff had a quantitative overweight on the decision making level (3 germans, 2 nicaraguans).
Of these five persons, 3 were permanently involved in technical aspects of biogas technology (2 germans, 1 nicaraguan), i.e. preparation, design and construction of plants and application equipment. 1 Person was permanently involved in administrative activities (1 german), and the other nicaraguan staff member (the project leader) divided her time over organizational matters (contact with the mother organization), technical aspects and administration.

7.4 Programme analysis

As in the INE analysis the programme will be analyzed in this paragraph in detail.
Since the objectives of this biogas extension programme correspond, to a large extent, with the pre-supposed objectives of a biogas programme in § 5.3.1 the evaluation is performed according to the analytical framework derived in chapter 5.

Therefore the objectives of the programme will be considered in detail first, after which the primary process and the secondary processes will be analyzed and, por fin, the relations of the programme with its environment.

7.4.1 Objectives, task objectives and project classification

From the sequence of task-objectives, as outlined in § 7.2, it may be concluded that a staged project approach was a carried through:
- After an orientation- and study-period (= phase 1) some pilot- or demonstration plants were planned and constructed (stage 2);
- Next to this, in stage 3, a start was made with more extended implementation activities, which may be characterized, in the Rondinelli classification, as demonstration- or dissemination projects.

Compared to the Rondinelli model of gradual up-grading of projects when introducing new technology (see § 5.2) it could be concluded that the approach of the GTZ project fits quite well to this model.
Extension of biogas technology was up-graded slowly, in which:
* the plants at CEID and the three agricultural schools may be regarded as pilot projects;
* after this plants were more and more constructed as a serial product, characterized by uniformity of design.

Up-grading the programme was done after obtaining certainty about the performance and reliability of the applied technology.

The fourth activity, i.e. waste treatment for the ENPRA farms, lies outside the scope of the GATE-objectives of the programme (see § 7.3.1.1).
It was presumably included in the interest of ENPRA: The intensive pig farms of this empresa caused huge pollution problems to the environment, and little alternative solutions to solve these problems, others than biogas, were available in Nicaragua.

During 1986 plans were being made for the introduction of a woodstove component in the programme.[9]
It was the idea that in situations were biogas would be a too high investment, a woodstove would offer at least some saving of energy. Because of the termination of the programme in december 1985 this activity never took shappe.

The programme did not select beneficiaries (or plant locations): Every farmer who wanted a biogas plant was, in principal, supported by the programme. Demand was not such that strict limitations should be put to the number of projects.

7.4.2.1.2 Project formulation

Purpose of the formulation phase of a project is to develop a set of possible project proposals as a solution to the identified problems or needs, which fit into the systems of various interest groups (see § 5.3.2.1).

In the GTZ programme project formulation can better be described as "finding the way in which biogas technology could best be introduced into a specific situation": Not a set of possible project proposals was developed, but specifications for the design-phase were set.
Aspects considered were (see also page 5-14):

- the availability of dung;
- the availability of water;

Examining the <u>constant</u> availability of water was rather difficult, since often no such information was available. In many cases the beneficiary under-estimated the availability of water, maybe also out of fear of canceling the project. This under-estimation may also be caused by unawareness of the possible problems caused by the lack of water.

- the possible application of manure and/or fertilizers;

This is something different than investigating the <u>need</u> of dung and/or fertilizer.
In the case of "Las Piedrecitas", e.g, where elephants grass (as feed for milk cows) was cultivated close to the farm, it was decided, without further investigation, to use the plant effluent for these fields.
The GTZ-engineers could not tell whether the produced bio-fertilizer was more suitable than chemical fertilizers, or whether the amount of fertilizer produced would be sufficient for the 2 hectares of grass to be treated.
No questions were asked whether other products were cultivated at the farm, in order to determine the economically most favorable application of the plant effluent.

- the need of infra-structural adoptions at the farms, needed for a smooth introduction of biogas technology (adaption of stables, kitchen, water supply, etc.).

Here again the fertilizer-using sub-system was under-estimated.
Also in "Las Piedrecitas" no attention was paid to needed fertilizer treatment systems. As a consequence, plant effluent was simply poured on the fields, causing severe local over-fertilization of the cultures. Better advise and studies of the local situation could have avoided these problems.
In other situations the use and treatment of plant-effluent got too little attention. Only in few cases in GTZ projects attention was paid to the use of effluent (e.g. the EGA-plant in Esteli, also on initiative of the beneficiaries themselves (teachers of the agricultural school where the plant was situated).

Other elements of the formulation phase are the identification of particular constraints for the application of a certain solution in the local situation. Economic costs and benefits of the various

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[9] G. Ullrich, pers. comm.

7.4.2 Primary process analysis

In § 5.3.2 (page 5.13 and fig. 5.3) the primary process was divided into three sub-processes, which (more or less) corresponded to the phases of a project cycle for implementing biogas plants (pre-investment, implementation and after-care).

Since the programme mostly functioned project-wise, this analysis can well be applied to the GATE/CITA-INRA/ENPRA programmes.

7.4.2.1 Pre-investment

In the pre-investment phase a most feasible solution to an identified need should be formulated, and it should be anticipated to problems which may occur in the implementation- or operation phase.

7.4.2.1.1 project identification

The purpose of the identification stage of a project is to identify the needs of a certain target group, or to assess the problems to which the project should offer a solution.

* In practice, no real problem- or need-assessment was carried out: The beneficiary contacted the biogas programme for a biogas plant, and the programme was able to offer him support to this. The GTZ programme was, in the ENPRA and in the CITA setting, a programme which aimed, primarily, at the extension of biogas technology.
  This can be seen as a rather limited and narrow approach, which indicates the focus of looking at the beneficiary's problems.

For example: The ENPRA mother organization had high expectations from the programme on solutions to the waste-disposal problems of the various pig farms. From the point of view of sanitation and of waste treatment these solutions can only be found in the field of sanitary engineering and water purification technology. Simple biogas technology, as proclaimed by the GTZ programme, could not offer a satisfying solution.
The german project team did not have expertise on this field.
Still an installation was built at the ENPRA farm "El Repliege", which should serve as a pilot for other ENPRA pig farms.
In this project the objective of waste treatment played a role,[a] also regarding the fact that more biogas was produced than could be used by the farm.

* Next to biogas-technology the GTZ programme also paid attention to the introduction of sanitation (latrines) and to water supply. These activities, however, should be seen as an extension of the service to biogas beneficiaries;

In spite of the official "integrated project-approach" of the GTZ organization (see 7.3.1) and of the programme (7.1) no such strategy was observed in the nicaraguan biogas extension programme:
Expertise was present only on the field of biogas technology, and to my knowing no alternatives other than biogas were present in the scope of the project.

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[a] E. Astorga, Dir. ENPRA, pers. comm.

solutions should be considered in order to make a global statement on the economic feasibility of the involved options, and financing possibilities should be investigated.

* In two cases (San Jacinto and Buenos Aires) disputable decisions have been taken towards the construction of a biogas plant because of lack of primary matter.
  In both cases the concerned farm did not produce sufficient organic waste to run a biogas plant. Organic material had to be obtained from a neighbor, having chickens or cattle. In practice this appeared to be an insuperable restraint: Both plants functioned irregularly (see fig. 7.1).

* Insufficient attention has been paid to the socio-economic aspects of the application of biogas. In the best case a global estimation of the investment-costs of a plant could be given, but no reliable data could be offered to the beneficiary on aspects such as return of investment, pay back period or most feasible alternative.
  This point is one of the major points of criticism towards the GTZ programme: Although the counter-part organization ENPRA demanded a profound study on this theme (see § 7.3.1.3) and the programme organization had the disposition of a (german) specialist in this field, this analysis has not been made properly.
  Information given was based on approximative and (over-) optimistic estimations based on too little data.
  Project co-operators[10] and a GTZ-evaluation commission[11] share this point of view.

In an information folder based on the E.G.A.-plant in Esteli[12] only the direct investment costs for the plant are counted. Not included were costs for gas-using equipment (kitchen, motor and gas-heaters in a pig stable), certain labor costs (which would have to put the beneficiary) and costs for changing the stables.
In my calculations (see chapter 4) those costs could easily add about 50% to total investments in biogas.
On the benefit side saving electricity and a vague sum because of a declining mortality among piglets are counted for, at a total of 43% of total annual benefits. Besides this, the calculations are based on the fermentation of pig waste, producing **twice** the amount of gas from cow dung. Only few farmers in Nicaragua have pigs.
Correcting for these factors would increase the pay back period for a biogas plant from 1.5 to approximatively 6 years in a still optimistic estimation!!
In my opinion it is not only insufficient, but also one-sided and betraying information which paints an interested farmer an over-optimistic view of the potentials of biogas technology.

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[10] G. Ullrich, pers. comm.
[11] W. Maennling and U. Werner, 1986
[12] GATE-CITA/INRA, 1984

	GTZ	corrected version	this study (ch. 4)
costs (first year)			
labor			
- excavation	0	84.000	173.500
- construction	55.957	56.000	123.900
materials			
- construcution	37.260,40	37.000	378.300
- gasholders and others	31.430,01	31.000	711.500
others	18.769,70	45.000	100.000
	---------	---------	---------
total costs	143.417,11	253.000,00	1.487.200,00
benefits (annual)			
energy	18.180	9.100	43.400
fertilizer	33.200	33.200	56.400
extra income because of smaller pig mortality	32.000	0	0
	--------	--------	--------
total benefits	83.380,00	42.300,00	99.800,00
approx. pay back period (discount factor = 0%)	1,7 year	6 years	15 years

fig. 7.7: GTZ cost-benefit analysis[13]

* Concerning the consideration of financing possibilities it should be remarked that the project did have orientating talks with the National Development Bank BND, and got the commitment that requests for financing biogas plants would be regarded as productive investments, and would therefore be considered for (subsidiary) credits.
  In practice no farmers have used this facility up to june 1986, partly since mostly rich farmers were reached, but also because of the credit- and subsidiary facilities the project funds offered to farmers who wanted biogas.

7.4.2.1.3 Project appraisal

The purpose of project appraisal is to select the most appropriate solution of a set of options which was formulated in the former phase. Next to this an estimation should be made of the solvability of problems (in the economic, social, cultural or organizational respect) which can be expected to occur during the later phases.

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[13] Source: "Planta de Biogás E.A.G. Estelí, Nicaragua" GATE/GTZ 1984

* Regarding the selection to a most feasible solution out of a set of possible alternatives no more statements can be made, since, in general, biogas technology was the only alternative considered from the beginning.
* Regarding the anticipation of non-technical problems it can be remarked that in most cases enough attention was paid to this aspect.
  No constructed installations are out of use because of this reason.
  This was achieved, in my opinion, through the participation of the beneficiaries in decision process regarding the planning and global design of the plant (see also the next paragraph). It should be remembered, however, that most plants are in use since a limited period only, and it cannot be foreseen yet whether major problems will occur in the future.

7.4.2.1.4 Participation in the pre-investment phase

During the pre-investment stage of the project the target population (i.e. the population of the co-operative, (state-)farm or enterprise) was involved in several ways in the decision making processes leading to construction:
* During a first visit a general estimation was made of the population's attitude towards change in general, and more specifically the changes brought about by the introduction of biogas.
  Emphasis is placed on the attitude towards dung-handling, stable cleaning, use of firewood and application of animal wastes.
* In a later phase information would be given on biogas: What is it, how does it work, what does it require from the farm people and what kind of changes can be expected.
  For that purpose some simply written (and illustrated) information material was available.[14]
* Next to this the opinion of the farm workers was asked on biogas at their farm: Their opinion of the appropriateness of the technology in their specific situation, and their expectations were evaluated.
  Here it should be mentioned that special attention was paid to the opinion of the person(s) who would have to work with the fuel (mostly the cook). Changes for her daily work would be most dramatically, and she would be a key person in the eventual success or failure of the project.
* The population was involved in planning the digester. Especially in plant location, adaption of the stables and kitchen, and eventual uses of plant effluent were discussed with the people. The preparation process would only be continued after reaching agreement on this issues.

In general it can be concluded that a positive attitude existed towards participation of the involved groups.
Some small points of criticism, however, should be made:
o Demonstrations were only given to a very limited extent, and if they were organized, mostly only to the owner. Most of the information was verbal, and with written and illustrated

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[14] See, e.g, the folder "Biogas en el Campo"

material. This, especially in areas where no biogas plant operated so far.
This made, that the image the people got from biogas was quite at a distance and abstract.

- The beneficiary did not get sufficient information on alternative solutions to his problems, others than biogas.
- The investment decision to be made was based on insufficient information of the economic kind: The farmer did not get a good idea of the costs and benefits of the investment he made.

7.4.2.2 The implementation process

In the implementation process the eventually formulated and accepted project will be executed. In the case of biogas projects this can be described as construction of the biogas plant and installation of the user equipment.

As outlined in § 5.3.2.2 the implementation process for biogas projects can be divided into **detailed design** and **construction stages**.

These tasks were executed by the project organization, local contractors and the beneficiary. Designs of the plants were introduced and adapted by the german engineers. Construction was executed by masons from the project-team (the first plants) or by local contractors, together with the beneficiary (unschooled labor). Supervision was performed by engineers from the project team.

<u>detailed design</u>

All built installations are based on the same design: The "BORDA" design is a modificated China-type digester, which is known for its simplicity, little requirements for construction and operation, and also for a somewhat smaller gas-production per cubic meter in comparison with other, more "advanced" designs (see annex 1).
This digester design has been chosen deliberately: It was the idea to develop a general applicable, reliable digester type.
Use has been made of knowledge and experience of other german organizations in the field of biogas, who developed the basic elements of design.[15]

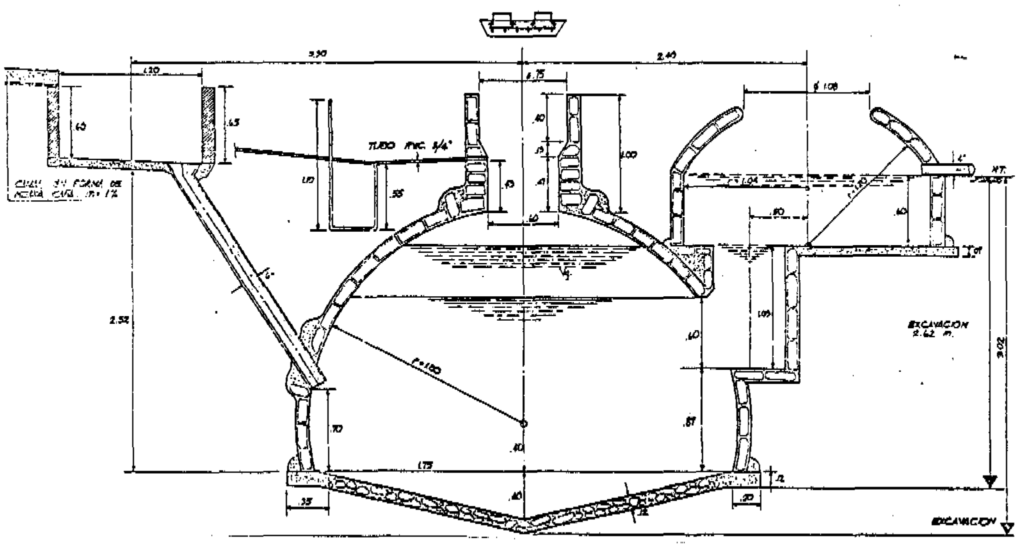

fig. 7.7: The "BORDA" digester design

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[15] See, e.g, L. Sasse, 1984 and G. Eggeling, 1980

In a later stage the existing design was upgraded to such an extent, that adaptions were necessary (the "El Repliege" digester, with a contents of 134 m^3).
Designs were drawn by draughtsmen, in service of the project.

Before introducing a completely new reactor design, the concerning digester was tested at the ENPRA farm, in order to avoid technical problems in on-site situations.

In the course of 1985 some tests were done with a red-mud reactor imported from Costa Rica.
The reactor seemed interesting because of its low price and transportability.
Tests were done at the durability of the rubber material and the connections, known week points of these digesters (see also § 6.4.2.2).

Use is made of only tree different types of prime matter, i.e dung of cows, pigs and chickens. These organic materials are known for their gas-producing qualities, and need little further technical investigation when introduced in new surroundings: The process parameters of the digestion of these materials are well known.

Digestion of pig dung gave some problems in the beginning.
Small-scale tests have been executed before upgrading the process and applying it at full scale.[16]

construction

The construction phase of the BORDA plants can be divided into excavation, construction and installation of the kitchen.
Depending the specific situation it may be necessary to adapt the stables (floor and gutters) and make constructions for effluent treatment and/or storage.

In general the beneficiary was supposed to take care of the unschooled labor, such as excavation and assisting masons in construction and installation. This, in order to save direct labor costs to the beneficiary.

The project had the disposition of a regular crew of masons, who first were on the payroll of the project. They were trained and educated by the german staff in constructing biogas plants, and they performed the installation of the kitchen.
In a later phase the masons worked as free entrepreneurs for the project.

Production of gas-holders, gas-stoves and adaptions for engines were executed by a workshop craftsman, at ENPRA's payroll.

Fig. 7.8 resumes the division of tasks and activities in the various phases of the primary process.

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[16] S. Bonilla a.o., 1984

organ \ process	PRE-INVESTMENT	DESIGN	EXCAVATION	CONSTRUCTION	INSTALLATION
FINANCES	- financing - contact with banks	- capital planning		- budget control	- budget control
PERSONNEL	- studies (german and nicar. staff)	- techn. design - drawings (nica) - planning constr.	- beneficiary - project staff (supervision)	- masons (craftsmen) - beneficiary - project staff	- craftsmen (from project) - project staff
EQUIPMENT	- from project	- from project		- project - masons & craftsmen - beneficiary	- project
MATERIALS		- acquisition - planning		- beneficiary - project - suppliers	- project - suppliers (local and international)
INFORMATION	- info. to beneficiary - specifications	- specifications - planning		- info. and training of beneficiary	- informing farm-workers

Fig. 7.8: Activity matrix for the primary process

In general some remarks can be made by the involvement of local contractors in the implementation phase. This, with the objective to endogeny the technology in the nicaraguan society (see 5.3.4.2):

- Only a selected group of masons was attracted for construction work of biogas plants. In this way the existing contractors were passed by. In the Rivas-region these craftsmen already became a kind of monopoly-position in the construction of biogas plants, which may lead to higher prices of the plants;
- Construction work of burners and other gas-user equipment was performed in the own organization.
  No local craftsmen, outside ENPRA, were involved. Gas burners (for liquid butane gas) were already made in Nicaragua, so that knowledge and experience were already present.
- On the other hand, courses were organized for local craftsmen (mostly not contractors), interested in building biogas plants. These courses were, however, limited to the construction of the digester part of a biogas system.

7.4.2.3 Introduction, operation and maintenance

The after implementation phase has been divided into two stages in § 5.3.2.3: Introduction of the plant to the local community, and aftercare. In the introduction period the local community is to be prepared as such that she can perform plant operation and simple maintenance. Attention should be paid to items of all sub-systems of the biogas system as outlined in fig. 2.3 and § 5.3.2.3.

<u>introduction</u>

Purpose of the introduction phase is to incorporate biogas technology in the existing working routine of the beneficiary. In the GTZ-projects generally much attention was paid to introduction aspects:

- **organic matter supply**: The changing routines brought about by the use of organic wastes in the digester were introduced through training "on the job": Operating personnel were accompanied several times while doing their daily work in cleaning the stables and filling the digester, until no more problems were to be expected in this field.
- **water supply**: During the "training on the job", as mentioned above, attention was paid to the aspects of water supply in the operation of the biogas process.
- **gas use**: The cook was guided in the use of gas burners and other new cooking equipment. In many cases problems arose as described in page 5-20: The total transition from firewood to the use of biogas appeared to be very problematical to most women (see also page 2.8). Within the GTZ or mother-organizations setting no further research was done towards the causes of these problems.[17]
- **treatment and use of bio-fertilizer**: In my opinion the value of this economic most important product of the biogas process was under-estimated by the project staff.
  This, unless the fact that in a (very global) cost-benefit analysis based on the EGA-plant in Esteli (fig. 7.7) it appeared that economic benefits from the fertilizer would be as much as 100% higher than benefits from the fuel.
  As in the INE project fuel was regarded as the principal product of the biogas process.
  As a consequence too little attention was paid, in my opinion, to the fertilizer aspects when introducing biogas to owners and farm-workers.
  It may be possible that this pre-occupation with fuel-aspects of the technology is rooted in the background and primary interests of the project staff: They see themselves as energy specialists, not as agricultural advisors.

- **use of the digester**: In general good attention was paid to instructions on daily use and maintenance of the digester. Only in few cases technical problems appeared, leading to a break-down of the plants.

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[17] W. Maennling, U. Werner, 1986

Most difficult aspect in this part of the introduction to the beneficiary is the recognition and remedying of basic problems. Trouble shooting is difficult to teach, since it is best learned by experiencing the problems which arise with a biogas plant.

operation and monitoring

In case the beneficiary could not shoot his own troubles, the project would provide technical assistance: After care was extended over a long period after plant construction, in the form of:
- verbal advise, and
- technical assistance.

To my be knowing the GTZ project did not spend much attention to the organizational problems which arise within a community after the introduction of biogas, as described in § 5.3.2.3 and fig. 5.7. A reason for this may be that the projects which were executed all took place at farms with clear hierarchical organizations, or at family plants. In the only case with a co-operative (Los Zarzales, near León) each family would obtain her own small biogas plant. Besides, the project still had not been completed when I left.

Monitoring should be done on the technical as well as the social performance of the biogas technology: Next to the collection of data on gas-production loading of primary matter and water it is very important to know how the target population experiences the newly introduced technology.

Regarding the technical data to be recorded it can be remarked that in most GTZ-plants no such monitoring took place. In general the beneficiaries did not keep an administration of in- and out-puts of their biogas system.
This is to be regretted, since very little data are available now, concerning the technical performance of the plants. This may be of interest for improving the technical design of the plants, and for evaluating the actual costs and benefits of the system to the farmer.

The same may be remarked for monitoring on social aspects: Only from the fact whether a plant is used or not it may be derived how the target-population stands to the introduction of this technology. Besides, social monitoring may offer a tool in getting to know the way in which locally the operation and maintenance of a plant is organized. Such information is not recorded now.

7.4.2.4 Conclusions regarding the primary process

In general it can be stated that the GTZ worked in a careful and rather professional way on the dissemination of biogas technology in Nicaragua. There was an eye to the most important aspects influencing the success or failure of a project, and a reasonable feeling for participation of the beneficiary in the project.

Points of criticism which should not remain unmentioned, are:
* The lack of a profound socio-economic evaluation of biogas technology in the local situation;
* Poor, and sometimes even false information on this aspect to the beneficiary;
* limited attention paid to application of plant effluent as a fertilizer in the pre-investment and introduction phase;
* limited involvement of local contractors in the construction of plants and application equipment.

The fact that 12 out of 14 plants worked without major problems shows, that the GTZ/ENPRA approach in the dissemination of biogas has not been unsuccessful.
It should be born in mind, however, that most of these installations haven't functioned for a very long time yet. Most technical problems, however, only appear after a certain period of functioning (say, one year), due to corrosion of metal parts, decomposition of gas pipes or the concrete getting porous.
Real conclusions, especially towards the phase of after-care, can only be taken after a few years.

7.4.3 Secondary Processes

In § 5.3.3 five secondary processes were identified relevant to biogas extension programmes: research and development, supply of resources, training and education, marketing and administration. The presence and performance of these processes in the GTZ programme will be described in the following sub-paragraphs.

7.4.3.1 Research and Development

R&D activities in a biogas extension programme should be performed to such an extent that they support the primary process in solving certain technical, practical problems, which have a direct relation to the main project activities (see § 5.3.3.1).

In the case of the GTZ project this approach of R&D was applied: R&D was only a minor activity, and only in case enough literature and experience lacked for responsible technical application some laboratory experiments were done.[16]
In the field of treatment and application of bio-fertilizer some more attention could have been paid. Some experiments towards the consequences of plant-effluent for the specific crops cultured in Nicaragua might have been useful. Such experiments were done, later, by the agricultural school in Esteli (EGA plant).

7.4.3.2 Supply of resources

The programme organization has played a promoting role through the organization and coordination of acquisition of financial, material and human resources:

<u>Financial resources:</u>
Most farmers financed their investment from **own money**, for reasons as mentioned on page 5-25.
For the poorer farmers (the "Los Zarzales"-co-operative, and the "Valle de los Aburtos"-family plants) credits and gifts were granted from the **project budget**.
Also in cases were the construction of a new plant may serve demonstration purposes (e.g. the "Las Piedrecitas" plant in Matagalpa) the project financed a substantial part of the needed investments.
Next to this the project did have contacts with the national development bank BND, but up to june 1986 no farmers had used the opportunity offered for subsidiary loans.

<u>Material resources:</u>
The project kept good contacts with national and local producers of building materials, PVC pipes and kitchens, in order to guarantee the acquisition of the needed materials. Such contacts were needed more and more in Nicaragua for the increasing scarcity of all possible resources.

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[16] See, e.g, S.Bonilla, R.Georg, R.Hoffmann, G. Ullrich, 1984

Human resources:
As mentioned in § 7.4.2.2 the programme made use of a pool of own trained craftsmen, who formerly were in a permanent engagement with ENPRA. For that reason no good overview of the possibilities of the local labor market existed.
A consequence was that in some cases interested farmers had to wait a very long time (several months) before the needed craftsmen were available.
Another problem was that the trained masons began to realize their monopoly position, which made the construction of the plant considerably more expensive to the beneficiary.

The same kind of statements can be made on the craftsmen needed for the construction of metal equipment (gas stoves, metal gas holders, engine adaptions). Although it should be stated that the master craftsman of ENPRA was a professional metal worker, it might have been better to involve local craftsmen in the construction of these products, for the reason of extension of the technology in society.

7.4.3.3 Training and education

In § 5.3.3.3 various target groups for training and education programmes were indicated, such as engineers and local counterparts, local craftsmen and contractors, owners and institutions, operators and users, and cooks and housewives.
In fig. 7.10 these target groups, and the training programmes in which they were involved, are outlined:

target group	description of Training & Education
housewives and cooks	"on the job" -training; written and illustrated material
operators and users	"on the job" -training;; written and illustrated material
owners and institutions	individual information; demonstrations, folders, brochures
local craftsmen and contractors	"on the job"-training; masons training courses (2)
engineers and local counterparts	"on the job" -training (working in learning situations); literature, etc.
german project staff	courses and congresses abroad; literature, etc.

fig. 7.9: Training and education in the GTZ programme

Training and education of local engineers and counterparts seems rather neglected in comparison to the other target groups. This, in spite of the fact that these people would have to continue the pprogramme after the Germans had gone.

This lead to the situation that alsso the nicaraguan staff did not feel very much for courses and rrefreshment: I noticed an attitude with these people that they woulld not need extra courses, since they already had enough experience with biogas, and understood the matter very well.

Theree have been attempts to have one of the nicaraguan engineers placed on an international course on biogas and anaerobic wastewater treatment in Wageningen, The Netherlands. For various organizational problems (on the dutch side) this course still has not taken place yet.

For the other parts T&E facilities the GTZ programme offered seemed sufficient. Only in a later stage lacks can be identified, and (if necessary) the programme will have to adapt her strategy in this.

7.4.3.4 Marketing aspects

In § 5.3.3.4 the task of marketing activities was described as "to facilitate and promote exchanges within the (dynamic) environment". Two major tasks were identified:
1. determination of, and operation in the market of renewable energy sources;
2. promotion of biogas technologies.

In § 7.4.2.1.1 it already has been mentioned that, within the framework of the programme, too little attention was paid to other renewable energy sources.
This was also the case in the market approach. It would have been good if the programme had a complete product-mix on this segment, in order to offer each individual costumer the most appropriate solution for his energy problems.
This was not the case.
Together with the insufficient attention paid to socio-economic aspects of biogas technology this may have lead to situations in which biogas technology was appraised, while smaller solutions (such as, e.g, an economic wood-stove) would have given a better economic revenue.
The programme was, in this respect, orientated rather on technology than on the costumer.

Next to this the following remarks can be made regarding the marketing approach of the programme:
1. Market research, or active attempts to extend the customer base, were hardly undertaken.
   This has to do, as in the INE case, with the fact that the programmes' capacity did not reach to extend the activities very much.
2. The programme did spend much attention to promotion.
   Folders, stickers and T-shirts were printed to give publicity to biogas technology and the programme's activities.
   Good relations were kept with newspapers, radio and television, and quite regularly some promotion was made through these official channels.

7.4.3.5 Bookkeeping and adminstration

Administration was kept by the central organization of the ENPRA (or CITA-INRA) organization, and by the german project staff. A project administration was kept by the project staff, so that an overview could be obtained of expenditures on the various projects. It is not known whether post-calculations were done in order to improve cost estimations before starting a project.

7.4.4 The programme's environment

7.4.4.1 The mother organizations

Because of the involvement of GTZ, as an official foreign participant, in the project the position of the biogas programme in the mother organization has been special.
This may be shown by the position of the programme in the ENPRA organization (see fig. 7.5), in which it had the position of a staff organ.

In her task-objectives (see page 7-3) ENPRA had given her directives and interests, and the programme was supposed to work within this (very broad) framework. This gave the programme a rather independent position.

The division of responsibilities and tasks between the various involved organizations (in the ENPRA era) is shown in fig. 7.10.

	involved organizations
responsibility	GTZ; ENPRA
finance	GTZ;ENPRA;beneficiary (direct project costs)
personnel	GTZ (german staff); ENPRA (nicaraguans); beneficiary (constructors)
equipment	GTZ (project donations)
materials	project org; beneficiary (project mmaterial)
transport	GTZ (2 cars); ENPRA (1 car) + maiintenance
information	GTZ (professional); ENPRA (commmunication)

fig. 7.10: Division of tasks and responsibiliities between the involved organizations

What strikes is a rather balanced involvement of both organizations in the project, in which ENPRA contributes to a large extent (considering her capacity). This underlines the interest ENPRA has in the programme.

Since each organization involved in the programme has had its own objectives, it is interesting to make a distinction between the various parties involved, their speciific task-objectives in the programme, and the extent to which thhe programme worked on the effectuation of these objectives.
Regarding the different objectives of the mother organizations and the way they were achieved by the programme organization a survey is given in fig. 7.11.

party involved	objectives	activities
GATE / GTZ	- promotion of rural development through	yes
	- extension of biogas technology	yes
	- based on integrated project approach	no
	- adapted to local requirements	yes
	- focussing on small family plants	yes/no
	- development of extension strategies	yes
	- cooperation with local organizations	yes
	- integration into international biogas development	?
CITA-INRA (MIDINRA)	- experimentation in on-site situations	little
	- small scale applications (co-operatives)	yes
	- diminish national economic foreign dependency	??
ENPRA	- T & E of ENPRA personnel on biogas	
	* on pig farms (agro-industrial scale)	yes
	* cattle farms (agro-ind. & family scale)	yes
	* regional extension of biogas	yes
	- technical and social evaluation	no
	- sanitation and waste-treatment pig farms	little
	- biogas techn. for human sanitation	yes/no
	- use of biogas for motor engines (electricity)	yes

fig. 7.11: Interest of involved parties and task objectives

Regarding this table it should be concluded that the ENPRA task-objectives have been achieved to a lesser extent than the GTZ objectives.
This may be signative to the situation: When the programme was transferred from CITA/INRA to ENPRA the latter had specific expectations, namely the solution of the waste problems of the ENPRA farms. The development of a new commercial activity (the design and construction of biogas plants) should, in my opinion, be regarded as a second objective.
These expectations could not be fulfilled, because of a lack of technical expertise in the german team.

As an indication for the above mentioned: After terminating the german involvement in the programme (december 1985), the ENPRA direction put more priority the own ENPRA problems (waste-treatment), and less to the objectives of biogas extension in the country.

7.4.4.2 Relations with other organizations

In § 5.4.2 it has been stated that the involvement of other organizations could be desirable for reasons of dissemination of the biogas technology in society. With the growing of the programme tasks should be left to other, civil organizations in order to promote dispersion of knowledge and experience.

In the GTZ biogas extension programme such a strategy was only followed to a marginal extent: Most tasks were executed by the programme organization, together with the beneficiary (see fig. 7.12 and 7.13).
Casting off project tasks to civil organizations in the construction phase did only take place after the own craftsmen had terminated their contracts with the project and started to work for their own.

Relations with other organizations working in a related field were also rather scarce: Although the programme was a member of the Grupo Nacional de Biogás (see also § 6.4.4.2), it didn't play a very active role in it. Meetings of the group were rarely visited and little importance was attached to the existence of the group. The poor relationship between the ENPRA/GTZ and the INE programmes (but also with the UNI) must have played a role in this.

organ \ process	PRE-INVESTMENT	EXCAVATION	CONSTRUCTION	INSTALLATION	AFTER-CARE
BENEFICIARY	- participation in planning, design - go ahead dec.	- unschooled labor	- unschooled labor	- unschooled labor	- training "On the job" - unschooled labor with reparations
FINANCIERS	- go ahead decision (GTZ)				
LABOR MARKET AND CONTRACTORS		- via beneficiary	- own personnel - contractors - administration	- own permanent personnel - administration	- own permanent personnel - administration
SUPPLIERS			- delivery via the project organization		- central delivery via project organization
RELATED ORGANIZATIONS					

fig. 7.12: Environment matrix for the primary process, external organizations

organ \ process	ADMINISTRATION	R&D	ACQUISITION	TRAINING & ED.	MARKETING
BENEFICIARY			- part of materials	- "on the job"	- information with folders and other materials
FINANCIERS	- budget control - administration		- acq. of finance (GTZ)		- contacts with local banks
LABOR MARKET AND CONTRACTORS	- personnel administration		- acquisition of personnel - contractors	- training of local craftsmen in courses	- own contractors (permanent)
SUPPLIERS		- sale of materials and equipment	- sale of materials and equipment		- contacts with local wholesalers and producers
RELATED ORGANIZATIONS					

fig. 7.13: Environment matrix of the secondary processes, external organizations

7.5 Conclusions

Regarding the objectives of the GTZ programme as it was executed until 1985 (see § 7.1 and fig. 7.11) the following conclusions can be taken:

- During the programme period the GTZ biogas projects have contributed considerably to the dissemination of biogas technology in Nicaragua;
- It was the objective of GTZ to achieve this objective by means of an integrated project approach. This has not been realized. One of the reasons for this was the lacking experience of project staff in the other fields of rural energy provision;
- In the GTZ programme objectives it was stated that the biogas extension programmes should aim, in the very first place, on the dissemination of biogas plants for small families. This has only partly been effectuated: Especially after the transition of the programme to ENPRA the agro-industrial sector had become a second major target group. It is logical that these two approaches must have conflicted;
- The programme tried to develop his strategy and technology in a way fitting in the local situation. A technical design of a plant was made, which could be realized with local materials, local craftsmen, and locally known construction techniques;
- The programme has only partly been integrated into the national *biogas development*: Relations between the GTZ biogas programme and the other (read: INE's) programmes worsened during the course of time, which formed a major limitation for contact with other national programmes.

Regarding the fulfillment of the objectives of other involved parties we referre to fig. 7.11: It appears that in the very first place the objectives of the GTZ programme were achieved, while the interest of the others seemed to play a less important role.

Regarding the transition of the programme organization to ENPRA it may be remarked that:

* From the point of view of dissemination and more massive dispersion of biogas technology in the country it was necessary to leave the CITA-INRA organization: CITA-INRA was not prepared to undertake this activity, so that another counterpart-organization was to be found;
* However, ENPRA had her own expectations and objectives with the programme. It should have been realized, in my opinion, that activities inside and outside the ENPRA organization might conflict. Now the ENPRA has had a project which hardly worked on her own interests.

As a summary the following weaker and stronger points of the GTZ programme can be mentioned:

strong points:

a. The programme had a complete control of the entire project cycle, with respect to financing, personnel, equipment, materials, transport and information (§ 7.4.2);
b. She approached the problems of biogas dissemination in a careful and professional way; She made an appropriate estimation of her capacity;
c. The programme had good expertise on technical aspects of biogas technology (7.4.2.2);
d. There was room for participation of the beneficiary in the decisions to be made in the pre-investment phase (7.4.2.1.4);
e. Training and education of beneficiaries, operators and local craftsmen were provided and well organized (7.4.3.3);
f. The programme spent much attention to promotion and publicity (7.5.3.4).

weak points:

g. The programme was strongly orientated on technical and aspects of biogas technology as an energy supplier. Bio-fertilizer, as a second product of the biogas system, was under-estimated and neglected (7.4.2.1 and 7.4.2.3);
h. A poor estimation was made of the socio-economic aspects of biogas technology, and unreliable information regarding this aspect was given to the beneficiary (7.4.2.1.2);
c. Limited involvement of contractors (7.4.2.2 and 7.4.4.2);
d. Limited training and education of local engineers and counterparts (7.4.3.3);
e. Limited attention and expertise for solving ENPRA's waste treatment interests (7.4.4.1);
f. Poor relations with other organizations on the field of biogas, or rural energy supply (7.4.2.2).

How these "weak points" will influence the practice of the implemented biogas plants is rather difficult to forecast. Most installations only exist since a relatively short period (1-2 years, of 10% of the estimated economic life-time). Problems will possibly appear after a few years.

Conclusions about the process of transfer of technology to the nicaraguan staff (and society) can therefore only be taken after a period in which the nicaraguan counterpart will perform all activities by herself.

Chapter 8: Conclusions, systhesis and perspectives

contents:

Chapter 8: Conclusions, systhesis and perspectives

8.1 Introduction

The analysis of two biogas implementation projects in Nicaragua was meant, for me, to discover why so many development projects do not achieve the set objectives.

The study is based on the assumption that problems in the implementation of biogas projects are mostly caused by a complexity of factors. These factors may be situated inside the project organization, or in its environment.[1]

One of my assumptions was that the management of these projects often showed severe lacks. Therefore a detailed analytical instrument was designed in chapter 5, enabling the identification of the lacks in project preparation, implementation and after-care.

Another assumption was that the poor achievements of some programmes were caused by the difficult situation in the country. Therefore, chapter 3 intended to describe part of the political and economic environment in which projects are to be developed in Nicaragua.

In this chapter I would like to reconsider these two points, and to make an estimation of the possibilities of these kind of projects in Nicaragua, in the future.

Therefore, in 8.2, the major conclusions of the former chapters will be reconsidered and compared.

In 8.3 I will try to give an outlook for the development of biogas activities in Nicaragua. Especially attention will be paid to the possibilities of a newly proposed biogas project in Matagalpa region.

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[1] In this I agree with Blankenberg, when he states that "it is impossible to explain implementation problems by a single factor, of even a single complex of factors" (Blankenberg, 1985, p. 250)

8.2 Conclusions and systhesis

<u>1. the analytical instrument</u>

The conclusions of the chapters 6 and 7 gave a sufficient impression of the elements which have lacked in each of the programmes, when comparing them with the analytical framework of chapter 5.
Here it should be the place to reconsider the value of this framework for the made analysis.

Regarding the INE programme it may be opposed that the used analytical tool was very detailed, and therefore too powerful. The accomplished activities were cut down in minuscule pieces, each of which deviated from the ideal model of chapter 5. The quantity of identified problems in the projects was abundant, and every deviation could have been a cause for some failed aspect of one of the projects.
From the point of view of project evaluation, a less detailed analysis of the stronger and weaker points of the project would have brought the most important lacks in the programme to light.

A second crititcal aspect of this analytical tool is the question of causality: It is always disputable to name causal relations between two phenomena when they occur in a complex environment. It is my opinion, however, that many of the project failures could have been avoided if more attention would have been paid to the identified lacks in project management.

The prevailing reasons to present the analysis in this way, however, were:
1. The INE analysis showed in detail the working of the model of chapter 5. Also in less obvious situations the model can be used, which gives it some more universality.[2]
2. The model brought many questionable situations to light, which also occur in other institutions in Nicaragua. To put it even stronger: The INE organization can not be called a negative exception among the nicaraguan institutions.

Regarding the analysis of the GTZ programme the major part of this study existed of the identification of deviations of the idealized model of chapter 5. Only in some cases the consequences for the beneficiary could be recorded.

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[2] Robert Pirsig would refer to the limitations of the scientific method, as a "precise instrument", as opposed to the "common sence" and the "fingerspitzengefühl" of the professional. The scientific method will always lead to the solution, but the "common sence" track will provide a shorter cut... (R. M. Pirsig: Zen and the Art of Motorcycle Maintenance; New York 1974)

In my opinion one is to be especially pessimistic about the transfer of the developed experience in the programme to the nicaraguan society. Very little attention was paid to the involvement of other organizations in the developed activities. This counts especially for the involvement of local contractors, and the communication with other organizations, working in the same field of rural energy supply.

However, these and other deviations from the model mentioned in chapter 7 have had little or no time to exercise their effect to the individual projects. Especially the lack of training and education, and the small educated staff which was left behind, will probably reveal themselves only after a few years.
The same can be notices about technical mistakes, which haven't shown up yet, but which may shorten the economic lifetime of a biogas plant to a considerable extent.

The value of the model of chapter 5 should, in my opinion, above all seen in the relative completeness of the described necessary activities. It is a kind of inventory of the necessary activities needed for a successful execution of a biogas project, and may as such serve as a checklist for future projects.

2. costs and benefits

The most important conclusions of the cost benefit analysis were (see also $ 4.5):

1. Biogas installations for industrial applications are not attractive from an economic point of view, for the investigated scale of operation. This counts for as well the financial analysis (the point of view of the farmer), and the social analysis ("general interest").
   With industrial application, in this context, is meant the application of biogas as a fuel for stationary engines, i.e. for the production of mechanical energy, or for conversion to electricity.
2. The application of biogas technology is not economically feasible if the produced bio-fertilizer is not utilized.
   It appeared that the plant-effluent forms the system's most important benefit, and the mere application of biogas as a fuel producing system is not attractive from a (financial or social) economic point of view.
3. Economy of scale is especially important for the financial analysis: It appeared that biogas plants, when applied for domestic purposes (cooking and lighting) and when the bio-fertilizer is fully utilized, is only financially feasible at a scale larger than 10 m^3 digester volume.
   In a social analysis, however, plants of this type seem feasible at every scale from $5m^3$.
   This justifies the supply of (governmental) financial support to small farmers who want to invest in biogas.

Now, some limitations should be mentioned of the importance of the economic evaluation:

- The Nicaraguan farmer tends to be more interested in the application of biogas as a fuel. Organic fertilizers are hardly applied in rural Nicaragua.

- Next to this, most farmers want to have their little engine run on biogas. The extra investments they have to do, don't seem to hurt them.

A reason for the farmers to deviate from the "economic sould behavior" is, that official prices in Nicaragua do not reflect the real value of commodities to the people. Energy is scarce, whether diesel or electricity. If it is there, however, it is very cheap. Prices, up to now, do not form an objection for many people to buy most commodities. The simple availability of them does.

This situation of scarcity is worsening.
The USSR has reduced the guaranteed oil supply from 90 to 60% of total Nicaraguan demand. Since the beginning of 1987 oil products have become more scarce.

Firewood is mainly available at prices which are much higher than officially set. This may amount to a factor 5-10 higher (see § 4.3.1, p. 4-12).

Another limitation of the cost-benefit analysis is the irregular inflation: At this moment (june 1987) most prices are about a factor 10 higher than the prices of april 1986.
Especially the prices of basic food products have risen, and the falling dollar has elevated the prices of many imported European and Japanese goods.
Salaries have stayed behind the rising prices. The buying power of the nicaraguan citizen has decreased considerably.

These factors may make biogas technology more attractive: Depending on the shift between the prices biogas may become (financially) more attractive.

Still, in my opinion the presented cost-benefit analysis has its value: It attracts the attention to the other factors of biogas technology, and opens a view for more needed research:

* Conclusions as resulted from the analysis have, up to now, not been realized in Nicaragua. It is good to set, e.g, the value and importance of plant effluent to paper, to attract attention to this problem. Still biogas plants are being planned in situations where the produced bio-fertilizer can not be applied.*
* The CBA model, as presented, may serve as a tool to calculate, at any given moment, the probable costs and benefits for a specific case.
* The analysis attracts the attention to new research topics: when e.g, the bio-fertilizer appears to be the most important product of the process, it is not unlikely that other techniques to produce organic fertilizers are even more attractive than biogas.

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* In 1986 a new biogas plant at a pig farm near Jinotega has been built. Here even the produced gas is lost, since no application possibilities exist in this place!

Besides, the part of the social analysis, appraised in foreign currency, has a less dated character. Shadow prices in this analysis were mainly based on needed energy and steel inputs. These prices seem not extremely turbulent at the moment.

3. the environment

From chapter 3 it appeared that the present economic and political situation in Nicaragua is far from ideal for the development of innovative activities. The social situation is very turbulent, mainly because of the precarious economic and military situation.

Reflecting the course of the INE and the GTZ programmes, a major difference should be noticed:
The INE project was entirely set up and maintained by Nicaraguans, in a local organizational context.
In the beginning some foreign (financial and material) input took place, but later all activities were developed with own means. Especially during the later stages, after 1983, this was a very difficult situation to work in: Government cut budgets of all institutions, especially of those activities which could not be regarded as "directly productive".
It was very difficult to obtain specialized and expecienced personnel, while the organizational support of the mother organization got less, since other activities were priorized.

The influence of the mentioned "turbulent environment" should not be underestimated. The efficiency of INE, but also of other nicaraguan state organizations, has worsened very much because of the economic crisis.
Many organizations are no more capable of paying their employees salaries.
The informal sector sucks qualified personnel away from their responsible work, since selling icecream in the streets of Managua yields as much as working a month at the INE office.

The GTZ project, on the other hand, was equipped from the beginning with foreign specialists and foreign financial and material inputs.
The programme had the disposition of people who had an excellent education (compared to the Nicaraguans), and who got backstopping from Germany.
Next to this, the nicaraguan counterpart organization ENPRA was in the lucky situation to make enough profits to be able to finance a considerable part of the programme, and pay her employees well.
As a consequence, this programme operated in a more protected organizational setting than INE's, in which the bad environmental situation of the country did have full impact.

This, of course, is a considerable advantage.

A drawback of GTZ's position was, that the programme activities seemed to take place in an enclave. The lack of communication with other organizations can partly be explained from this position: Why contract other local constructors when personnel inside the project can do the job much faster, and with better resources? Concluding: it should be recognized that the GTZ programme organization was under the wings of two strong mother hens, and therefore could deliver acceptable results.

8.3 Perspective

Considering all factors above, the perspective of biogas technology seems a little confusing: On the one hand the biogas seems economically attractive, so that enough demand will exist for this technology.
On the other hand, however, severe doubts should be placed on the management problems of effectuating a biogas extension programme: The introducion of this technology needs support in the form of expertise and financial support. Such support is probably to be provided by the government organizations.

Because of the bad economic situation of the country, and the bad position the institutions have, their capacity may be insufficient to support the dissemination of biogas.

Besides, in the contemporary situation the institutions have to set priorities. It is the question whether the introduction of biogas deserves such priority.

The INE organization wants to stop her biogas extension programme, because of the lack of perspective.
However...

In Matagalpa the regional department of MIDINRA Reg. VI is starting a new biogas extension programme.
Objective is to promote biogas technology in the region.
Support is obtained from the dutch non-governmental development aid organization NOVIB, while SNV will supply personnel assistence.[4]

The programme should more especifically be connected to the MIDINRA dairy projects in the region (see fig. 3.21), aiming to intensify husbandry and to produce milk for the internal market. Biogas technology can play a constructive role in these projects, since the products and the positive side-effects of this system (see chapter 2) may show its full advantage.

Next to this the programme is to participate in investigations towards a solution to contamination problems in the region: Coffee- and dairy industry severely pollute open waters in various parts of the region, and are a threat to the drinking water supply of the city of Matagalpa, and the irrigation water supply of many farmers. Special biogas techniques may offer a solution to these problems,but they require substantial material input and qualified operation and maintenance personnel.[5]

Another reason to start a biogas dissemination project in this region is the lack of firewood, especially in the southern sector of the region and near the cities: Many farmers and small entrepreneurs have applied for the construction of a biogas plant, to solve their daily fuel problems.

Even when the local market seems to demand for new technological input of this kind, questions should be raised at this proposition: Does the MIDINRA organization have enough capacity

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[4] MIDINRA, 1986
[5] Wasser, 1986

and resources to realize such a programme? Doesn't she suffer from the general bad situation of the government institutions in the country? How can local personnel be guaranteed, when in this region 75% of the males, between 19 and 40 years old, are under military service (exceptions are hardly ever made, for men who are needed in civil positions)?

These are only the first problems to be faced.

It should be admitted, however, that pessimism is not a very nicaraguan feature.

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Annex 1: Digester design

1. The fixed-dome digester

The Chinese, of "fixed-dome" digester is an underground structure that is entirely made out of bricks and cement and contains no metal (difficult to purchase) of moving (vulnerable) parts. It is the basic concept of biogas digestion: A simple, round tank for the hold-up of a certain amount of slurry for a certain period of time.
The digester and gasholder form one unit (see fig. 1). The generated gas presses the slurry into an outlet (or compensation) tank. The differences of height between the slurry level in the outlet and inlet compared to the height of the slurry inside the digester determine the gaspressure.
The digester pit mus be absolutely sealed, so that the whole pit is watertight and the gas section is gastight (normal concrete and brick masonry structures are not gastight).

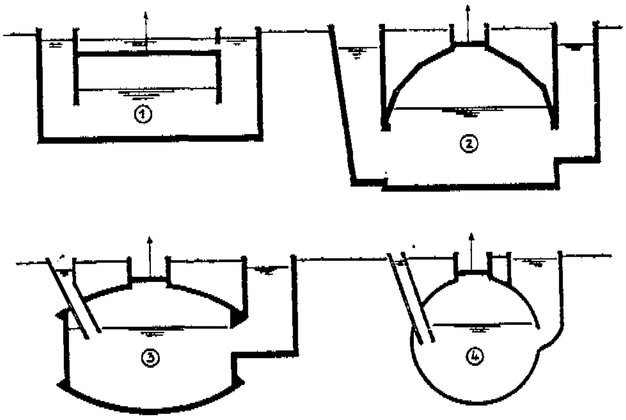

Fig. 9: Example of Chinese fixed dome plants.
1. Rectangular plant for the 1960; 2. Plant using stone slabs; 3. Szechuan plant: "small, round, flat"; 4. Shanghai spherical plant

fig. I.1: fixed dome digester

Originally the fixed dome digester was developed in The People's Republic of China. There the people are used to feed the digester with a mixture of dung and plant material.
Sedimentation and slum formation will occur and will have to be removed. A special manhole is fitted in the dome to be able to empty the digester regularly.
The same model has been introduced in Indonesia and India, in different modifications.

In Nicaragua, GTZ introduced a BORDA-modification (see fig. 2). It has several advantages over the conventional Chines types:

* The oulet chamber has been enlarged, so that is became possible for a man to enter the digester via the outlet;
* Also because of the enlarged outlet, it is now possible to remove the slurry "automatically" from the digester through an overflow: Because of the fact that the compensation tank has the same volume as the gas-storage room, surplus slurry will leave the tank when the gas chamber is completely filled with biogas.

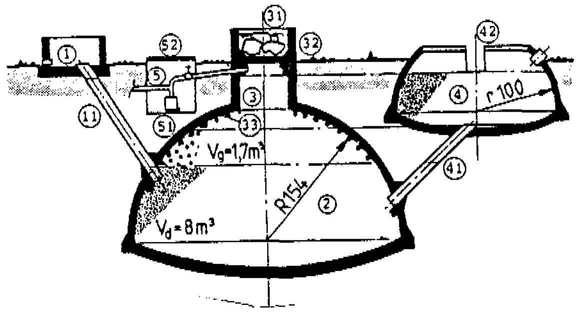

fig. I.2: The BORDA fixed dome plant

Especially in cultures where the people are not used to handle animal- or human excreta this is a big advantage.

* The tank proved, because of its round construction, to be resistent to small earthquakes, which is a considerable advantage in Nicaragua.

General advantages of fixed-dome types are:

* <u>maintanance:</u>
  Since the digester has no metal or moving parts, it will not require any maintanance. However, when cracks develop in the structure, repairs will be needed. About once in two-three years it may have to be emptied to remove the sedimentated sludge;
* <u>costs of construction:</u>
  The construction of such a digester is in many situation cheaper than the Indian digester, with a floating (steel) gasholder;
* <u>availability of building materials</u>
  In most rural areas the building materials required for the construction of a fixed dome digester are usually available. This is particularly so, since no metal gas holder is required. For Nicaragua it can be stated that all needed construction materials are produced in the country.

Disadvantages of this digester are:

* <u>leakages:</u>

  It is said to be very difficult to make the masonry structure and the cement plaster of the dome gastight.
  In Nicaragua, however, I noticed only one out of 15 built BORDA-installations suffering these problems. Reasons that these problems have not been reported yet, might be:
  . The relatively recent construction of the installations: Cement has the feature to get weaker and porous over the years, particularly if the cement fraction in the mortar is low;
  . The relatively qualified peronnel used in construction: Only qualified craftsmen have been used to construct the biogas tanks.

2. The floating gasholder design

The digester is a brick construction resembling a water well installed below the ground level. An inlet pipe connects a slurry mixing chamber with the bottom of the digester. The fresh incoming slurry is forced to rise because in most cases a division wall is placed in the digester. At the other side of the partition wall the slurry moves down and can leave the digester via the bottom through an outlet pipe. The gas which bubbles from the digesting slurry is captured by a metal drum like a gas holder. The drum is free to move vertically in the slurry and as gas accumulates the gas holder will get lifted. A lexible gas pipe is connected to the gas holder and supplies gas to the appliances.

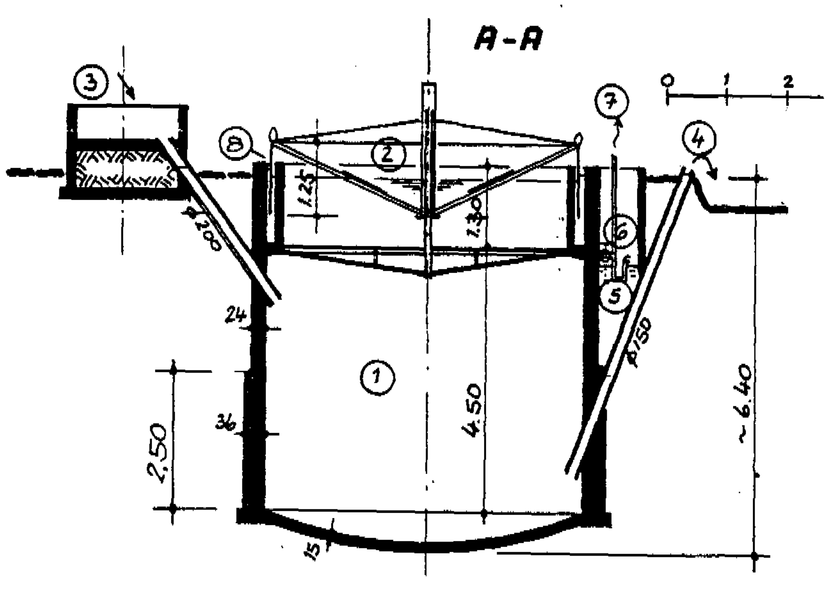

fig. I.3: The floating gasholder design

Designs of different sizes have been worked out. The most common model has a volume of 4-6 m^3. The depth of these digesters may vary between 3.5-6 m and the diameter between 1.35-6 m.
The gas holder is made of mild steel sheets.

Advantages:

* <u>gas pressure:</u>
  Due to the lifting of the gas holder and its own weight the gas pressure will be very low and not exceed 10 cm water column. This pressure is sufficient to supply gas to the soves and avoid wasting of gas due to a too high flame;
* <u>scum removal:</u>
  The gas holder can be removed form the digester to break up the floating scum manually or empty the digester in case of blockages or repairs to be carried out.
* <u>mixing:</u>
  The floating gas holder can be rotated occasionally. The mixing bars which are fitted inside the digester cause agitation of the slurry. Mixing of the slurry may lead to higher gas production due to the increase of contact between substrate and bacteria, and/or throught the forced removal of small gas bubbles from the slurry that congregate to form larger bublles that can rise to the surface. The daily rise and fall of the gas holder will also break up the scum layer.

Disadvantages:

* <u>Depth of the digester</u>
  Digging the "required" depth for the digester is often a difficult and laborious job particularly in rocky soil. This depth will also restrict construction of a digester in areas with a high ground water table.
* <u>gas holder</u>
  a The gasholder is the most costly part of the digester. It can amount to 35% of the total expenditure of a digester (in India). These high costs are due to the high price of metal sheets and the high quality welding;
  b A most serious problem of this type of digester is the corrosion of the metal gas holder. Because the drum is usually floating in the slurry, rusting takes place very quickly. Particularly the zone of the drum that is in contact with the surface of the slurry and which is alternatively dipped under and exposed to the air is affected. Painting of the drum is essential, at least once a year, and should be executed very careful. In India, this problem causes most complaints on biogas plants.
  Variations on this type of digester overcome these problems to a large extent: The introduction of a water jacket in which the metal gas-holder can move, and the introduction of the seperate gas holder reduce corrosion problems considerably. Still, a maximum life time of a gashoder will be no more that 6 years, if good maintanance is applied.
  c The metal gas holder is an ideal conductor of heat and transmits most heat from the slurry into the air. Especially differences between day- and night-temperature may affect digestion velocity, and with this, the gas production.

3. The plug-flow digester

The plug-flow digester is a long, horizontal, tube-like digester with a length-diameter ratio of L:D = 3-7:1, circular or rectangular.
Of this digester exist various variations, but all are based on the principles known form chemical reactor engineering, form which appears that higher conversion rates in chemical reactors can be exepected when using a plug-flow system in stead of completely mixed reactors.
In practice, plug-flow biogas digesters produce more gas than for example a Chinese reactor.

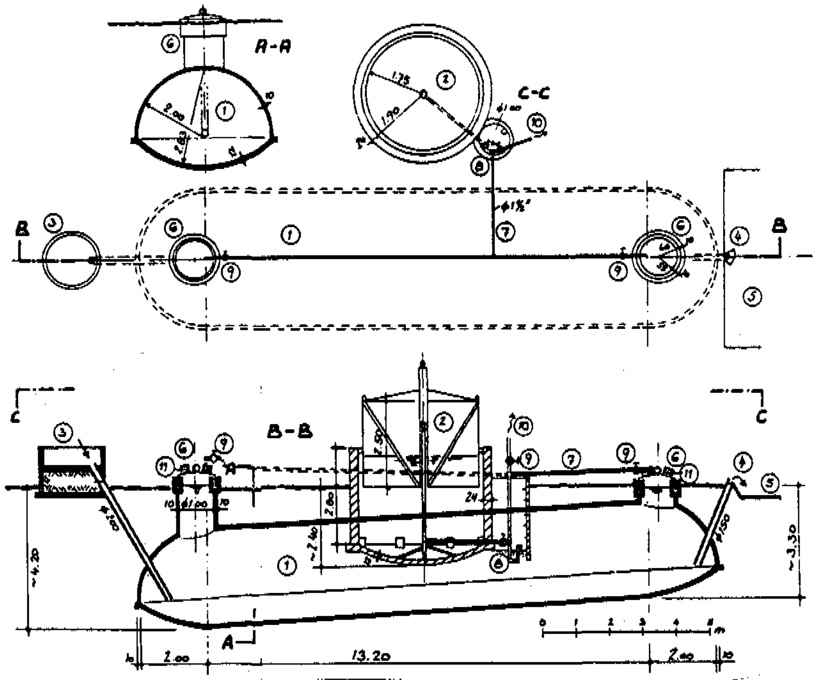

fig. .4: Example of the plug-flow reactor design

The reactor may be constructed of steel, bricks or rubber (red-mud digester), and usually has a seperate (steel, concrete or PVC) gas holder.

Advantages:
- gas production:
  Through the application of the plug-flow principle, higher conversion rates are reached, signifying a more complete digestion of the organic matter, and a better gas production;
- maintanance:
  When placed aboveground, the digester can be repaired and maintained very easily: The problems of accessability of underground structures are avoided;
- seperate gasholder:
  The usually applied seperate floating gasholder does not come in contact with the slurry, so that corrosion processes are slowed down.

Disadvantages

- <u>costs:</u>
  A metal gasholder, a seperate structure in which floats the gas holder, and an aboveground structure (necesarrily stronger than an underground structure) make most plug-flow digesters much more expensive than the fixed-dome type and the simple Indian type;
- <u>vulnarable:</u>
  If constructed aboveground, the digester may be easier damaged through exposure to climatological conditions, and damage through machanical fraction.

Annex 2: Cost calculations of biogas digesters

The calculations in this annex are based on the design of the BORDA installations. In part A you will find the expected expenses for a fixed dome type, whereas in part B the metal gasholder design will be calculated.

A. Fixed dome design

Volume of digester parts

	5 m^3	10 m^3	15 m^3	20 m^3	30 m^3
digester vol (m^3)	5.0	10.0	15.0	20.0	30.0
gasholder vol (m^3)	1.0	2.0	3.0	4.0	6.0
total vol (m^3)	6.0	12.0	18.0	24.0	36.0
excavation vol (m^3)	15.1	27.8	39.5	50.9	63.2

PERSONNEL, based on design calculations and estimated productions

PERSONNEL	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
unschooled (d)	33.1	51.2	67.5	84.9	104.2
schooled (d)	14.4	20.3	25.0	30.5	38.1
excavation (10^3C$)	46.4	81.4	112.0	142.3	179.2
construction	49.0	67.9	84.0	105.0	129.9
installation	14.0	14.0	14.0	14.0	14.0
(* C$ 1,000)	109.4	163.3	210.0	261.8	323.1

List of materials, incl. 15% extra, based on design calculations

	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
brickstones	897.0	1381.3	1794.0	2164.7	2792.6
sand (m^3)	1.8	3.0	4.0	4.9	6.5
cement (qq)	12.2	19.3	25.9	31.4	41.6
lime (qq)	2.9	4.6	6.1	7.3	9.5
stones (mcu)	0.7	1.1	1.6	2.0	2.7
paint (l)	0.4	0.7	1.0	1.2	1.6

(* 1000 C$)	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
brickstones	19.5	30.0	39.0	47.0	60.7
sand	6.9	10.9	14.6	17.9	23.9
cement	5.3	8.4	11.2	13.6	18.1
lime	2.6	4.0	5.3	6.3	8.2
riverstones	3.8	6.2	8.4	10.5	14.4
paint	0.2	0.3	0.5	0.6	0.8
TOTAL(*C$1000)	38.4	60.0	79.2	96.1	126.2

relative	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
brickstones (%)	50.7	49.9	49.2	48.9	48.0
sand	18.0	18.2	18.5	18.6	18.9
cement	13.8	14.0	14.2	14.2	14.3
lime	6.7	6.6	6.6	6.6	6.5
riverstones	9.9	10.4	10.7	10.9	11.4
paint	0.5	0.6	0.6	0.6	0.6
TOTAL	100.0	100.0	100.0	100.0	100.0

KITCHEN AND GASPIPES

	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
stove, 2 burners	30.0				
ind. stove, (2)		70.0	70.0		
ind. stove, (3)				100.0	100.0
tubes 1/2"	2.0	2.0	2.0	2.0	2.0
tubes 1"	9.6	9.6	9.6	9.6	9.6
assecoires	2.9	2.9	2.9	2.9	2.9
TOTAL	44.5	84.5	84.5	114.5	114.5

TRANSPORT

	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
carga (tones.)	8.0	13.3	17.0	21.1	27.9
number of rides	2.0	3.0	4.0	5.0	6.0
fixed costs	1.0	1.5	2.0	2.5	3.0
variable costs (C$/km)	184.0	305.9	391.0	485.3	641.7
in case of 20km (* C$ 1,000)	3.6	6.1	7.8	9.7	12.8

TOTAL COSTS

(* C$ 1000.=)	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
Personnel	109.4	163.3	210.0	261.8	323.1
Materials	38.4	60.0	79.2	96.1	126.2
Kitchen and pipes	44.5	84.5	84.5	114.5	114.5
Transport	3.6	6.1	7.8	9.7	12.8
TOTAL	195.9	314.0	381.5	482.2	576.7

relative costs	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
Personnel (%)	55.8	52.0	55.0	54.3	56.0
Materials	19.5	19.1	20.7	19.9	21.8
Kitchen and pipes	22.7	26.9	22.1	23.7	19.8
Transport	1.8	1.9	2.0	2.0	2.2
TOTAL	100.0	100.0	100.0	100.0	100.0

B. Metal gasholder design

Volume of digester parts

	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
digester vol (m^3)	5.0	10.0	15.0	20.0	30.0
Vexc	10.5	19.4	28.2	36.0	53.3
Radius gasholder (dm)	5.4	6.9	7.8	8.6	9.8
Surface idem (m^2)	2.7	4.5	5.8	7.0	9.1

PERSONNEL

EXCAVACION	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
obreros (d)	10.5	19.4	28.2	36.0	53.3
official (d)	6.7	10.7	14.2	17.0	22.3
TOTAL EXC.	41.1	70.9	99.0	123.2	173.5

TOT.PERSONAL	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
unschooled (d)	25.1	39.2	52.2	64.8	88.7
schooled (d)	14.0	20.6	26.2	31.4	40.0
excavation (10^3C$)	41.1	70.9	99.0	123.2	173.5
construction	37.5	55.3	70.4	86.8	109.9
installation	14.0	14.0	14.0	14.0	14.0
constr. gasholder	136.7	223.2	285.3	346.8	450.3
total (* C$ 1,000)	229.5	363.5	468.7	570.8	747.8

List of materials, incl. 15% extra, based on design calculations

	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
brickstones	783	1238	1627	1956	2548
sand (mcu)	1.4	3.1	2.8	3.2	4.3
cement (qq)	8.6	13.8	18.0	21.6	28.8
lime (qq)	1.9	3.0	3.9	4.8	6.2
riverstones(m^3)	0.5	0.8	1.0	1.2	1.7
gasholder					
steel (kg)	509.4	831.7	1062.8	1292.0	1677.8
paint (l)	1.0	1.7	2.1	2.6	3.4

Costs of materials

(* C$ 1000.=)	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
bricks	19.5	30.9	40.6	48.8	63.6
sand	6.0	9.6	12.6	15.0	20.1
cement	4.3	6.9	9.1	10.9	14.4
lime	2.2	3.4	4.5	5.5	7.2
riverstones	3.4	5.6	7.3	8.6	11.7
paint	0.6	1.0	1.3	1.6	2.1
steel	78.6	128.3	164.0	199.4	258.9
TOTAL MATERIALS	114.9	186.1	239.8	290.1	378.3

relative (%)	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
brickstones	17.0	16.6	16.9	16.8	16.8
sand	5.2	5.1	5.2	5.2	5.3
cement	3.8	3.7	3.8	3.7	3.8
lime	1.9	1.8	1.9	1.9	1.9
riverstoned	3.0	3.0	3.0	2.9	3.1
paint	0.5	0.5	0.5	0.5	0.5
steel	68.3	68.9	68.3	68.7	68.4
TOTAL	100.0	100.0	100.0	100.0	100.0

KITCHEN AND GASPIPES

	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
stove, 2 burners	30.0				
ind. stove (2b)		70.0	70.0		
ind. stove (3b)				100.0	100.0
tubes 1/2"	2.0	2.0	2.0	2.0	2.0
tubes 1"	9.6	9.6	9.6	9.6	9.6
assecoires	2.9	2.9	2.9	2.9	2.9
TOTAL	44.5	84.5	84.5	114.5	114.5

TRANSPORT

	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
carga (tones.)	8.0	13.3	17.0	21.1	27.9
number of rides	2.0	3.0	4.0	5.0	6.0
fixed costs	1.0	1.5	2.0	2.5	3.0
variable costs (C$/km)	184.0	305.9	391.0	485.3	641.7
in case of 20km (* C$ 1,000)	3.6	6.1	7.8	9.7	12.8

TOTAL COSTS

(* C$ 1,000.=)	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
Personnel	229.5	363.5	468.7	570.8	747.8
Materials	114.9	186.1	239.8	290.1	378.3
Kitchen and pipes	44.5	84.5	84.5	114.5	114.5
Transport	3.6	6.1	7.8	9.7	12.8
TOTAL	392.6	640.3	800.9	985.2	1253.5

relative costs	reactor 1	reactor 2	reactor 3	reactor 4	reactor 5
Personnel	58.4	56.7	58.5	57.9	59.6
Materials	29.2	29.0	29.9	29.4	30.1
Kitchen and pipes	11.3	13.1	10.5	11.6	9.1
Transport	0.9	0.9	0.9	0.9	1.0
TOTAL	100.0	100.0	100.0	100.0	100.0

<u>COSTS GASHOLDER</u>

materials	79.2	129.4	165.4	201.0	261.1
personnel	136.7	223.2	285.3	346.8	450.3
TOTAL	216.0	352.7	450.7	547.9	711.5
% total:	55.0	55.0	56.2	55.6	56.7