Implementation Plan
National Programme on Domestic Biogas in Rwanda

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September 2006, Kigali, Rwanda

Acknowledgements

It was a pleasure to formulate this implementation plan for the first phase of a Rwandan national domestic biogas programme. This plan is the outcome of intensive consultation, discussions and field visits in which many knowledgeable individuals were involved. It was a joint initiative of MININFRA and SNV/Rwanda that was undertaken during the period of December 2005 to April 2006 by a team comprising of Guy Dekelver, Anaclet Ndahimana and Silas Ruzaigana.

We received full cooperation of our future partners and their suggestions and comments were found very helpful in order to elaborate the scope, content and quality of the plan. We like to extend our gratitude to SNV/Rwanda and MININFRA for entrusting us with the responsibility to formulate this plan and to all informants for their constructive contributions and hope this plan will serve its purpose.

National Domestic Biogas Programme fact sheet

Title of programme: National Domestic Biogas Programme (NDBP)
Duration of programme: five years • 2006: preparatory phase (ongoing, funding is mentioned but not taken up in this proposal) • January 2007 to December 2010: implementation phase
Target: 15 000 domestic size biogas plants
Overall objective: to establish a sustainable and commercial domestic biogas sector in Rwanda
Expected results: the reduction of biomass resource depletion and a significant improvement in the quality of life of the families concerned: • saving of conventional fuel sources (mainly firewood); • reduction of workload, especially of women and children; • improvement in health and sanitation conditions, benefiting especially women and children; • increase in agricultural production with proper utilization of slurry; • employment generation; • reduction in green house gas (GHG) emissions, especially of CO_2 and CH_4.
Plant design: fixed dome
Programme area: the NDBP will kick off in the districts of Kamonyi, Ruhango, Muhanga, Rwamagana, Gasabo, Gicumbi and Rulindo. By the end of 2010 efforts in these districts will be expanded and replicated so that ten districts are expected to be covered. During later phases, the programme area can expand further to even more districts, in line with the human resources and financial capacity of the NDBP
Target group (TG): households who own at least 2 bovines and who have at least 20 kg of dung at their disposition on a daily basis
Implementing partner: Ministry of Infrastructure (MININFRA) with capacity building support of SNV, the Netherlands Development Organization
Partner organizations: private companies, NGOs, associations, financial institutes and government departments
Investment subsidy per plant: 300 US$
Budget: besides the 272 727 US$ provided by MININFRA as start-up funds in 2006, the total financial requirement is 14 943 630 US$ (subsidy: 4 455 000 US$, credit: 7 024 050 US$, farmers direct contribution: 1 277 100 US$, programme implementation cost: 1 447 480 US$ and SNV technical assistance: 740 000 US$)
Sources of funding (total budget: 14 943 630 US$): • Government of Rwanda (GoR) - subsidy (25 %): 1 113 750 US$ • Donor (to be identified) - subsidy (75 %): 3 341 250 US$ • Donor (to be identified) - programme cost: 1 447 480 US$ • Netherlands Development Organization (SNV) - technical assistance: 740 000 US$ • Farmers, via revolving fund of 5 494 500 US$ provided by a donor (to be identified) to a credit institute – credit: 7 024 050 US$ • Farmers - cash/labour contribution: 1 277 100 US$

Executive summary

Domestic biogas plants have a direct positive effect on rural peoples' energy supply, environment, health and agricultural production. Therefore, the Netherlands Development Organization (SNV) supports the formulation and implementation of national programmes on domestic biogas in some developing countries. In these programmes, multiple actors at different levels cooperate on the basis of proper institutional arrangements to provide access to sustainable energy for households raising livestock. SNV advises these actors in developing a commercially viable and market oriented biogas sector.

Biogas has a large number of potential **benefits**. It is part of a closed ecological cycle, which makes it a sustainable and renewable source of energy. By replacing traditional energy sources and by digesting dung in a closed environment, it yields a significant reduction in the emission of green house gasses (GHG). Biogas replaces firewood as the principle source of energy for cooking. This saves women time from collecting firewood, cooking and cleaning cooking utensils. Cooking with biogas instead of firewood or coal reduces the amount of smoke and health damaging particles. This has a beneficial effect on the health status of the households concerned, especially women and children. On top of that, if properly stored, treated and applied to the fields, biogas plant effluent has a far higher fertiliser value than ordinary farmyard manure.

Based on a feasibility study executed in March 2005, the Ministry of Infrastructure (MININFRA) and SNV have positively assessed the potential to emerge a National Domestic Biogas Programme (NDBP) in Rwanda. Subsequently, MININFRA and SNV have agreed on cooperating in the set-up and implementation of a National Domestic Biogas Programme in Rwanda. To this end, a Memorandum of Understanding (MoU) has been signed between MININFRA and SNV/Rwanda in October 2005.

The **overall objective** of the NDBP is to establish a sustainable and commercial domestic biogas sector in Rwanda, resulting in the reduction of biomass resource depletion while providing a significant improvement in the quality of life of the families concerned. The **specific objectives**, contributing to the overall objective, are:

- to develop, strengthen and facilitate a commercially viable and market oriented Rwandan biogas sector;
- to increase the number of family sized, quality biogas plants with 15 000 in the country;
- to ensure the continued operation of all biogas plants installed under the NDBP;
- to maximise the benefits of the operated biogas plants, in particular the optimum use of digester effluent.

The duration of the first phase of the NDBP is 5 years, 2006 being the preparation and piloting phase and 2007-2010 the implementation phase.

The implementation plan, reflected in this document, is based on the findings of the feasibility study and discussions with potential partners in the course of preparing the plan.

The NDBP requires efforts in the fields of promotion and marketing, construction, operation and maintenance, extension, monitoring and evaluation, quality control, credit and subsidy, research and development and training.

Besides face to face marketing (word of mouth) and 'Biogas Programme and Technology promotion workshops' organized by the District Biogas Programme Offices (DBPOs), **promotion and marketing** will mainly be undertaken by building contractors and mason teams. Also (I)NGO's, financial institutes and line agencies will play their part by using their existing extension channels. The National Biogas Programme Office (NBPO) will undertake supporting activities at the national level like the development and production of posters and brochures and the broadcasting of messages in the national media.

Construction, maintenance and repair will be done by registered commercial construction companies or, if such companies do not yet exist, by mason teams. They will only be allowed to operate under the NDBP after the successful completion of a technical training (a Biogas Technical Training Centre will be established) and will be subject to a series of strict conditions and responsibilities laid down in an agreement. In the long run and with the support of the DBPOs, the mason teams will develop into registered companies.

Financing of the construction of biodigesters comprises a subsidy part and a farmers' contribution. An **investment subsidy** of 300 US$ is considered sufficient to attract potential farmers while not being significantly excessive as to result in high Financial Internal Rates of Return (FIRRs) for the farmers. By providing a fixed sum subsidy for all plant sizes, the smaller farmers get percentage wise a higher subsidy on their investment while the administration is simplified. The **farmer's contribution** has to come from their own financial reserves and/or bank loans. Through the Rwanda Micro Finance Forum (RMF) an arrangement will be made to provide loans for biodigester construction to farmers at 18 % interest per year and a four year repayment period.

The **quality of goods and services** provided to the clients are key to the success of the NDBP. Therefore the quality of construction and after sales service will be checked randomly and if not found as agreed upon, corrective measures will be taken.

Applied research and development (R&D) will focus on development and testing of plant and appliances modifications in order to reduce costs and to improve reliability and user friendliness. It will also comprise activities to solve emerging technical problems of the present design, while special attention will be given to the most effective digester effluent use. In addition to more technical R&D, **monitoring and evaluation (M&E)** will take place to study the impact of biogas on poverty reduction and livelihood improvement.

As the introduction of domestic biogas technology is relatively new in Rwanda, **training of all parties involved** in the NDBP will be essential. This includes training of companies, mason teams and DBPO staff in construction, maintenance, quality control, management, marketing, etc. Bank and (I)NGO staff will be trained in promotion and extension, users on operation and maintenance (O&M).

The focus of **extension** will be on an optimal use of biodigester effluent. A special section for this purpose will be established within the NBPO to determine the possible uses of the effluent in the Rwandan context and how to best reach the farmers with this message. Close cooperation with line agencies and agricultural projects will be sought on this topic.

The NDBP has the larger aim of building institutions needed for the sustained viability of the sector beyond the duration of the programme itself. This implies that the above mentioned activities will be conducted by existing national and district governmental, private sector and non governmental organizations.

Benefits deriving from the implementation of the proposed programme are considerable, they include:

- significant reduction of the workload of 13 500 households (10 % failure rate), mainly for women and children;
- annual savings on fuelwood of 36 450 ton;
- annual savings on charcoal of 1 296 ton;
- annual reduction in CO_2 emissions of 53 865 ton (based on a 90 % success rate and preliminary calculations indicating that domestic biogas plants reduce GHG emissions to the tune of 4 ton CO_2 equivalent per year);
- use of bio-slurry resulting in significant annual savings on plant nutrients (NPK) and organic matter available in the soil to improve fertility;
- significant improvement of health by the reduction of indoor air pollution and smoke exposure and in the future by the use of toilet attachments, benefiting especially women and children;
- generation of employment in the rural areas.

Some of the costs and many of the benefits of the programme are in the non-market sphere and this makes it difficult to determine financial and economical values. Furthermore, the programme has a number of social benefits which are difficult to quantify and/or value.

The NDBP runs a number of risks which have been incorporated in the design of the programme:

- lack of firm data makes it difficult to arrive at reliable predictions on effective demand;
- little information available on the presence of companies and masons that fulfil the conditions to participate in biodigester construction trainings. The NDBP might have to actively recruit technicians from the artisan sector, to form trained mason teams and build-up production capacity;
- high material and transport costs;
- financial institutions in the programme area are willing to participate in the NDBP but it is uncertain whether farmers are willing and able to accept the high interest rates.

Besides the 272 727 US$ provided by MININFRA as start-up funds in 2006, the financial resources required for a successful implementation of the proposed programme amount to 14 943 630 US$ considering an average digester size of 6 m^3. Of this amount 8 301 150 US$ has to be financed by the users through their own means and/or loans and donors will be requested to provide a revolving fund of 5 494 500 US$ to cover the farmer's credit needs in this regard. They will also be requested to fund the required expenses for programme (1 447 480 US$) and 75 % of the subsidy (3 341 250 US$) costs. SNV is requested to provide technical assistance to a total cost of 740 000 US$ while MININFRA will contribute 25 % of the subsidy (1 113 750 US$) and non-quantified means such as programme office accommodation, water and electricity.

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List of acronyms and abbreviations

CDM	Clean Development Mechanism
CITT	Centre for Innovations and Technology Transfer
DBPO	District Biogas Programme Office
DBSC	District Biogas Steering Committee
FAO	Food and Agricultural Organization
FIRR	Financial Internal Rate of Return
FRw	Rwandan Franc
GDP	Gross Domestic Product
GGC	Gobar Gas Company
GHG	Green House Gasses
GI	Galvanized Iron
GoR	Government of Rwanda
GPS	Global Positioning System
IMF	International Monetary Fund
INGO	International Non Governmental Organization
IRST	Institut de Recherche Scientifique et Technologique
KIST	Kigali Institute of Science and Technology
LWF	Lutherian World Federation
MDG	Millennium Development Goals
M&E	Monitoring and Evaluation
MFI	Micro Finance Institutes
MININFRA	Ministry of Infrastructure
MINERENA	the former Ministry of Energy, Water and Natural Resources
MINITERE	Ministry of Environment and Natural Resources
MoU	Memorandum of Understanding
NBPO	National Biogas Programme Office
NBSC	National Biogas Steering Committee
NDBP	National Domestic Biogas Programme
NGO	Non Governmental Organization
O&M	Operation and Maintenance
PRSP	Poverty Reduction Strategy Paper
R&D	Research and Development
RMF	Rwandan Micro Finance Forum
RPSF	Rwanda Private Sector Forum
SNV	Netherlands Development Organization
TG	Target Group
UNDP	United Nations Development Programme

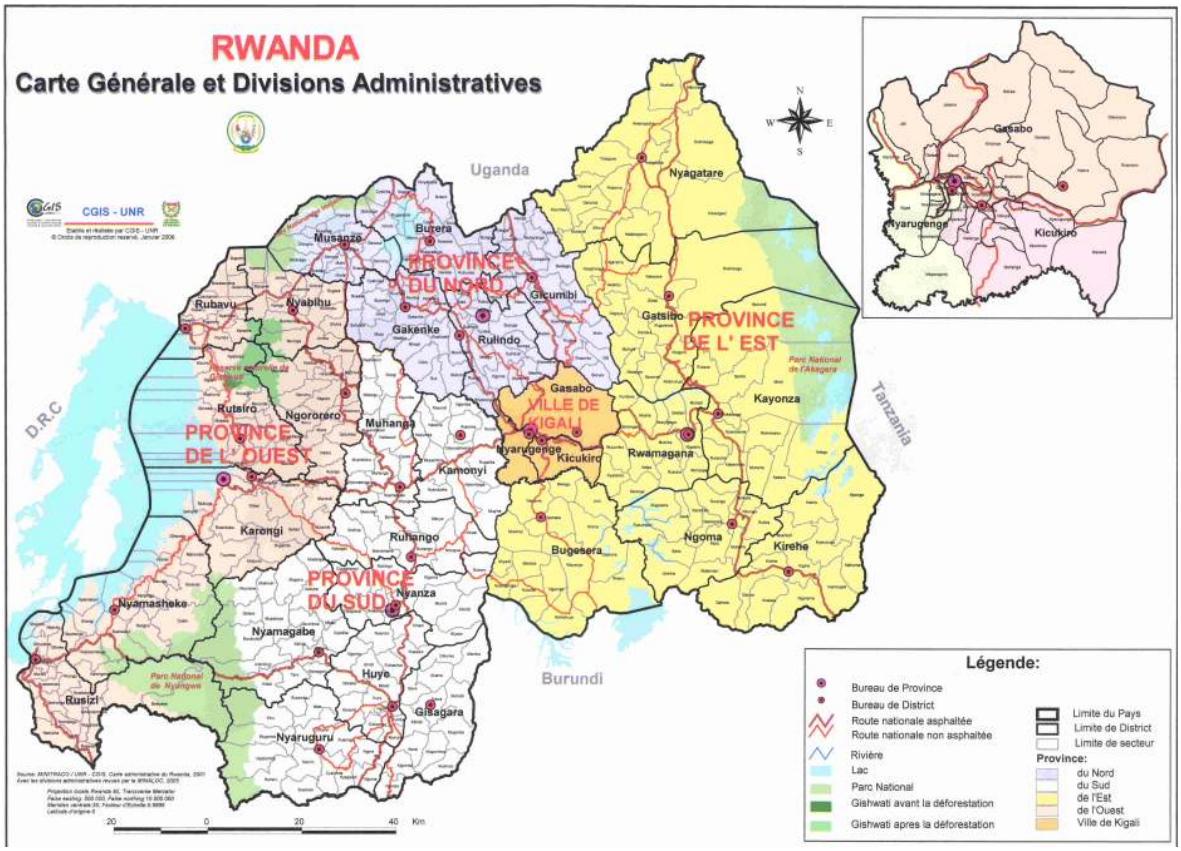
Exchange rates	1 Euro = 700 FRw
	1 USD = 550 FRw

1 Introduction and background

Chapter 1 sheds some light on the energy situation in Rwanda. Chapter 2 elaborates on the history and potential of biogas in Rwanda. Chapter 3 describes the objectives and the strategy of the NDBP. Output targets are described in chapter 4 while chapter 5 describes the activities to be undertaken in the NDBP, followed by financial arrangements in chapter 6. An overview of the institutional aspects required in a national programme and the actors involved is provided in chapter 7. Programme implementation arrangements are tackled in chapter 8, to end with assumptions and risks in chapter 9.

1.1 Country background

The Republic of Rwanda is located in central Africa, just south of the equator with the Democratic Republic of Congo at its western border, Uganda in the north, Tanzania in the east and Burundi in the south. The total surface area is 26 340 km^2 of which 1 400 km^2 is water. Kigali, the capital and largest city, is located at the centre of the country. The terrain is mostly grassy uplands and hills and the relief is mountainous with a declining altitude from the west to the east. The highest point is Mount Karisimbi (4 519 m) in the north, the lowest the Rusizi River (950 m) which drains into Lake Kivu. (See map 1)



Map 1: Rwanda

Due to the combination of a tropical location and high altitude, most of Rwanda has a year-round temperate climate. Generally, temperatures range between a low of 15°C at night to a high of 30°C by day with fairly insignificant seasonal variations in temperature. The exceptions are the chilly upper reaches of the Virunga Mountains and the low-lying border area of Akagera National Park. Most parts of Rwanda receive annual precipitation in excess of 1 000 mm. The driest months are usually July - September, the wettest February - May.

At present, there are five provinces: North, East, South, West and Kigali city, whose administration is headed by a centrally appointed Governor. These provinces are divided into 30 districts with a mayor at the helm.

The Rwandan population grows at 2.8 % per year (*www.rwandagateway.org*) and currently stands at 8 162 715 (48 % male, 52 % female) for an area of 26 340 km^2, which corresponds to a density of 310 inhabitants per km^2. Keeping in mind that the effectively useful surface only amounts to 18 740 km^2, this corresponds to an average population density of 433 inhabitants per km^2.

Rwanda is a poor rural country with about 90 % of the population engaged in agriculture with limited participation in the market economy (30 to 50 % of the rural population on a given year may not produce a marketable surplus, *www.worldbank.org*). It is the most densely populated country in Africa, landlocked with few natural resources and minimal industry. Respiratory illnesses come second after malaria in terms of causes of morbidity in health facilities (p.22, *Rwanda PRSP, 2002*). Primary foreign exchange earners are coffee and tea.

The 1994 genocide decimated Rwanda's fragile economic base, severely impoverished the population and eroded the country's ability to attract private and external investment. However, Rwanda has made substantial progress in stabilizing and rehabilitating its economy to pre-1994 levels, although poverty levels are higher now. The Gross Domestic Product (GDP) has rebounded and inflation has been curbed. Export earnings, however, have been hindered by low coffee and tea prices, depriving the country of much needed hard currency. Despite Rwanda's fertile ecosystem, food production often does not keep pace with population growth, requiring food imports. Rwanda continues to receive substantial aid money and was approved for the IMF-World Bank Heavily Indebted Poor Country debt relief initiative in late 2000. An energy shortage and instability in neighbouring states may slow growth, while the lack of adequate transportation linkages to other countries continues to handicap export growth.

Table 1: an overview of the most important socio-economic indicators

Life expectancy at birth (years)	Adult literacy rate (% ages 15 and above)	Combined gross enrolment ratio for primary and secondary schools	GDP per capita (US$)	Human Development Index	Overall rating on a list of 177 countries
38.9	69.2	53 %	1 270	0.431	159

Source: *UNDP Human Development Report 2004*

1.2 Household energy situation in Rwanda

Throughout the entire country, the main sources of lighting energy are oil (64 %), wood (17.5 %) and kerosene (10 %). Even in Kigali city, only 37 % of the households use electricity. (*2002 population and housing census*)

Firewood and charcoal are practically the sole providers of cooking energy in the rural areas. Firewood covers 90.4 % of the demand and charcoal 7.4 %, the remaining 2.2 % being mainly covered by agricultural residues. Even for the urban households firewood (52 %) and charcoal (39.5 %) are by far the main sources of energy used, other sources being gas and kerosene. (*2002 population and housing census*)

This dependency on firewood and charcoal creates an unsustainable situation as the demand (1.93 kg/capita/day, *MININFRA, 2005*) largely surpasses the production (0.46 kg/capita/day, *MININFRA, 2005*) as is shown in table 2 (see table 2).

Table 2: wood reserves and consumption (*Republic of Rwanda, MINITERE, 2005*)

	1960	**1970**	**1980**	**1990**	**1996**	**1999**	**2000**	**2004**
Population	2694990	3763259	4831527	7157551	6167500	7165108	7497644	8162715
Natural forest surface (1000 ha)	634000	591000	513600	451160	383660	221200	?	?
Planted forest surface (1000 ha)	24500	27160	80000	247500	232500	252000	282563	282563
Sustainable wood production (1000 m^3)	368	407	1200	3713	2790	2268	2261	2261
Wood demand (1000 m^3)	2695	3763	4832	7158	6784	7882	8249	8979
Balance (1000 m^3)	-2327	-3356	-3632	-3445	-3994	-5614	-5987	-6718

The GoR is trying to curb the rate of deforestation amongst others by banning the felling of trees without a permit. This rule applies to all trees including the ones in privately owned production forest. However, it is doubtful whether this measure will help without the availability of energy alternatives and fuel efficient woodstoves.

1.3 Programme background

Interest for a biogas programme in Rwanda was first of all expressed by Mr. Sam Nkusi, the former Minister of State for Energy and Communications, during the Energy for Development conference in Noordwijk, The Netherlands, in December 2004. This request was followed up by the current Minister of State, Mr. Albert Butare, showing the continued political will from the GoR to support a national biogas programme. A brief fact finding mission was conducted in February 2005 to assess the possibilities of a national biogas programme (Lam, March 2005). This mission concluded that the circumstances in Rwanda seem favourable (see annex 2) to establish a national biogas programme and recommended commissioning of an in-depth study on its feasibility. This study addressed the country background, the history of domestic biogas, the potential demand for domestic biogas, the possible supply of services for domestic biogas and proposed an outline for a national domestic biogas programme (recommendations for set-up and implementation). The study recommended:

- to establish a National Biogas Programme Office (NBPO) to initiate and coordinate the different activities that need to be undertaken. The Department of Energy and Communication under the MININFRA will host this office. The participation of other organizations active at the national level (line ministries, NGOs, financial and research institutes) is indispensable and they need to be represented in a National Biogas Steering Committee (NBCS);
- to gain market confidence in the technology, there must be a strong focus on quality. This includes quality of information, construction and after sales service;
- a mechanism needs to be established to make finance for domestic biodigesters available under reasonable conditions. Preferably, this finance has to be channelled through existing banking institutes and/or programmes. Provision of subsidy will be an important marketing tool and must be linked to predefined quality standards;
- for the actual construction and the after sales service of biodigesters, the establishment of local biogas enterprises must be encouraged;
- research on the use of the full potential of digester effluent and dissemination of the research results must be an integrated and substantial part of the programme;
- SNV, with its experience regarding this type of sector development, will provide capacity development services to the NDBP and to the various actors in the biogas sector, aiming at capacity building of the respective organizations (government, civil society, private sector);
- MININFRA will host the Rwandan NDBP and provide the working conditions to achieve the programme's objectives.

October 25th, 2005, MININFRA and SNV/Rwanda have signed a MoU for the establishment and the implementation of the first phase of a Rwandan NDBP that helps to develop a socio culturally acceptable, commercially viable and environmentally sustainable market oriented biogas sector, aiming to increase the number of quality biodigesters with 15 000 by December 2010.

To this matter, SNV recruited an additional biogas advisor. A National Domestic Biogas Programme coordinator will be identified once funds are secured. At that time, also a national biogas programme office will be put in place and a steering committee set up. This implementation document elaborates on the activities to undertake and the different actors that will play a role in the NDBP.

The pilot phase will cover 2 regions with the construction of 150 biogas plants by the end of 2006, using MININFRA funds, followed by implementation phase I (2007 – 2010) with a projected construction of 14 850 biogas plants.

2 Biogas technology in Rwanda

2.1 History of biogas

The first record of the construction of domestic biogas plants dates back to 1982. On the invitation of the FAO, a biogas consultant from Nepal constructed 4 plants ranging in size from 8 to 20 m^3 at the '*Projet Développement du Petit Elevage*' at Kabuye. At the same time a biogas training course was organised for technicians. Following this course and with support from SNV/Rwanda, plants were constructed in Rwesero near Lac Muhazi and at the PADEC project in Murambi. The plants proved to be successful but discussions between SNV and the General Directorate of Energy within the Ministry of Public Works, Water and Energy on a biogas dissemination programme did not lead to anything.

According to an international biogas survey published by BORDA in Bremen, some hundred domestic biogas plants of the fixed dome model have been constructed, at the end of 1990, in schools and barracks by the Ministry of Public Works and Energy and by the International Association for Rural Development (AIDR). Some others have been constructed for religious organizations and rich families.

At present, there are no ongoing programmes aimed at the large scale dissemination of domestic biogas plants in Rwanda. The following organizations with ongoing activities in the biogas sector were identified and contacted:

- **Centre for Innovations and Technology Transfer (CITT):** the CITT is part of the Kigali Institute of Science and Technology (KIST), established in 1997 as Rwanda's first technological institute for higher education and supported by the Ministry of Education, UNDP Rwanda, GTZ and the Governments of Japan and The Netherlands. CITT is a centre for applied research leading to environmentally friendly technological innovations and the subsequent transfer of these technologies to rural areas. The centre has installed a number of large institutional biogas systems at prisons and schools in collaboration with the Ministry of Energy, Water and Natural Resources (MINERENA). These systems, the CAMARTEC model, range in size from 75 to 1000 m^3 and are primarily meant for waste treatment. Also a smaller 35 m^3 plant has been constructed at the dairy demonstration and training farm of NGO Send a Cow;
- **Institut de Recherche Scientifique et Technologique (IRST):** the IRST is a research centre allied to the National University of Rwanda in Butare. The centre has research departments relevant to biogas, being: fertiliser production with locally available raw materials; local construction materials and renewable energy. At the institute's compound the renewable energy department is conducting experiments with solar drying, water heating and solar stills, improved wood stoves, small biogas plants and gasification through pyrolysis. Furthermore it is conducting studies on the use of methane gas from the Kivu Lake, rural electrification through Solar Home Systems and micro-hydro plants. At the 10 m^3 fixed dome plant installed at the institute's site, experiments have been conducted with different feeding materials and the use of slurry as fertiliser. A small number of plants have been installed at schools as an energy source for the school kitchen. The aim of the institute is to spread the use of plants at schools and it is working together with the Ministry of Education to achieve this goal. A concrete programme has not yet been developed though. According to the institute, the cost of a small brick made fixed dome plant is about FRw 90 000 per m^3;

- **Ministry of Infrastructure (MININFRA):** the Minister of State is heading the departments of communication and energy within the MININFRA. Biomass is a section of the energy department. Within the framework of a technical cooperation agreement between Rwanda and China, two technical training courses were conducted in 2004 in Kigali. Each course was attended by 17 participants and lasted for 5 weeks. As part of the training, two domestic biogas plants were constructed at dairy farms in the vicinity of Kigali. The participants invited for the courses were civil servants, engineers and technicians, working for schools, hospitals, prisons and army camps in the provinces. The idea behind this selection procedure was that the participants would gain the technical know-how and become motivated to introduce biogas technology in their working environment. Besides the two domestic plants, one 100 m^3 decentralised waste water treatment system (DEWATS) was installed during the trainings at the Kigali Institute of Education. The biogas produced by this system is used for lighting 8 lamps and fuelling one stove. No further biogas collaboration with the Chinese is currently planned. The Minister of State for Communication and Energy is of the viewpoint that it is now time to start with the mass dissemination of the technology among the rural population.

2.2 Technical potential of domestic biogas

Households in rural Rwanda depend for more than 90 % on fuelwood to meet their domestic energy needs. For many of these households it becomes increasingly difficult to satisfy their daily domestic energy requirements, due to the high population pressure and stringent legislation designed to reduce (fuel)wood consumption.

The majority of households own two or more cattle, used for milk, meat and dung production and for financial security. Legislation is in place that prohibits free roaming of cattle. Almost all cattle is kept in stables overnight, while a growing part is kept on zero-grazing. At farms where stabling is practiced, farmers have access to water.

Most farmers till plots to satisfy the families need for vegetables and staple foods like banana, sorghum and beans. The quality of the arable land is mostly poor due to the high cultivation intensity. Due to the consequent need for fertilizers, the composting of dung is commonly practised to maintain or improve the soil fertility.

The climatic conditions in Rwanda are favourable to operate biogas plants all year round.

Socially spoken, livestock keepers are active members of and well represented in associations and there are no restrictions for women to be involved in domestic decision making and the operation of biogas plants.

Over 110 000 Rwandan families (6 % of all Rwandan families, MINAGRI, NKEZABAHIZI, D., January 2005) have the technical potential (collect at least 20 kg of dung on a daily basis) for biogas plant installation, a number that is expected to rise with the continuing enforcement of zero-grazing legislation. When access to credit is made available to farmers on reasonable terms, a substantial portion of these households is able and willing to invest in the technology. For more information please check the *Report on the feasibility study for a biogas support programme in the republic of Rwanda* (Dekelver, G., Ruzigana, S. and Lam, J., August 2005).

2.3 Benefits of biogas and its impact

Biogas technology can play an important role to improve the quality of life for these rural households where the technology has been introduced. The emphasis of biogas use will be on domestic cooking, as electric energy is far more convenient for lighting. At the end of the programme period, an estimated additional 13 500 biogas plants will be in operation (10 % failure), annually producing about 8 100 000 m^3 biogas (600 m^3 per plant per year) and 202 500 tons (about 15 ton per plant per year) of digested slurry (8-10 % dry matter).

Assuming 90 % of the replaced fuel to be firewood and about 10 % charcoal, the following amounts are expected to be substituted annually:

- 36 450 tons of fuelwood (by 7 290 000 million m^3 biogas) since 1 m^3 of biogas will replace about 5 kg fuelwood;
- 1 296 tons of charcoal (by 810 000 m^3 biogas) since 1 m^3 of biogas will replace about 1.6 kg of charcoal.

On top of that, the following benefits are expected:

- improvement of hygienic conditions, especially of women and children, by eliminating indoor air pollution and by stimulating better management of dung (the stable is cleaned and the dung fed into the digester on a daily basis) and night soil (latrine attachments);
- reduction of the daily workload of women of 13 500 households (wood collection, cooking, cleaning cooking utensils) since O&M activities hardly require extra labour. Biogas does not require constant attention or blowing on the coals, so the user can put a pot on the burner and do other activities while the food is cooked. Introduction of biogas does not necessarily change traditional patterns in the division of labour. Strategic gender needs are thus not specifically addressed by biogas. However, in many cases the reduction of workload can be considered as a pre-condition to make opportunities available for women to organise and attend meetings, increase skills and awareness through training courses, etc;
- natural resources protection:
  - combat soil depletion: the organic materials that are fed into the plant are used without being destroyed. The nutrients and organic matter (apart from some carbon and hydrogen) will still be available in the effluent of the biogas plant and can be returned to the soil;
  - reduce deforestation by reducing the consumption of fuelwood and charcoal;
  - reduce erosion: biogas slurry contributes to sustain the amount of organic matter in the soil, improving infiltration rates and water holding capacity on its turn having a positive effect on reducing run-off and limiting soil erosion;
  - reduce harmful emissions (at local and global level): burning biogas is much cleaner than burning biomass and coal. Apart from being smokeless, it submits only CO_2 and H_2O to the atmosphere whereas a wood or coal fire gives much more pollution. Burning biogas does not contribute to global warming, because the fodder used to feed the animals uses an equal amount of CO_2 in the ecological cycle. The reduction on the emission of CO_2 will amount to 51 030 tons of CO_2 per year on account of the imbalance in fuelwood consumption and production, assuming an emission coefficient of 1.4 tons CO_2 per ton firewood (M. Keeman, Avebury studies in Green Research, Brookfield, USA). Furthermore biogas is not released in the atmosphere in the natural dung digesting process. This burning of the CH_4 component in the biogas leads to an additional CO_2 equivalent emission reduction;

- micro-economical benefits:
  - energy and fertiliser substitution, e.g. reducing the need to buy expensive fuelwood and chemical fertilisers;
  - additional income sources, since time saved can be used in more directly economically productive ways;
  - increasing yields in animal husbandry and agriculture by using the full potential of digester effluent as organic fertiliser. If properly stored, treated and applied to the fields, biogas slurry has a higher fertiliser value than ordinary farmyard manure;
- macro-economical benefits:
  - import substitution (fossil fuels and fertilizers);
  - job creation: the NDBP is expected to generate a fair amount of employment in the regions where it is active, through the staff of biogas companies, by the labour required for the production of appliances and building materials and through the unskilled labour used during the construction of the plants.

All these benefits clearly show the MDG relevance of this biogas intervention:

- **MDG 1,** *target 1: to halve extreme poverty***:** households who install biogas are not amongst the poorest due to the fact that a household must have a minimum number of animals that is often higher than a very poor family has. However, the biogas dissemination process and the resulting reduced claim on common ecosystem services do affect the livelihood conditions of (very) poor non-biogas households as well. For example through employment creation and biogas saving on the use of traditional cooking fuels, increasing the availability of these fuels for (very) poor members of the community;
- **MDG 3,** *target 4: eliminate gender disparity in education:* it are predominantly women and girls who spend time and effort providing traditional energy services. Biogas directly benefits this group by reducing exposure to the dangers of wood smoke and reducing the workload, extending the amount of time to study or to engage in economic activities;
- **MDG 4,** *target 5: reduce by two-thirds the under-five mortality rate:* indoor smoke claims nearly one million children's lives per year and diseases that result from a lack of basic sanitation cause an even greater death toll. Biogas stoves substitute conventional cook stoves and energy sources, virtually eliminating indoor smoke pollution. On top of that, biogas significantly improves the sanitary condition of the farm-yard and its immediate surrounding, lowering the exposure of children to harmful infections. Finally, proper application of biogas slurry will improve agricultural production, contributing to food security for the community;
- **MDG 6,** *target 8: halt/reverse the incidence of malaria and other major diseases:* biogas virtually eliminates health risks (e.g. respiratory diseases, eye ailments, burning accidents) associated with indoor air pollution. Biogas improves on-yard manure and night-soil management, thus improving sanitary conditions and protecting freshwater sources, lowering the exposure to harmful infections generally related with polluted water and poor sanitation;
- **MDG 7,** *target 9: integrate the principles of sustainable development into country policies and reverse the loss of environmental resources:* large scale domestic biogas programmes positively influence national policies on sustainable development and usually support government policies and programmes that have positive environmental impacts (reducing GHG emissions and the need for chemical fertilizer);
- **MDG 7,** *target 10: halve the proportion of people without sustainable access to safe drinking water and basic sanitation:* biogas reduces fresh water pollution as a result of improved dung management and connection of the household toilet to the biogas plant significantly improves the sanitary conditions in the farmyard.

2.4 Financial and economic potential

Given the distribution figures of the national herd over the rural households, the gathering practices of dung and the climate, 6 m^3 will presumably be the most common plant size to be constructed over the first years. With a feeding of 40 kg/day, such a plant will produce on average 1.6 m^3 gas per day. Given that not always all gas is used and that for various reasons the plant might not be used every day the whole year round, the analysis is based on a plant with a used gas production of 1.4 m^3/day. Most families are now cooking on traditional 3 stone-ovens, meaning that the daily replacement value of the biogas amounts to 7 kg/day (versus a daily firewood requirement of 10 kg for an average family) or 2 555 kg/year.

The basic data for the financial analysis are presented in table 3 (see table 3). The benefits associated with the use of biogas plants are derived essentially from the savings in expenditures from biomass fuels. Fuelwood prices vary from 18 to 30 FRw per kg. The value of saved labour and the recovered nutrients from biogas slurry are assumed to be zero because they do not yield an immediate financial return.

Table 3: basic data for financial analysis

Costs	FRw	US$	Remarks
Investment costs	472 275	859	See paragraph 6.1 for cost calculation of a 6 m^3 plant
Ann maintenance costs	18 891	34	4 % of investment costs
Subsidy	165000	300	35 % of investment costs
Net cost	307 275	559	-
Down payment	47 228	86	10 % of investment cost
Loan amount	260 047	473	18 % Annual interest on a 4 years term
Ann loan payment	-87 892	-160	-
Annual savings	**Unit (kg)**	**FRw/unit**	**Total (FRw)**
Biomass	2 555	24.00	61 320

The base analysis indicates a financial internal rate of return (FIRR) of 8 %. An investment subsidy of 165 000 FRw (300 US$) is considered sufficient to attract potential farmers while not being excessive as to result in relative high FIRRs for the farmers. The loan requirement for a biogas plant will be around 260 000 FRw (473 US$). There are some 250 micro finance access points spread throughout the country that can provide credit to farmers on a repayment period of 4 years (if the programme provides a guarantee for 50 % of the risk) and annual interest rates of 18 %.

At present, a hard economic analysis is not yet possible due to the lack of data. Based on similar installations though, functioning in a similar economy (Nepal), we can say that the economical conditions to set up a national biogas programme are met and that the economical internal rate of return value rises in proportion with the amount of factors taken up in the analysis (indoor air pollution, toilet attachment, soil fertility, working hours saved, …).

3 Objectives

3.1 Overall objective of the NDBP

The overall objective of the NDBP is to establish a sustainable and commercial domestic biogas sector in Rwanda, resulting in the reduction of biomass resource depletion while providing a significant improvement in the quality of life of the families concerned.

3.2 Specific objectives

The specific objectives, contributing to the overall objectives, are:

1. to develop, strengthen and facilitate a commercially viable and market oriented Rwandan biogas sector;
2. to increase the number of family sized, quality biogas plants with 15 000 in the country by the end of 2010;
3. to ensure the continued operation of all biodigesters installed under the programme;
4. to maximize the benefits of the operated biodigesters, in particular the optimum use of digester effluent.

3.3 Linkages of programme objective to Government objectives

As indicated in the first chapter, Rwanda faces one of the highest human population densities in Africa with most of the population relying on subsistence farming for their livelihoods. As this population increases further, land and other resources become scarce and pressure on these resources increases, leading to unsustainable use and destruction. Vision 2020 identifies the reduction of soil productivity and arable land per capita as a main constraint to the development of Rwanda (Vision 2020, June 2003).

According to the Organic Law determining the modalities of protection, conservation and promotion of the environment in Rwanda (law N° 4/2005 of 08/04/2005), the State is obliged to promote the use of renewable energy and to discourage wastage of energy sources in general and particularly those derived from wood.

MININFRA's mission is to create favourable conditions allowing the population to have access to basic infrastructure for sustainable development. MININFRA consists of 5 units: (1) planning, (2) public works, (3) transport, (4) information and communication technology and (5) energy. It is the Government agency designated for leading and managing the energy sector. The national policy goal in this regard is to meet the energy challenges and needs of the Rwandan population to effectively contribute to the growth of the national economy and thereby improve the standards of living for the entire nation in an environmentally sound and sustainable manner.

The mission of the energy division is to create conditions for the provision of safe, reliable, efficient, cost-effective and environmentally appropriate energy services to all sectors on a sustainable basis. For this to happen, combined strategies stated in the Energy Policy for Rwanda consist of:

- sustainable management of existing resources by improved carbonization techniques and improved stoves dissemination;
- substitution fuels development, e.g. biogas, briquettes from crops and papyrus, peat carbonization and methane gas;
- tree planting (MINITERE, the Ministry of Environment and Natural Resources being the lead institution).

Furthermore:

- the 2002 Rwandan Poverty Reduction Strategy Paper (PRSP) defines the promotion of biogas in rural areas as a priority activity;
- rational and sustainable management of national space, of the environment and natural resources, land, water, energy sources and biodiversity is one of the major aspirations of the Vision 2020. In terms of energy it states that *Rwanda will be producing enough energy required for economic and social development, while avoiding the degradation of the environment. The country will have considerably reduced the role of wood in the national energy use while expanding electricity, solar energy, methane gas, wind energy and other forms of energy*. One of the indicators in this context being that the consumption of wood energy in the national energy consumption reduces from over 90 % to 50 % by the year 2020. Vision 2020 also indicates that, as a matter of priority, particular attention should be paid to labour and job creation in all the sectors of the national economy. At a modest level, the set-up of a national biogas sector can contribute to this (*Vision 2020*, June 2003);
- the Rwandan energy policy (October 2004) acknowledges that energy services have an impact on all rural economic activities. Addressing energy requirements in the rural areas will ensure improvement of the welfare of the rural population and the attainment of sustainable economic growth. The policy also stresses the need to have affordable and reliable energy supplies country wide and to enhance the development and utilization of indigenous and renewable energy sources and technologies. Some relevant policy statements in this context:
  - *Introduce appropriate rural energy development, financial, legal and administrative institutions;*
  - *Establish norms, guidelines and standards for renewable energy technologies, to facilitate the creation of an enabling environment for sustainable development of renewable energy sources;*
  - *Promote efficient biomass conversion and end-use technologies in order to save resources, reduce rate of deforestation and land degradation, and minimise threats on climate change;*
  - *Support research and development in renewable energy technologies;*
  - *Promote application of alternative energy sources other than wood and charcoal for cooking, heating, cooling, lighting and other applications, in order to reduce deforestation, indoor health hazards and time spent by rural women and children in search for firewood;*
  - *Promote entrepreneurship and private initiative in the production and marketing of products and services for rural and renewable energy;*
  - *Encourage energy education in school curricula*;
- a cabinet retreat in December 2004 recommended to direct more efforts to the energy sector and to overcome the triple crisis of electricity shortage, woodfuel depletion and increasing oil product prices. In all these efforts, community based organizations will play a key role, especially regarding female ownership and participation in domestic energy programmes**.**

3.4 Programme strategy and set-up

The main reason for the low penetration rate of biodigesters at the household level in the African setting can be considered to be the focus on technology, not always resulting in the best design at the best place and therewith tarnishing the reputation of the technology.

Therefore, another approach is proposed in Rwanda. The principle of this programme can best be described as "development through the market". The ground rule in the market approach is that the (potential) user is the single most important factor in a particular sector. All goods and services offered (pre-sales information, financial incentives, biogas plant and appliances, user training, after sales service) to this user have to be presented in such a way that they can easily be adopted. Through growing competition the potential user will be assured of reduced cost while the increase in demand ensures long-term business opportunities for the private companies. A controlling mechanism ensures minimum quality levels for the different goods and services to safeguard the reputation of the technology and therewith the long-term demand for the product.

The following main activities are implemented to achieve market development:

- by establishing consumer confidence through a reliable product, promotion activities, the initial incentive of a subsidy (until sufficient market penetration has been achieved) and provision of credit facilities, a long-term demand for the product is created and therewith a promising market for construction companies;
- through demand generation and a range of trainings (technical, marketing, management) new companies are supported and offered the perspective to grow and develop;
- by conducting applied research, the product is modified to meet the exact need of the consumer, therewith improving the quality-price ratio;
- by establishing national standards, harmonization can be achieved in promotion, training and construction, leading to lower overhead costs while the user is ensured of a minimum quality;
- regulatory and control mechanisms through which a level of customer protection is achieved and therewith again long-term confidence of the market in the product;
- organizational and institutional strengthening for development of the sector.

Once this confidence in the market is installed, the sector should be self sufficient and the ultimate aim of the programme has been reached.

4 Output targets

4.1 Type and number of plants

The target group (market) for the NDBP consists of farmers who have a minimum of 20 kg of animal waste at their disposal on a daily basis. This amounts to the daily dung production of two average and stall fed head of cattle or four adult pigs. Table 4 shows the projected production of biogas plants during the first phase of the programme.

Table 4: projected production of biogas plants

Oct. 2005 - 2006	**2007**	**2008**	**2009**	**2010**	
Preparation phase	**Implementation phase**				
0	I	II	III	IV	**TOTAL**
150	1 150	2 300	4 200	7 200	15 000

The National Domestic Biogas Programme will adopt a design which fulfils the following criteria:

- reliable, durable and user-friendly: the digesters should have an estimated lifetime of over 20 years with a minimum of maintenance;
- replicable: with local available material and local skilled manpower, the digesters must be able to be constructed nation wide;
- adapted to local conditions (climatic and soil conditions, quality and quantity of feeding material, etc.);
- the cost of the digesters should be as low as possible without affecting the durability.

The fixed dome plant on which the programme will focus, comprises a closed digester with a fixed, non-moving gas space and a compensating tank. The gas is stored in the upper part of the digester. Gas production increases the pressure in the gas space of the digester and pushes the slurry into the compensating tank. When the gas is extracted, a proportional amount of the slurry flows back into the digester.

The main advantages are as follows:

- a long life span (no moving and steel parts);
- its total cost is less than that of a floating gasholder plant;
- can be built below ground level: saving space and easier to insulate and protect the digester;
- provides opportunities for skilled local employment;
- the long-lasting technology enables banks to avail loans with sufficient recovery time;
- the technology will have less failure and risk resulting in high consumers confidence.

The disadvantages are as follows:

- they require more skilled masons in order to keep the plant gastight with risk of gas losses if the construction is not properly done;
- transport of building materials to scattered Rwandan residences significantly affects the prices of biogas plants;
- gas pressure fluctuates substantially depending on the volume of gas stored and the height of the slurry level in the outlet chamber.

Initially only one design fixed dome plant will be approved, be it in different specified sizes and materials (bricks or stones according to prices and availability). For this national model, guidelines and construction manuals, bills of quantities, equipment requirements, etc. will be developed for the construction by local masons. Other proven designs can be admitted later on if there would be a demand for a new design and if all conditions for the smooth implementation of the programme are in place.

In this first phase, only modified 2047 design GGC digesters of 4, 6 & 8 m^3 will be constructed (see drawing 1). If the design and size of a plant other than mentioned above is chosen, the subsidy is not allowed. The size of the plant is selected on basis of the available dung and not on the family size. Therefore, in order to decide on the plant size (based on table 5), it is necessary to collect dung for several days to determine the average daily dung production. Farmers requiring larger systems are considered wealthy enough to decide for a biogas plant without a subsidy incentive.

Table 5: plant size in function of the available dung

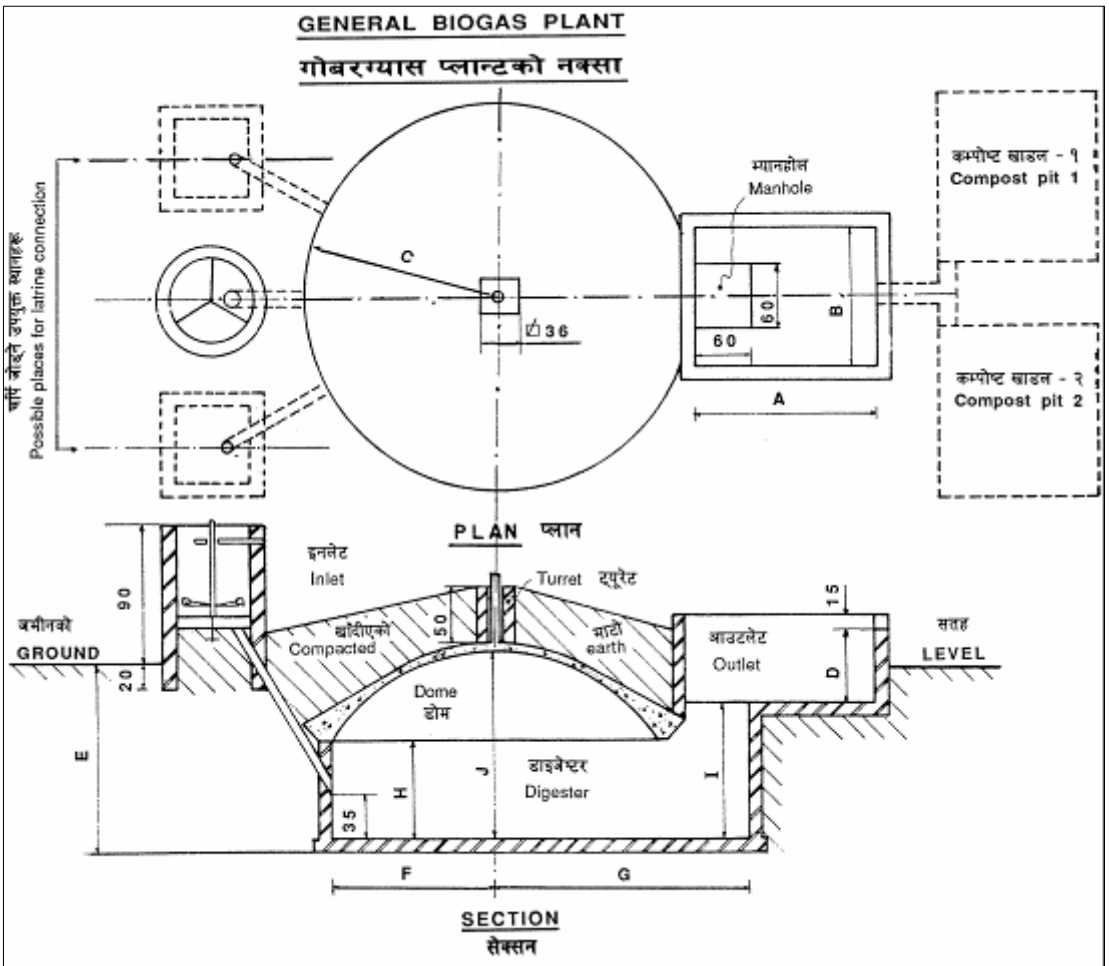
PLANT SIZE (m^3)	Daily fresh dung (kg)	Daily water (l)	Head of cattle
4	20-40	20-40	2-3
6	40-60	40-60	4-5
8	60-80	60-80	6 or more
• Plant size is the sum of digester volume and gas storage • Based on a hydraulic retention time of 45 days			

The experience with domestic biogas programmes in other countries has shown that the establishment of quality standards and their enforcement is vital for the success of the programme. All involved and in particular the users, must have full confidence in the technology and the programme in order to let the commercial approach work. Together with the partners involved in the construction work, the quality standards will be developed as well as the methods to control and enforce these standards. Annex 3 highlights some basic design quality standards (see annex 3).

On top of these criteria, the following points should be kept in mind when deciding on a site for biogas plant construction:

- convenience is key, to make plant operation easy and to avoid wastage of raw material, the plant must be as close as possible to the cattle shed and water source. Ideally, the concrete slab from the stable should be connected directly to the tank. If the nearest water source is at a distance of more than 20 minutes walking, the burden of fetching water becomes too much and no plant should be installed in such places;
- if longer gas-pipes are used, the cost and the risk of gas leakage will increase. The main valve has to be opened and closed before and after use. To eliminate the above problems, the plant should be as close as possible to the point of use (maximum 20 meters away);
- the edge of the foundation of the plant should be at least two meters away from the house or any other building to avoid risk of damages;
- the plant should be at least 10 meters away from the well or any other under ground water sources to protect water from pollution.

If the concerned masons and plumbers strictly follow these instructions during construction, the complete plant will be of high quality. Hence, the plant owner will benefit ultimately from the investment and positive return will be achieved as per the expectations. This again will persuade his relatives and neighbours to install a biogas plant, while a poorly constructed plant will do harm to the reputation of biogas technology.



Size (cm)	4 m^3	6 m^3	8 m^3
A	140	150	170
B	120	120	130
C	135	151	170
D	50	60	65
E	154	155	172
F	102	122	135
G	185	208	221
H	86	92	105
I	112	116	127
J	151	160	175

Drawing 1: drawing and sizes for the GGC2047 fixed dome biogas plant model

4.2 Geographical coverage

The NDBP will start with a preparation phase (2006) to gain experience and to fine-tune the programme set-up. The most suitable areas for biodigester dissemination have been selected, based on a combination of the most important factors in Rwanda, being: livestock numbers and availability of water at households practising zero-grazing or semi-intensive livestock keeping.

Zero-grazing is best established in Kamonyi, Ruhango, Rwamagana, Gasabo, Gicumbi and Rulindo districts, where cattle farmers have stables in which the cattle are kept at least overnight, if not permanently. At farms where stabling is practiced farmers have access to water and often rainwater harvesting is introduced when stables are constructed. Heavy pressure on arable land for food crop production led to land degradation and the need for fertilisers. Composting is therefore common practice on most farms.

Although during the initial stages of the NDBP, focus will be on these districts who are rather close to Kigali (and thus banking infrastructure, construction materials, …), there will be a possibility for expansion to the national level when demands of eligible households arise.

During the preparation period, as promotion, all provinces will be visited and discussions held with key potential actors on provincial and district level. These potential actors are: livestock and agricultural offices, Farmer's and Women's Associations, local NGOs, financial institutions, etc.

4.3 Number of installers

The number of construction entities per district will be dependent on the demand per district. Since plant construction and maintenance needs highly trained technical human resources, it will take some time for the plant constructors to build their capacity and be fully prepared to take on the challenge of quality construction. Gradual inclusion of new constructors in the sector is therefore envisaged. Initially these constructors will be free to set their own construction targets but we can assume 300-500 plants per constructor per year, resulting in the amount of construction companies indicated in table 6 (see table 6).

Table 6: projected number of construction companies

Year	**2006**	**2007**	**2008**	**2009**	**2010**
Production	150	1 150	2 300	4 200	7 200
Construction companies	2	3	6	10	18

4.4 Number of appliances manufacturers

The number of qualified appliances manufacturers will increase as per the increment of biogas plants. The required number of manufacturers is proposed with the assumption that one manufacturer produces 1 500 - 2 000 sets of appliances per year.

Table 7: projected number of appliances manufacturers

Year	**2006**	**2007**	**2008**	**2009**	**2010**
Production	150	1 150	2 300	4 200	7 200
Appliances manufacturers	0	1	2	3	4

4.5 Number of persons to be trained

Table 8: projected number of persons to be trained

TRAINING	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTAL**
Mason	36	120	220	360	640	1 376
Mason refresher	0	24	120	220	360	724
Supervisor	8	24	44	72	128	276
Supervisor refresher	0	4	24	44	72	144
Appliance manufacturing	0	2	2	2	2	8
Managers	0	3	6	10	18	37
Technical instructors	4	5	10	15	25	59
Extension (banks, NGOs, government)	0	30	30	30	30	120
Users	150	1 150	2 300	4 200	7 200	15 000

5 Activities

In order to achieve the specific objectives and output targets of the NDBP, a number of comprehensive activities need to be undertaken as indicated in table 9 (see table 9).

Table 9: NDBP activities and the potential actors

FUNCTION	ACTIVITIES	POTENTIAL ACTORS
Promotion & extension	• extension and promotion services at community and household level. Activities include awareness raising, technical advice on digester size and capacity, advice on effluent use, financial advice, …;	• civil society organizations with extensive experience in awareness raising, such as Heifer International, LWF, …; • MININFRA, provincial and communal veterinary services, provincial forestry and environmental services, RARDA (l'Office Rwandais du Développement des Ressources Animales); • biogas programme offices at all levels; • construction companies and mason teams; • loan officers from credit institutes; • dairy farmers associations; • mouth to mouth by the beneficiaries.
Credit provision	• making the required credit available;	• Rwanda Micro Finance (RMF) members.
Construction, After sales service	• local construction entrepreneurs trained in biodigester construction by the NDBP;	• interested and trained mason teams and private construction companies through the assistance of the Rwandan Private Sector Forum (RPSF).
Quality control	• development of quality standards for plant construction and after sales-service; • quality control on the construction and the after sales services provided by the private entrepreneurs;	• biogas programme offices at all levels (through biogas technicians assigned to the programme).
Training	• technical training; • private enterprise development; • user training;	• KIST/CITT (technical); • technical schools (technical); • RPSF (managerial); • private companies (user training).
Applied R&D	• plant design and appliances; • appropriate use of the plant's effluent; • developing training and extension methods;	• KIST; • IRST.
Coordination at implementation level	• annual plan and report formulation; • registration of constructed plants; • registration of annual after sales service visits; • channelling and administration of subsidies; • certification of construction companies; • contracting of organizations for tasks as stipulated in the annual plan; • administration of the NBPO; • coordination of training and extension efforts; • monitoring and evaluation;	• NBPO, through the National Biogas Steering Committee (NBSC), chaired by a MININFRA appointee; • DBPO through the District Biogas Steering Committees (DBSCs).
Coordination at Government / policy level	• mobilization of funds; • integration in existing programmes and policies; • monitoring.	• MININFRA; • NBPO.

5.1 Promotion, marketing and extension

At the moment, biogas technology, its benefits and requirements are hardly known to the potential users. As a result of this, a major challenge lies in motivating the potential households to invest in the technology. To introduce the technology and the functioning of the NDBP to a broad public and to generate a demand, a promotion and marketing campaign will be prepared and carried out. This campaign will be aimed at the rural population as a whole and at some groups such as dairy and cattle farms in specific.

An essential part of the biogas promotion strategy will be the quality of the product in combination with adequate farmer support in the form of after sales service, consisting of repair and maintenance as well as feedback on operation to the user. As the investment for a biogas plant is high, low quality plants with a short lifetime can not be accepted. Furthermore, a well functioning plant is the best possible promotion and a satisfied user the best promoter for biogas since (s)he can easily convince her/his neighbours and friends through her/his practical experiences on biogas. Therefore, control of the quality regarding plant sizing, construction, after sales service and user training on O&M will be of utmost important, especially during the pilot phase of the programme.

To increase the number of plants with 15 000 over 5 years, it will be necessary to approach potential customers more actively. In a market oriented biogas sector, it will be essential for each private sector company to find and develop its own market segment. In the beginning, construction companies will not have to fear much competition because of the unexploited market and the limited number of companies or organizations active in the biogas sector. This will change when more companies are concentrated in one area. Therefore, their marketing capability and skills will be assessed and, if needed, upgraded, since in order to be successful in the biogas sector it will be necessary to develop a marketing strategy, to establish a brand name, to identify unique selling arguments.

The working model for biogas promotion and marketing will consist of the following phases and activities:

1. promotion: to create awareness on the advantages of biogas technology and to raise interest to all potential users through mass communication in the local language (short radio messages and posters that contain information on the functioning of the NDBP, biogas, its benefits, costs, services, installers, and subsidy and loan provisions);
2. in the districts selected to start the programme, 'Biogas Programme and Technology promotion workshops' will be organised to inform village leaders and organizations working with rural communities such as local banks & cooperatives and particularly present extension workers;
3. information/education: group approach with extension workers or company to farmer communication to raise active interest of potential users in a way that they can evaluate the advantages and disadvantages for the possible adoption of biogas in their particular situation (district information workshops in promising districts, promotional posters, involvement of NGOs to introduce biogas technology in their programmes);
4. personal persuasion: to give the final push for adoption to potential users who have shown active interest in biogas through personal communication ('pre construction user training' providing further information on the daily use of the plants and on the financial requirements and provisions) from extension workers to potential users, farmer to farmer or company to farmer communication (promotional posters, subsidy provision);

5. the actual decision/adoption in which the subsidies provided by the NDBP can play an important role;
6. training to provide users with the necessary knowledge and skills for the proper O&M of their digester;
7. after sales service: fast and reliable service after user complaint and yearly visits with emphasis on O&M, to have good functioning plants with satisfied and positive users, leading to farmer-to-farmer motivation.

The lead for the promotional activities will be taken by the DBPOs, however, promotion activities can also be undertaken by other organizations such as (I)NGOs active in the agricultural sector, line agencies and Micro Finance Institutes (MFIs). Biogas promotion at the national level will be a task for the NBPO.

Where promotion relates to activities to be undertaken before the construction of biogas plants, extension is focused on activities needed after installation. Proper training of especially female users on O&M does not only benefit the users but also the biogas companies in reducing their workload in after sales service provision. The programme will provide modest financial support for development of extension materials and user group trainings (see the budget in annex 4).

The NDBP will also initiate a slurry extension programme, an important issue for the economical feasibility of biogas plants and therewith for the success of the NDBP. Use of biodigester effluent has to be an integral part of the plant's overall functioning. The digging of two compost pits will be made compulsory, as it is a first step in the proper use of slurry. The programme will conduct research on how the effluent use can optimise the benefits of the digester. Extension materials will be developed and distributed while agricultural extension staff will be trained on the most beneficial effluent use.

Connection of a toilet to the biogas plant is most advisable to improve the hygiene situation of the households. In case the farmer would reject to connect the toilet presently, the possibility for connection at a later stage will remain open by providing a second inlet pipe during construction. Cooperation will be sought with existing sanitation programmes, in popularising the use of biodigesters for human waste treatment.

5.2 Subsidy and credit rationale and administration

There are two main reasons to provide subsidies:

- **promotion and marketing:** the idea that the true value of a product is higher than the actual price that needs to be paid for it, is for any potential client a good argument to make a positive decision regarding a purchase. This makes a subsidy component an effective promotional tool. Furthermore, the market segment at the lower income end is enlarged. Overall, a subsidy component will facilitate reaching the quantitative objective of the NDBP;
- **introduction and enforcement of quality standards:** an important aspect of the programme will be the definition of quality standards and their enforcement. A guaranteed minimum quality level will give a long-term return on the investment made and boost the confidence of (potential) owners in the product. As only plants that fulfil the required quality levels are eligible for subsidy, a subsidy scheme enables the programme to enforce the standards.

The subsidy level is determined by a number of factors, being:

- the 'added value' of a biogas plant for the society in terms of reduced CO_2 emissions, deforestation and reduced soil degradation through the use of plant effluent as organic fertiliser;
- the part the purchaser has to pay which has to be substantial enough to give him/her sufficient 'ownership feeling' towards the plant to ensure long-term interest in the plant from his/her side.

To fulfil all requirements mentioned above, for administrative reasons and to relatively give some additional support to smaller farmers, the NDBP will assist farmers with a flat rate investment subsidy (35 % of the total investment). This investment subsidy of 300 US$ is considered sufficient to attract potential farmers while not being excessive as to result in relative high Financial Internal Rates of Return (FIRRs) for the farmers.

Unless monitoring efforts strongly recommend adapting the subsidy levels, these subsidy figures will not be changed during the first phase of the programme to allow the potential clients to decide without being influenced by speculations on subsidy changes.

In order to reach the quality standards, potential beneficiary households have to meet some conditions to be subsidised by the programme:

- only one plant per household;
- only for domestic size biogas plants;
- only for approved plant design;
- at least 4 pigs, 4 semi-intensive (stabled at night) or 2 stall-fed (zero-grazing) cattle (20 kg of dung/day) at farm;
- availability of water;
- biogas plant can be well spaced in the compound:
    - there is enough space for biodigester construction;
    - construction site is not more than 20 meters from kitchen;
    - construction site is not more than 20 meters from cattle shed or pig sty;
    - components of the biodigester are at least 2 meters from existing structures or trees;
- farmers live on the farm and own the farm so they can use their title deeds as collateral;
- ready and in a position to cover expenses for construction of biodigesters and upgrade toilets, kitchens, compost pits (in case credit is needed this precondition includes the access to credit);
- commit to cooperate with biogas technicians and to participate in biogas trainings, supervising, testing, operating and maintaining the digester in accordance with programme technical requirements;
- operating the biogas plant can be integrated into the normal working routine of the house and the farm, no extra time required.

Although most of the early adopters of biogas technology are expected to be the larger and medium farmers, even smaller farmers are expected to be attracted. However, biodigesters will never directly benefit those without livestock and these are generally among the poorest strata of the society.

The subsidy will be channelled through certified construction companies and will be reimbursed to the company on a monthly basis after receiving the plant completion forms together with a copy of the sales contract between the user and the company. Time limits for sending of statements and completion reports will be stipulated in detailed agreements signed between the NDBP and the construction companies. The construction company therefore needs to be registered with the proper authorities and be account holder with a recognised banking institution. The company will indicate the subsidy amount on the quotations for plant construction it offers to potential users.

Besides subsidies, farmers have to bring in 10 % of the investment cost. Many households will not be in a position to present this money in cash, unless they can get a loan. Besides increasing the market potential by providing loans, involvement of the RMF in the biogas sector has the advantage that its vast rural network can be used for promotion and extension, making them a natural partner in the NDBP. Their standard repayment period of 2 years with annual interest rates varying between 18-36 % does not suit the programme though and therefore special biogas credit arrangements will be made so that these loans can be repaid over a period of 4 years (the period on which the total investment can be recovered) with an annual interest rate of 18 %. In this respect, since biogas loans are a new area for the financing institutes in Rwanda, RMF staff will receive a 1 day training on lending procedures and biogas technology promotion and extension. The details of this arrangement will be laid down in an agreement between the RMF and the NDBP.

For biogas plants financed on cash basis, a standard contract will be introduced to be concluded between the biogas company and the client.

The registration procedure for a plant to the programme and the general procedure for releasing subsidy will be as follows:

1. interested households get further explanation regarding biogas technology and programme assistance/support (technical assistance, subsidy, construction of high quality digesters by experienced masons, …);
2. when still interested, it is investigated whether household conditions meet programme requirements as per the Pre Construction Form to be filled in by the plant constructors;
3. upon approval of the Pre Construction Form, households sign construction contracts with approved companies or mason teams as per their choice after which the biogas plant will be constructed as per the standards and agreement signed with the NBPO;
4. after full completion and testing, plant constructors will send the Plant Completion Report to the NBPO along with the sales contract and subsidy receipt signed by the farmers;
5. the NBPO will process the completion report, check the site if necessary and will approve the subsidy after acceptance of the installation as per the plant construction standards and guidelines of the biogas program. The subsidy will then be transferred to the account of the constructor, deducting the maintenance fee.

Since plant constructors will have to pre-finance the subsidy amount while constructing the biogas plant and may encounter scarcity of working capital, the NBPO will disburse the subsidy as soon as possible. The NBPO will produce monthly compiled construction progress reports. The NBPO may also apply alternatives to overcome the problem of working capital through the provision of a certain subsidy fund as an advance once the agreement is signed with plant constructors. To this matter a finance officer will then be recruited into the programme.

5.3 Quality management

The use of market forces, letting different companies compete for clients, will lead to more efficient building practices and company management and therewith lower prices for the users. At the same time, competition and the quest for lower prices can lead to cost-cutting on material and manpower resulting in a lower quality of the product. Therefore it is essential to control the quality of the biogas plants installed by the companies.

Non-functioning plants damage the reputation of biogas technology and it is imperative that the quality of biogas plants is safeguarded with the compliance of set quality standards during construction, O&M. The establishment and enforcement of these quality standards will be instrumental in achieving a high operational success ratio for biogas plants in terms of reliability, efficiency and durability. Farmers must have full confidence in the product to let the commercial approach work.

The quality of the constructed biogas plants will be controlled by the programme. The first plants constructed by new mason teams or companies will all be inspected and of all plants constructed in the first year, at least 50 % will be controlled for quality on a random basis. As from the second year, once the completion reports of biogas plants are received from the installers, the NBPO will randomly select 25 % of plants and check and certify the quality as per the quality standards. Such quality control will be continued for 3 years to check the quality of after sales services (has it been done and is the plant operational from a technical point of view). Sample of after sales service will be at least 20 % of maintained plants.

The quality control inspectors will use a standard questionnaire while inspecting the following topics which are all equally important for the overall impact of the NDBP:

- the quality of the construction materials and appliances (to be approved by the quality control authority);
- the standards on construction (trained personnel; correct mixing of materials; construction as per the standard dimensions; proper piping; proper fitting of gas appliances);
- the O&M and after sales service provisions (user instructions on O&M; provision of instruction booklet; guarantee on construction and appliances provided).

The information collected through quality control visits will be entered into a computer database and at the end of each year the NBPO will calculate the overall performance ratings of the biogas plant constructors. This rating will be one of the bases for renewing agreements for another year. Masons and/or companies with less than satisfactory performance will be facilitated in upgrading their skills and in case of persisting poor performance, they will be disqualified from the programme. The companies are thus responsible for the quality delivered by the masons as well as for the quality of the building materials collected by the farmer upon the recommendations of the company. To this matter, two quality inspectors will be recruited in the NBPO.

Besides the quality check of biogas plants by the NBPO, a Global Positioning System (GPS) may be introduced to ensure the existence of plants and to locate them easily. To this matter, each biodigester will be given a special code: PP.DD.CC/plant no. (PP: name of province, DD: name of district, CC: name of commune/plant no.: sequence number). This plant code will be mentioned in a Certificate of Acceptance and be registered in a programme management file (database) where all information regarding a plant will be recorded.

5.4 After sales services

After sales services form an integral part of the product delivered by mason teams and biogas companies. Having good functioning plants with satisfied and positive users leads to farmer-to-farmer motivation and serves as a guarantee for poorer farmers. It includes proper instruction of the user on the O&M of the plant as well as the provision of guarantees. Biogas companies will be required to give a 1 year guarantee on biogas appliances and 3 years on the structure of the plant. This includes 2 visits to each installed biogas plant, respectively one and 3 years after completion of the installation.

To this matter, on the hand over date, the company will supply the buyer with a warranty certificate according to an example provided by the programme. For every plant constructed, a charge of 10 US§ for the guarantee and the 2 visits will be deposited by the construction company or mason team into a special 'guarantee fund' account, jointly administered by the programme and the company concerned. This amount, with interest, will be repaid to the company or mason team if there are no problems with the plant after the warranty period has expired and after approval of the maintenance reports submitted by the companies to the programme. Although the administration of this system is quite labour intensive, it ensures the quality of the guarantee and after sales service. The money also allows for companies to follow up (tender) the after sales of companies that cease to exist or plant constructors that don't want to continue working with the programme. With prior approval of the NBPO, it will handover all the constructed plants to another approved constructor with proper information of the users. Proper handover of plants to other capable constructors and assurance of proper maintenance of these plants will be the responsibility of the NBPO.

The instruction of the users will include the following aspects of plant O&M:

- plant start up;
- proper feeding of the plant;
- proper use of biogas;
- regular simple maintenance like cleaning of the burner and the use of the water trap;
- proper use of the plant effluent;
- cooking habits and cooking environment.

On the yearly routine visits a qualified company employee will perform the following tasks:

1. inspection of the status of the plant (gas production) and the condition of the various plant parts. The employee repairs possible defects. If not possible at that moment, he makes an appointment to come back within a term of two weeks. Before leaving, he fills in three-fold a maintenance form, which will be signed by both the client and the employee. One copy remains at the client's house;
2. the employee hands over the signed forms of the routine visit to the construction company, which checks the form and submits one copy to the programme. If further repair work has to be done, the company takes action;
3. the company employee assesses at time of the visit the ability of the user to operate the biogas plant, and provides on-site instruction on operation and minor maintenance if necessary.

On visits in case of complaints:

1. at every company office there will be a register for complaints lodged by or on behalf of the plant owner;
2. after receipt of a written complaint, the company sends an employee to the plant owner within a period of two weeks;
3. the company employee analyses the problem and conducts the necessary repair. If not possible at that moment, he makes an appointment to come back within a period of three weeks. Before leaving, the employee makes a simple report on his work and he signs on the backside of the guarantee card kept by the farmer;
4. the employee hands over his visit report to the construction company, which checks the report and puts it in the owner's file after approval, together with the written complaint of the owner. If further repair work has to be done, the company takes action;
5. if the company or mason team does not send a technician for trouble shooting or for operation instruction to household heads then they can inform the DBPO. As soon as the DBPO receives the information, this office must react immediately, use the deposit amount to repair the biodigester and terminate the contract with that team.

Finally, the NBPO will also set up a 'help desk' to allow users to lodge their complaints, provide proper information on biogas and take necessary actions against malfunctioning biogas installers.

5.5 Research, development and standardization

Applied research is necessary for improvement of the NDBP, further optimalization of biogas benefits and its adaptation to changing circumstances:

- development and testing of alterations to and new biogas designs and applications in cooperation with biogas companies and appliances manufacturers in order to make them more efficient and better adapted to the Rwandan farmer;
- solving technical problems related to the construction, operation, maintenance and repair of biogas plants, including the appliances;
- standardization of designs of biogas plants and appliances (gas tap, stove, water traps) as well as construction and manufacturing methods;
- cost reduction of biogas installations;
- improving the efficiency of biogas plants (gas production and utilization);
- research to support extension (and the development of extension materials) on the optimal use of composted slurry as fertiliser;
- assess the exact impact of a large scale introduction of biogas plants on households and communities: measuring actual gas production, determining savings on traditional energy carriers and chemical fertilisers and the impact on crop production and the reduction of CO_2 emissions.

In addition to the more technical R&D mentioned above, M&E of the NDBP activities will be conducted. Some of the activities being:

- surveys to analyse willingness and ability to pay and determine effective demand;
- surveys why farmers do not install a biogas plant;
- study on the linkages between biogas and deforestation;
- study on the linkages between biogas and health;
- user surveys to study field experiences especially in relation to the impact on women;
- study on appropriate micro-financing systems (credit and loan groups);
- evaluation of the performance of financial institutes in the credit provision for biodigesters;
- evaluation of loan repayments;
- evaluation of the quality of after sale service;
- evaluation of trainings and extension activities.

Research and M&E activities will be done by capable research institutes, biogas companies and consulting firms on the basis of ToRs to be elaborated by the NBPO.

5.6 Training

Being a new programme and domestic biodigester technology being a practically unknown sector in Rwanda, training is a vital component for smooth implementation. The list below shows the type of training activities required in order to ensure that the NDBP can be successfully started. This list is not comprehensive but should be considered as being of high priority while other training requirements will be identified and executed once the programme is taking of. It is essential to keep on training personnel from the different organizations active in the biogas sector, including staff of the national and district steering committees:

- development of technical supervisor/instructor training materials and conduct **training programs of technical personnel** as well as **Training of Trainer programs for Instructors/Supervisors of the Technical personnel**;
- development of a mason training curriculum and conduct **mason trainings**;
- development of extension training materials and conduct **extension worker training** programs;
- development of pre- and post- construction user training materials and conduct **user trainings**.

These activities will be largely contracted out to appropriate and recognised training institutes and NGOs like the official technical school of Gitarama who has trained secondary school pupils on biogas and the CITT who can train technicians.

The programme also intends to support the establishment of a biogas training and reference centre in the country. This centre will not only train biogas masons and technicians, but will also act as support facilities for participating districts and enterprises. It will be established through the development of partnerships with training and research institutes.

The cost of the trainings will be fully borne by the NDBP for non-commercial training courses (annual programme, users' and extension trainings) only. The other training courses will be considered commercial and the concerned companies and banks will have to contribute by bearing travel and daily allowances of their staff.

The following trainings are scheduled:

Training of technical instructors (training of trainers) (8 days)

To install permanent training capacity and facilitate future technical trainings, appropriate technical training institutes (polytechnics, …) will be identified where a permanent biogas technical training centre can be established. These instructors will be permanent staff of this institute.

The trainers of the Biogas User Trainings on their turn will be selected from amongst biogas constructors and NGOs and will be trained on how to extend the users on the O&M of the plants and on cooking practices and conditions for maximum effectiveness. The training will also include training and facilitation methods, planning, organizing, evaluating and managing user trainings.

Supervisors training (8 days)

Biodigester companies have the full and final responsibility for the construction of the biogas plants while DBPO staff will perform quality control on a sample basis on behalf of the NDBP. Therefore both organizations will have supervisors who inspect the plants on quality and advise the masons on improvements to be made.

Suitable and responsible supervisors, selected by the DBPO on their affinity for biogas technology, will be trained and certified on inspection and supervision skills, quality control and administrative procedures at the Biodigester Technical Training Centre.

- Programme: 5 days theory + 3 days practice at 3 facilities under construction at different stages.
- Arrangement: the NBPO will be responsible for general training arrangements while the DBPOs are responsible to send supervisors to training courses.

Supervisor refresher training (2 days)

Active supervisors will be invited to attend a refresher course, one year after completion of their supervisor training. During this training the participants will acquire more in-depth understanding of biogas technology while attention will be given to programmatic aspects.

- Programme: theory (supplementary/updated information) + experience exchange (review performance in previous year, identification of major areas to be improved, orientation on changes in construction methods or quality standards).
- Arrangement: NBPO will be responsible for general training arrangements while the DBPOs are responsible to send supervisors to training courses.

Masons (50 days)

Training of masons will have a high priority because the masons will be the backbone of the programme. Besides the technical part of the training (construction, maintenance and repair) the masons will be trained on: promotion (how to attract new clients), user extension (how to explain O&M tasks to the user) and feed-back from users. The training is divided in 2 parts, a 10 day training at the Biodigester Technical Training Centre and 40 days on the job training (the time required to complete 2 plants) at field level under the supervision of a certified master mason.

Local persons who have some experience on masonry work will be selected for the mason training. Masons already trained by other organizations will be given high priority. These masons may not need a full 50 days training and as such the total duration can be decided based upon his/her level of competency. These trainings can be reduced up to 3 days of theory and 8 days practice. Masons will commit to carry out all responsibilities as mentioned in the assignment contracts with companies or mason teams.

Mason refresher training (2 days)

Trained masons who are active in construction will receive refresher trainings after one year of the completion of his/her mason training. If the quality of a mason's work is not good enough, additional training will be made compulsory.
The course will cover: reviewing of overall performance on construction in the previous year, identification of major areas to be improved, orientation on the changes on construction methods or standards (if any) and dissemination of other relevant information and instructions.

Appliance manufacturing (3 days)

Welders from interested construction companies can receive training on the construction of biogas burners and the adoption of existing burners.

Staff of DBPOs annual programme training (4 days)

The DBPOs will be responsible for the planning, implementation and reporting of the programme at the district level. For the members of the district committees, a workshop will be organised to introduce them to the NDBP and to train them in the proceedings and regulations.

MFIs, bank, (I)NGOs and line agencies extension & promotion training (1 day)

Extension staff of financial institutions, (I)NGOs as well as extension staff of line agencies (agriculture, forestry, health, women affairs) are expected to play a very important role in the promotion of biodigesters and the provision of proper information to the users. Staff of these organizations will be trained on the basics of biogas, the roles of the different actors, quality standards and how to promote biodigesters to potential users.

Programme: introduction to biodigesters (0.5 day) + discussion (0.5 day)

Pre-construction user training (1 day)

Potential users will be made aware about the advantages and disadvantages of biodigesters. A strong focus will be on the input requirement for feeding and the financial consequences. It will also be explained what the procedures are if people want to acquire a plant under the NDBP. The DBPOs will be responsible for organising user trainings at village and inter-village level.

Post-construction user training (1 day)

The functioning of a biodigester and its overall efficiency is for a large part determined by the user's efficiency in O&M of the plant. Therefore, besides training of users by plant constructors during the construction work and maintenance visits, new plant owners will also be invited to participate in a one day post construction user training.

Groups of mainly female users will be trained on how the plant works, what output can be expected, owners rights, hygiene aspects, how to use the effluent and what O&M activities are required, including some simple troubleshooting. This to provide users with the necessary knowledge and skills to use the plant efficiently and effectively. This one day training will be organized by the DBPO to provide factual information to the users.

Finally, biogas user instruction manuals containing all aspects of O&M will be made available by the programme and distributed by the companies to the households. Users will be instructed to read the instruction manual and to act accordingly. This will be a task for masons and supervisors who are most in contact with the users but also for the extension workers from (I)NGOs, financial institutions and line agencies. It is also important to inform the users that they have to inform concerned biogas constructors if they have any problem that they are unable to solve. Contact data of the NDBP will be given to them so that they can send their complaints provided that the biogas constructor does not listen to their request.

During the first phase of the NDBP the following trainings will also be developed:

Biogas company training

- Company office staff (2 days): a yearly training for the staff of the biogas company offices, called programme orientation training. The training aims to inform all the company offices on (new) developments and regulations. At the same time the NBPO will also have an opportunity to get feedback from construction companies on improving its working procedures;
- company managers (5 days): the biogas sector can only grow healthy if the biogas constructors are strong enough to deal with basic management issues. Therefore, the managers of the companies will be trained on marketing, promotion, personnel and company quality management. In the marketing training they will learn how to develop a marketing strategy and how to approach a selected market segment. The training will strengthen their financial and organizational skills and will address quality management aspects. Each year new topics will be included in these trainings as the companies will become more and more professional.

Gender mainstreaming training

Maximum participation of women in the programme will help to disseminate biogas information to households in the rural communities. Since women are the main beneficiaries of biogas, they will have to be well oriented about its usefulness. In this regard, training related to capacity strengthening of women on decision making, dealing with banks on borrowing and repayment of loans, income generating activities linked to biogas, health and sanitation improvement and plant O&M will be highly essential.

5.7 Slurry use

Gas production and utilization for cooking is the main purpose of biogas plant construction but proper utilization of slurry as organic fertilizer of high nutrient value is equally important. Properly used, it can give a 10-40 % yield increase compared to compost and mineral fertiliser! Without proper utilization of slurry, one can not get optimum benefits from a biogas plant. Therefore, to impart knowledge to the users on proper utilization of slurry, a 3 days' training will be organized for the staff of biogas constructors, NGOs and agricultural extension workers. These trained persons will work as resource persons to sensitize biogas users on the importance and methods of composting and slurry utilization.

To be convenient, slurry use is integrated in the overall set-up and compost pits are made an integral part of the biogas plant. A minimum of two compost pits will be dug near the overflow so that the slurry can run freely into the pits. Enough earth body, at least one meter, must remain however between the pits and the outlet chamber to avoid cracking of the chamber walls. The total volume of the compost pits must be at least equal to the plant volume. To make a potent fertilizer, agricultural residues should be added to the plant slurry in the compost pits since it has been generally accepted that biogas slurry is a good starter for composting other organic waste materials. The earth from digging the compost pits can be used for backfilling of the inlet and outlet chamber and for top filling on the dome.

Looking into the importance of biogas slurry as fertilizer, the programme will put high emphasis on maximising slurry use. A maximum number of biogas households will be trained on the method of proper utilization of slurry. Slurry utilization activities include proper composting and application methods through training and demonstration.

To carry out these activities, training manuals and posters will be developed and distributed. Since the staff of biogas companies is constantly in touch with biogas users, they will play an important role on advising and training the users on slurry utilization. It will also be a strong marketing tool for the biogas constructors. Similarly, staff of the Department of Agriculture, financing institutes and local NGOs can also play an important role.

5.8 Monitoring and evaluation

M&E are important as lobbying tools by following the impact of biogas on poverty reduction and livelihood improvement (in MDG context).

Overall progress monitoring of the NDBP will be MININFRA's responsibility. Day to day monitoring will be done by the NBPO which will ensure that high quality plants are constructed as per the plan and that all the stakeholders perform their roles as per the agreement. The NDBP regularly (monthly, half yearly and yearly) reports to MININFRA and donors in accordance with prescribed formats.

Both MININFRA and the NBPO will monitor the progress as per the indicators presented in table 10 (see table 10).

Table 10: indicators for successful implementation of the first phase of the NDBP

Activities	Success Indicator
Biogas plants constructed according to national standards: • number • construction defaults	 • minimum 75 % achievement • maximum 10 %
Operation and maintenance: • functioning rate • utilization of plant capacity • users training	 • minimum 90 % • minimum 80 % • minimum 75 % (at least 75 % female)
Institutional development: • number of constructors • number of appliances manufacturers • number of biogas lenders • management training	 • at least 12 companies • at least 2 manufacturers produce efficient appliances • at least 2 lenders • relevant bank and company staff trained
Maximization of benefits: • improved sanitation • saving of fuelwood • reduction workload • proper use of slurry	 • minimum 10 % of beneficiaries have toilet connection • 2 555 kg/household/year • 912 hrs/household/year • 70 % of the biogas users

In order to assess the comprehensive effects of the programme in all its aspects, the following studies will be required to collect and classify desired information on the impacts and the effectiveness of the NDBP:

- biogas users surveys to get a clear view in the acceptation and appreciation of biodigesters from the user's perspective – yearly;
- biogas plants cost survey (including access to loans for biogas development) – yearly;
- training evaluation – yearly;
- community health – every 2 years;
- slurry utilization and its effectiveness on crop/vegetable production – 2008;
- environmental impact assessment – 2009;

An internal assessment will be done by the end of 2007 to review the progress and suggest recommendations for the continuation of the programme. An external final evaluation will be carried out by the end of 2010. The evaluation dates will be determined in consultation between the parties involved, sufficiently in advance to allow the evaluation to become a joint exercise.

5.9 Financial arrangements

Money transfers for quarterly expenses will be based on reports of previous quarters and approved activity plans of ongoing quarters. Therefore district activity plans of the next quarter should be submitted to the NBPO by the end of the previous quarter for approval. Then the NBPO will transfer money to the DBPO bank account, which will be opened at district bank branches. These bank accounts are for DBPO activities only and account holders will be the coordinators of the DBSC. Modes of payment for DBPO expenses are: (1) bank transfer (payment orders/cheques), (2) cash and (3) advance then use that advance to make payment. The DBPO accounts will have separate cheque books and all payments larger than 500 US$ must be made by cheques or bank transfer. Basic accounting books will be kept and receipts must prove all changes in DBPO accounts.

DBPO coordinators have to keep the programme budget and approved quarterly finance plans in order to make sure all expenses are in accordance with the quarterly finance plans approved by the NBPO in terms of descriptions as well as allocations. Quarterly finance plans are the only basis for office activities and expenses, while programme budgets are for activity orientation only. All expenses which differ from approved quarterly finance plans must be approved in written by the NBPO in advance.

Every programme member can only keep cash as advance payments. DBPO coordinators will sign payment requests upon checking their reasonability. Accountants will write on 3 copies of payment vouchers, and attach supporting documents for the DBPO coordinator to sign. DBPO cash counts will be done by the end of each month and their results must be made in writing and signed by participants. Monthly reconcile activities based on data of bank account statements will be done at all levels by the 10th of each month, aiming to double check opening, closing and transactions.

Biogas companies or mason teams will deposit 10 US$ for every plant constructed. Therefore, a deposit account will be opened at district banks. These bank accounts are used for as a guarantee on the plant's warranty.

5.10 Gender mainstreaming

Since women are the primary users and managers of energy resources, the adoption of biogas technology largely depends on their needs and interests. Even though men play the primary role in decision-making at the household and community level, biogas development will be greatly hampered if the women are neglected. Hence, while planning biogas interventions, women's needs and priorities will be taken into account. Ideally, women's active participation in alternative energy initiatives including planning and energy based socio-economic activities will help women both to become empowered and to sustain the whole biogas system.

The role of women in the biogas sector in Rwanda will be enhanced by involving rural women in the programs as decision makers, as individuals or through existing institutions. Hence, women will be involved for adopting the technology and selecting the appropriate site for a plant. As primary users, women will be made familiar with the function of the biogas plant, the proper method of feeding dung and water, the procedure for removing water from the pipeline, methods of cleaning stove components and how to conduct minor repairs.

Taking the above facts into consideration, a detailed plan for gender mainstreaming will be prepared and put in operation with the support from gender specialists.

6 Estimated costs and proposed financing

Four components that make up the total financial requirement of the NDBP have to be secured: (1) programme costs, (2) subsidy, (3) technical assistance and (4) credit requirement (the amount the farmer has to contribute).

6.1 Biogas plant cost

The biogas plant cost is very important for both households and companies since it will be difficult to promote a too expensive technology as a commercial product. While determining the cost of a plant, the actual material cost, the labour cost and the company service charge will be considered as the total plant cost (see table 11). The subsidy and farmers labour and material contribution (if any) may be deducted from the total cost and the remaining net cost shall be charged to the farmers. This involves redemption and interest for the capital taken up to finance construction. Each of the recognized biogas constructors will be advised not to surpass this indicative price, since that way they would loose the market.

Table 11: cost calculation 6 m^3 stones and concrete GGC2047 plant

A Construction materials	***Unit***	***Qnt***	***FRw***	***US$***	***FRw***	***US$***
Cement	bag	13	6 800	12.36	88 400	160.7
Lime	bag	3.0	1 200	2.18	3 600	6.5
Water proof cement	kg	18.0	1 500	2.73	27 000	49.1
Sand	m^3	2.2	10 000	18.18	22 000	40.0
Stone	m^3	3.0	10 000	18.18	30 000	54.5
Gravel 3/4	m^3	1.2	10 000	18.18	12 000	21.8
Reinforcement rod (6 mm)	pcs	2.0	3 000	5.45	6 000	10.9
Binding wire (2 mm)	kg	0.5	1 000	1.82	500	0.9
Small items	FF	-	-	-	14 000	25.45
Sub total construction materials					***203 500***	***370***
B Labour cost						
Skilled labour	days	10	2 500	4.55	25 000	45.5
Unskilled labour	days	24	1 000	1.82	24 000	43.6
Sub total labour					***49 000***	***89***
C Pipes and fittings						
GI pipe (21 mm dia.)	pcs	3	12 000	21.82	36 000	65.5
PVC pipe (110 mm)-outlet	meter	3	5 000	9.09	15 000	27.3
GI pipe fittings 21 mm	pcs	12	750	1.36	9 000	16.4
Sub total pipes and fittings					***60 000***	***109***
D Appliances cost						
Stove	set	1	15 000	27.27	15 000	27.3
Main valve	pcs	1	2 750	5.00	2 750	5.0
Water drain	pcs	1	1 210	2.20	1 210	2.2
Gas tap	pcs	1	1 815	3.30	1 815	3.3
Sub total appliances					***20 775***	***38***
E Construction charge						
Transport cost					54 000	98.18
Entrepreneur overhead (incl. guarantee and after sales service)					85 000	154.55
Sub total Construction					***139 000***	***253***
GRAND TOTAL					***472 275***	***859***

6.2 Subsidy requirements

A flat rate subsidy will be offered to prospective users, amounting to 165 000 FRw (300 US$**)** per plant. The consequent subsidy requirement for the NDBP by year is presented in table 12 (see table 12), amounting to a total subsidy requirement of 4 455 000 US$. The subsidy will be throughout the first programme phase, unless the FRw would devaluate sharply over this period. This is not foreseen, as over the last 5 years the FRw has only lost 20 % compared to the US$. The subsidy cost will be born for 75 % (3 341 250 US$) by the donor and 25 % (1 113 750 US$) by the GoR.

Given a 15 year economical lifetime of a 6 m^3 plant and a daily feeding of 20-40 kg cow dung, we can expect a daily gas production of 1.6 m^3. With an investment cost of 859 US$ and a subsidy at 35 % of this investment we end up with a financial internal rate of return (FIRR) of 8 %.

6.3 Credit requirements and financing opportunities

A biogas plant will cost near to 472 275 FRw, leaving after subsidy (165 000 FRw) and down payment by the beneficiary (47 228 FRw in unskilled labour and provision of materials), a financing requirement of 260 047 FRw (473 US$) per plant. It is estimated that a majority of the plants will be financed on loan basis, through credit issued to the farmers. For this purpose banks and MFIs will be involved. The remaining biogas plants not expected to be financed through bank loans, will be constructed out of the user's own financial reserves or on the basis of self-help schemes. The absolute sum required for the first phase of the NDBP is estimated at 7 024 050 US$. In practice, a lower amount of about 5 494 500 US$ will be needed since this credit fund is a revolving fund.

The NDBP will work through existing MFIs with a well distributed infrastructure and interested in providing credit for biogas construction (though they indicated being in need of funding): Vision Finance, RIM and "Tuterimbere" (they tap money from the ICCO AMREP fund); the Rwanda Micro Finance Forum (RMF), a combination of 40 MFIs.

6.4 Overall programme cost

The overall cost includes the subsidy and credit mentioned above, which after adding programme costs (1 447 480 US$, see annex 3) and technical assistance costs (740 000 US$, see annex 4) amounts to a total financial requirement of 14 943 630 US$ to implement the NDBP (see table 12).

Table 12: total financial requirement

	Preparation phase	Implementation phase				
Year	**Oct. 2005 - 2006**	**2007**	**2008**	**2009**	**2010**	**Total**
Production	150	1 150	2 300	4 200	7 200	15 000
Subsidy Component (300 US$/p)	-	345 000	690 000	1 260 000	2 160 000	4 455 000
Credit Requirement (473 US$/p)	-	543 950	1 087 900	1 986 600	3 405 600	7 024 050
Farmers' direct contribution (86 US$/p)	-	98 900	197 800	361 200	619 200	1 277 100
Programme Cost	-	377 905	319 985	339 455	410 135	1 447 480
Technical Assistance	-	185 000	185 000	185 000	185 000	740 000
Total Financial requirement (US$)	272 727 covered by MININFRA	**1 563 429**	**2 494 179**	**4 132 749**	**6 793 429**	**14 943 630**

6.5 Proposed financing

Table 13 provides an overview of the proposed financing (see table 13).

Table 13: proposed financing

Cost description	US$	Proposed donor
25 % of the subsidy component	1 113 750	GoR/MININFRA
75 % of the subsidy component	3 341 250	Donor (to be identified)
Farmers' contribution (cash/labour)	1 277 100	Farmer
Credit requirement	7 024 050	Farmer via revolving fund of 5 494 500 US$ provided by a donor to a credit institute
Programme Cost	1 447 480	Donor (to be identified)
Technical Assistance	740 000	SNV
Total Financial requirement	**14 943 630**	

6.6 Carbon financing opportunities

Households without biogas are mainly using fuelwood for cooking, emitting high amounts of green house gasses (GHG) to the atmosphere. The fermentation of animal dung in domestic biogas digesters, and the subsequent application of biogas and slurry, replaces this traditional biomass and contributes to the global reduction of GHG emissions. As such, the reduced amount of GHG can be sold to the international market under the Kyoto Protocol, Clean Development Mechanism (CDM) and can generate a significant amount of funds that can be utilized for further development of the NDBP.

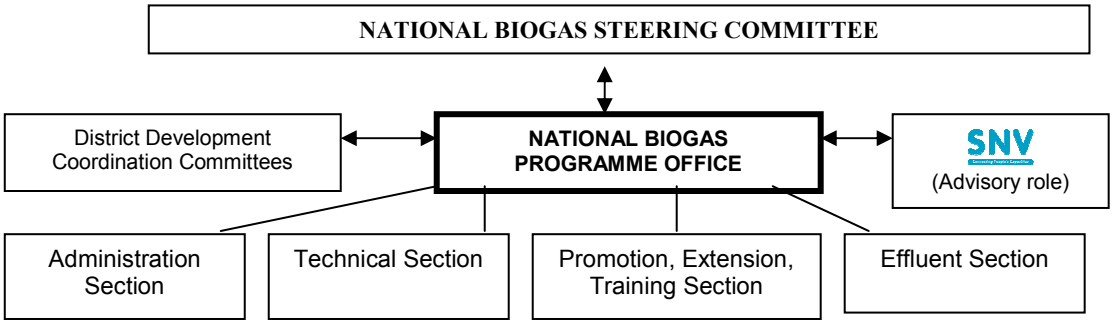
Although the capital costs of a biogas plant and its appliances are higher than for the traditional devices they replace, in the long-term this programme aiming for a sustainable way of energy production and increasing energy efficiency and conservation results in reductions in emissions that are additional to any that would occur in the absence of the programme activity. On top of that it contributes to sustainable development: socially (improve the quality of life, alleviate poverty and improve equity by providing more time for education and income generating activities), economically (transfer of technology and provision of financial returns through income and employment generation related to construction and maintenance) and environmentally (reduce GHG emissions and the use of fossil fuels, reduce pressure on the local environment, reduce local air pollution with associated health benefits and meet energy and environmental policies). (*Ed*. LEE, M-K, UNEP, CDM information and guidebook, December 2003)

7 Institutional aspects/implementing partners

The NDBP has the larger aim of building the institutions needed for the continued and sustained viability of the sector beyond the duration of the programme itself. It will seek the involvement of existing Government offices, (I)NGOs, financial institutions and private enterprises. If there will be a structural and long-term involvement of these parties, the NDBP can provide both financial and advisory support to enhance the capacity of the involved parties to continue activities in a more sustainable manner. Figure 1 gives a visual presentation of the set-up of the NDBP (see figure 1).

SNV/Rwanda, having valuable experience with this type of institutional coordination provides capacity development services to the NDBP and the various organizations in the form of two permanent Biogas Advisors. Other advisors will be deployed on a temporary basis if the need arises.

Figure 1: NDBP set-up



7.1 Apex organization

The lead organization, MININFRA, hosts the NBPO and provides the national director for the programme. MININFRA's main responsibilities as an apex organization will be as follows:

- proper coordination among the donors, the GoR and biogas stakeholders;
- policy formulation and ensuring endorsement of Government's renewable energy policies within the biogas sector;
- instruction/advising on behalf of the GoR;
- planning and progress reporting to government ministries.

7.2 National and District Biogas Steering Committee

There will be a provision of Biogas Steering Committees (BSC) consisting of representatives of the main national level actors in the programme, to coordinate and guide developments in the biogas sector and to look after the policy and programme matters related to programme implementation.

The national biogas steering committee (NBSC) will be in place at the time of the start of the NDBP and will meet at least twice a year and more often as the need arises. It will mainly be responsible to:

- approve the annual plans and reports of the biogas programme;
- approve partner organizations;
- advocate for the NDBP within their respective organizations and towards their (international) partners;
- set and endorse sector wide quality standards and guidelines;
- plan and coordinate biogas related research and development;
- analyse policy issues and advise on policy matters (subsidy, price, taxation, R&D);
- decide on programme related matters which are deviating from the approved plan;
- mobilise funds and liaise with donors;
- monitor progress and evaluate the NDBP.

The members representing the respective organizations must be of a seniority that will enable them to represent the programme's interests at the highest level within their organization. The members of this committee are proposed as follows:

- two representatives of MININFRA: the State Secretary as the chairperson and the officer in charge of renewable energy as the focal point for the NDBP within the ministry;
- 1 NBPO programme manager, as the Secretary;
- 1 KIST/CITT representative;
- 1 IRST representative;
- 1 RPSF representative;
- 1 MINITERE representative;
- 1 MINAGRI representative;
- 1 NGO representative;
- 1 SNV representative.

Similar to the national level, all biogas activities will be periodically monitored and advised upon by a district biogas steering committee (DBSC). At the district level, these committees will get established after the setting-up of district biogas offices and will consist of the main actors in the biogas sector at this level:

- 1 representative of the local administration (in charge of infrastructure or livestock);
- 1 representative of farmer's association (livestock keepers) ready to engage (providing data and doing extension work) and to present their interests;
- 1 technical person (from the NGO taking the lead in the district);
- 1 representative of ProFemmes;
- 1 representative of the lending institute used in the respective district.

This committee will periodically monitor and advise upon all biogas activities and will contemplate and endorse the annual activity plan for the biogas sector in the district. The DBSC will sign an annual cooperation agreement with MININFRA (and SNV co-signing on behalf of the NDBP). In this agreement, the responsibilities of both parties regarding to channelling of funds, quality control and enforcement, production targets, training, promotion and extension will be stipulated.

7.3 Programme implementation office

The **National Biogas Programme Office** (NBPO) is the executive agency for the programme. It will be housed in a renovated building of the Ministry of Agriculture. An appointee from MININFRA, the lead organization that chairs the steering committee, will be appointed national director (part-time) for the NDBP. Together with a programme coordinator, who is to be recruited from the labour market, they will have joint responsibility for the proper implementation of the NDBP. This team will be assisted by two SNV advisors making full use of the experiences gained so far in other national biogas programmes. Upon development of the programme, other personnel will be recruited: chief biogas engineer, effluent specialist, programme administrator, administrative assistant, support staff, …

The NBPO is the office responsible for the day to day management and coordination of all programme activities. The running of the office will include accounting and staff management according to the programme's rules and regulations that will be developed. Reporting to the GoR will be done through the lead organization and according to Government rules and regulations. The office will have to work with different sections of society, private and public, bearing in mind that an objective of the programme is to develop a durable biodigester industry by mobilizing the private sector.

The office consists of four sections: (1) administration; (2) technical; (3) training, promotion and extension and (4) effluent use. The main tasks and responsibilities for each sector are presented in table 14 (see table 14).

Table 14: the main tasks and responsibilities for each section in the NBPO

Administration	• Develop detailed annual plans and budgets in accordance with the objectives set in this implementation plan, submit them for approval to the NBSC and monitor their implementation; • contracting of organizations for tasks as stipulated in the annual plan; • registration of constructed plants; • registration of annual after sales service visits; • subsidy administration; • follow up of credit administration; • certification of construction companies; • administration of the NBPO; • internal monitoring of the NDBP.
Technical	• Selection of appropriate design and development of quality standards for this design; • development of quality standards for plant guarantee and after sales service; • quality control on construction and after sales service; • applied R&D on plant design and appliances; • support partner organizations: private enterprise development.
Promotion, extension & training	• Development of curricula for user training, extension staff training; • technician, supervisor and management training; • identifying appropriate training organizations and venues; • conducting training of trainers courses; • identifying, training and supporting extension services; • developing national and local promotional material (disseminate biogas information); • coordination of promotional activities.
Effluent use	• Applied research on appropriate use of the plant's effluent as fertiliser; • developing training and extension methods for this; • coordination of the training and extension efforts.

The first 3 sections will be established as soon as possible in order to be able to start the program. This establishment includes the physical setting-up of the office with all the necessary equipment, the recruitment and training of staff and the development of procedures, standards, curricula, etc.

Whereas at the national level policy making, R&D and administration are the main activities, the 'real work': extension and promotion, credit provision, construction, user training, quality control and after sales service take place in the districts. To this matter, **District Biogas Programme Offices (DBPO)** will be set up in existing offices accessible to potential beneficiaries, such as the district offices of the partner NGOs spearheading the programme in the respective districts. These offices will coordinate, facilitate and monitor daily programme activities at district level. They will produce a district annual activity plan regarding promotion, training and construction, to be ratified by the NBPO. On top of that, the DBPO is providing quarterly progress reports to the NBPO. They will also identify suitable partners for the different activities and draft working contracts for these partners, to be signed by the NBPO.

District programme guidelines will be developed and will detail the modalities for management, implementation and administration as well as the level of support made available by the NBPO.

7.4 Plant installers and promoters

For the actual construction of biodigesters and after sales service, the establishment of local biogas enterprises will be encouraged. The RPSF, an umbrella organization for private sector associations working at the improvement of the business climate and supporting entrepreneurs a.o. through management workshops, has offices throughout the country and will participate in the identification of interested and capable construction entrepreneurs and the organization of workshops.

Companies wishing to become biogas construction companies and willing to cooperate with the NDBP will seek recognition from the NBPO. These applications will be short-listed and based on the approval of the NBSC, eligible constructors will be selected, trained and accredited for plant construction.

Such recognition will be subject to a series of strict conditions and responsibilities to adhere to, such as:

- approval of standard design and sizes of biogas plants;
- using only NDBP trained supervisors and masons for the construction of biogas plants;
- construction of biogas plants on the basis of detailed quality standards;
- provision of quality biogas appliances (pipe, valve, water trap, stove);
- providing proper user training at the household level (especially to female members) and provision of a user instruction manual;
- provision of guarantee on appliances (one year) and the structure of the biogas plant (three years), including one maintenance visit every year during the guarantee period;
- timely visit to the biogas plant in case of a user complaint;
- timely provision of completion and yearly maintenance reports to the NBPO;
- proper management and administration;
- company registered with the local chamber of commerce and industry;
- a link with the rural setting (e.g. presence in the districts where construction takes place).

These conditions will be laid down in detail in a contractual agreement between the Construction Company and the NDBP.

If it is not possible to identify enough local construction companies in districts, DBSCs can build up mason teams at district level that can take up the construction until it is privatized. These mason teams will be managed by the DBPOs and should maintain at least one foreman trained and certified by the NBPO. A contractual agreement will be signed with the DBPO.

Biogas constructors will be the main service providers to the client. They will be monitored by the NBPO and with its technical assistance, biogas constructors will improve their professionalism on delivering quality services and marketing business services as per the demand.

Appliances used in biogas plants will be locally produced: water drain, gas stoves, gas tap and main gas valve. Appliances manufacturing workshops will have to be established and pre-qualified by the NBPO based on their technical capability, human resources, workshop facilities and equipments. For the sustainability of these manufacturers and production of quality appliances, they will be monitored closely and their products will be checked regularly.

7.5 Financial institutions

Only few farmers who have the technical potential (more than 20 kg dung/day) will have enough cash at hand to make the necessary investment for a biogas plant. Therefore, to increase the access of biogas to relatively small farmers, the access to reasonable credit is an essential part of the programme and the participation of (micro)finance institutes will be ensured. The required number of biogas lenders is based on the assumption that one lender provides loans to 600 biogas households (see table 15).

Table 15: the yearly required number of lenders

Year	2007	2008	2009	2010
No. of biogas lenders	3	4	8	12

The role of lending organizations will be to:

- identify potential biogas households;
- approve credit (not exceeding the requirement) and report to the NBPO on loan disbursement;
- verify plant construction against set standards and recommend endorsing plant completion reports.

The programme will work with RMF members, having 250 service points throughout the country. They are fully convinced of the need for a national biogas programme and will support investments with durations of 4 years and a yearly interest rate of 18 % against collateral of real property like houses and banana plantations. They do require the mobilization of credit funds though.

In some districts, farmers can also approach NGOs and special credit programmes for agriculture, providing credits to farmers through existing MFIs ranging between FRw 100 000 and 500 000 for a yearly interest rate of 16 % and a three year duration.

8 Programme implementation arrangements

8.1 Implementation strategies

- Integration of biogas with other activities: biogas can easily be linked with direct income generating activities by integrating it with agriculture and livestock initiatives. To generate income, slurry has to be used properly to increase crop and vegetable production. Hence, there exist promising possibilities for networking the biogas programme with sectors like dairy associations etc. This integrated approach will help to address the national objective of poverty reduction;
- maximum utilization of existing masons: encourage experienced persons to be trained in plant construction and to establish biogas companies;
- institutionalization and strengthening of biogas constructors: the biogas sector will be developed as a commercially viable and market oriented industry so that the private sector continues biogas construction, even without external support. In this context, biogas constructors will have to become strong entrepreneurs and one of the major efforts of this programme will be to facilitate these constructors to strengthen their capabilities to take up any role related to dissemination of biogas technology in the country;
- enforcement of quality control: a quality control system will be implemented to safeguard the interest of biogas households;
- encouragement of toilet attachments: households will be encouraged to connect their toilet to the biogas plant to supplement a small quantity of feeding and to contribute to better hygiene and sanitation;
- initial geographical coverage: construction will start in Gasabo, Gicumbi, Kamonyi, Ruhango, Rulindo and Rwamagana districts. Once the programme implementation modalities and institutional arrangements are fully established, the construction coverage will gradually be expanded.

8.2 Reporting

Regular monthly financial reports, half yearly and yearly progress reports will be prepared and submitted by the NBPO to the NBSC in accordance with the prescribed formats.

Based on district guidelines, DBPOs have to prepare quarterly activity plans and budgets by the 20th of the last month of the former quarter and have to send quarterly activity reports to the NBPO on every 10th day of the next quarter. The final approved quarterly financial plan will be the basis for all DBPO activities and expenses during that quarter. Quarterly financial plans should include activities from the previous quarter which have not yet been completed or paid (if any). Approved quarterly financial plans must be very specific and detailed and should show all activities and expenses. DBPO accountants should keep in file programme agreements, programme budget plans, quarterly plans approved by the NBPO as well as all approved changes in quarterly plans.

9 Constraints, assumptions and risks

Although there are many Rwandan biogas experiences at the institutional level (prisons, schools), the absence of a history of domestic biogas is a risk for the proposed programme. In addition, most of the registered construction companies are situated in urban centres. Yet, assuming stability in the Great Lakes region, all the conditions for people to accept the technology and to establish a successful national biogas sector in Rwanda are met. Nevertheless, the process of actual acceptance made us to take into account a slow start and to adopt modest production targets.

The success of the NDBP will largely depend on innovative farmers willing to take a risk by investing in a biogas plant. In analogy with what happened in other countries, it is expected that these initiatives will have a trigger effect by convincing others to accept the technology.

Provision of credit will be an important part of the NDBP since few households have the required amount of money. Yet, biogas is not considered as an income generating activity and the conditions for micro loans do not favour biogas farmers while on the other hand the lending institutes lack funding and have difficulties in liquidating collateral of non-performing loans. Discussions are ongoing to tackle this threat by setting up specific biogas loan arrangements.

It is important to get full support from different actors in the sector. So far, representatives of different stakeholders, including the government, showed a clear interest and will to participate and/or support such a programme, and thus it is assumed that their support will materialise formally.

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ANNEX 2 Conditions favouring widespread dissemination of domestic biogas plants

To launch a large scale domestic biogas programme based on a commercially viable, market oriented basis, a number of pre-conditions have to be met.

Technical conditions

- Daily ambient temperature above 20^{o}C throughout the year. The biological process in a digester is temperature dependent. The optimum temperature is 35^{o}C, below 15^{o}C the process comes practically to a stand-still;
- availability of at least 20 kg cattle and/or pig dung per day at a large number of farms. Cattle should be at least kept in a stable during the night. 10 kg of dung yields enough gas to operate a normal sized kitchen stove for 1 hour, to make an investment remunerative a minimum of 2 stove hours per day are required;
- availability of water. Cattle dung fed into a plant needs to be mixed with water on a 1:1 ratio.

Economic conditions

- Use of organic fertiliser is traditionally practised and integrated farming systems are common. Often it is not the saved firewood but increased crop production from the use of biogas slurry that generates additional income;
- traditional cooking fuels like firewood and charcoal are difficult (time consuming) to gather or expensive. If firewood is cheap and easy to come by, it will be difficult to motivate farmers to make the necessary investment;
- farmers should have access to (micro) credit on reasonable terms, and have the possibility to invest, e.g. by having the title deeds of their farms as collateral. Even with the use of subsidies, farmers still have to make a considerable investment.

Social conditions

- Role of women in domestic decision making. Women are the main direct beneficiaries of the biogas plant, they spend less time on fuel collection, cooking and cleaning of cooking utensils. Furthermore, as there is far less indoor air pollution, they will suffer less from eye and respiratory ailments. Therefore women should be accessible for extension services and have a say in the decision making process at household level;
- role of women in livestock keeping and dung handling. As women will be the users of the gas, they will be most motivated to keep the plant in good operational order. There should be no cultural barriers for them to operate the plant or to participate in local training programmes.

Institutional conditions

- Political will from the GoR to support a national biogas programme. Preferably a Governmental institution should act as a national coordinating body for the programme and governmental extension services should be involved in promotion and on farm training;
- the existence of farmer unions, like dairy cooperatives, is not essential but will be very helpful.

ANNEX 3 Basic design quality standards

- Cement has to be high quality Portland cement from a brand with a good reputation. It must be fresh, without lumps and stored in a dry place. Bags of cement should never be stacked directly on the floor or against the walls but wooden planks should be placed on the floor to protect cement from dampness;
- sand must be clean. Dirty sand has a very negative effect on the strength of the structure. If the sand contains 3 % or more impurities, it must be washed. The quantity of impurities especially the mud in the sand can be determined by a simple 'bottle test'. For this test, a small quantity of sand is put in a bottle. After this, water is poured in and the bottle is stirred vigorously. The bottle is than left stationary to allow the sand to settle down. The particles of sand are heavier than that of mud so it settles down quickly. After 20-25 minutes, the layer of mud versus sand inside the bottle is measured. Course and granular sand can be used for concreting work but fine sand will be better for plastering work;
- gravel should not be too big or very small. It should not be bigger than 25 % of the thickness of the concrete product where it is used in. As the slabs and the top of the dome are not more than 3" thick, gravel should not be larger than 0.75" (2 cm) in size. Furthermore, the gravel must be clean. If it is dirty, it should be washed with clean water. When stones are used for plant construction, the remains of shaping the stones can be used as gravel;
- water is mainly used for preparing the mortar for masonry work, concreting work and plastering. Besides these, water is used for washing sand and aggregates. Water must be clean since dirty water adversely affects the strength of the structure;
- bricks must be of the best quality locally available. When hitting two bricks, the sound must be clear. They must be well baked and regular in shape. Before use, bricks must be soaked for a few minutes in clean water, not to soak moisture from the mortar afterwards;
- stones used for masonry work have to be clean, strong and of good quality. Stones have to be shaped before use (to avoid having to use too much cement) and should be washed if dirty;
- the gas pipe conveying the gas from the plant to the user point is vulnerable for damages, therefore it should be of light, quality iron pipe which must be, were possible, buried 1 foot below ground level. Pipeline fittings must be kept to a necessary minimum and sealed with zinc putty, Teflon tape or jute and paint;
- for proper insulation and as counter weight against the gas pressure inside, a minimum top filling of 40 cm compacted earth is required on the dome.

ANNEX 4 Programme budget details

Total financial requirement for the implementation phase

	Preparation phase	Implementation phase				
Year	**Oct. 2005 - 2006**	**2007**	**2008**	**2009**	**2010**	**Total**
Production	150	1 150	2 300	4 200	7 200	15 000
Subsidy Component (300 US$/p)	-	345 000	690 000	1 260 000	2 160 000	4 455 000
Credit Requirement (473 US$/p)	-	543 950	1 087 900	1 986 600	3 405 600	7 024 050
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Programme Cost	-	377 905	319 985	339 455	410 135	1 447 480
Technical Assistance	-	185 000	185 000	185 000	185 000	740 000
Total Financial requirement (US$)	272 727 start up funds covered by MININFRA	**1 563 429**	**2 494 179**	**4 132 749**	**6 793 429**	**14 943 630**

Programme Management

Year	**2007**	**2008**	**2009**	**2010**	**Total**
Promotion & marketing	10 000	10 000	10 000	10 000	40 000
Quality control	11 500	11 500	21 000	36 000	80 000
R&D and standardization	35 000	20 000	15 000	15 000	85 000
Effluent programme (R&D, extension, training)	30 000	30 000	30 000	30 000	120 000
Training	33 490	30 570	45 540	71 220	180 820
Monitoring and evaluation	15 000	15 000	15 000	15 000	60 000
Institutional support	9 000	9 000	9 000	9 000	36 000
Programme Management National BPO	233 915	193 915	193 915	193 915	815 660
External evaluation				30 000	30 000
Subtotal in US$	**377 905**	**319 985**	**339 455**	**410 135**	**1 447 480**

Promotion and marketing budget breakdown

Year	**2007**	**2008**	**2009**	**2010**	**Total**
Radio messages	3000	3000	3000	3000	**12 000**
Biogas Programme and technical promotion workshops	7000	7000	7000	7000	**28 000**
Subtotal in US$	10 000	10 000	10 000	10 000	**40 000**

Quality control budget breakdown

Year	2007	2008	2009	2010	Total
Production	1 150	2 300	4 200	7 200	15 000
% of total production controlled	50 %	25 %	25 %	7 %	
Total no inspections	575	575	1 050	504	1 579
Cost per digester	20	20	20	20	
Subtotal in US$	**11 500**	**11 500**	**21 000**	**36 000**	**80 000**

Research, development, standardization budget breakdown

	2007	2008	2009	2010	
Year	I	II	III	IV	Total
Standardization	10 000	7 500	5 000	5 000	27 500
Plant R&D	15 000	5 000	5 000	5 000	30 000
Appliance R&D	10 000	7 500	5 000	5 000	27 500
Subtotal in US$	**35 000**	**20 000**	**15 000**	**15 000**	**85 000**

Training budget breakdown

Year		2007		2008		2009		2010		Total	Total
	Rate per Trg (US$)	#	Cost	#	Cost	#	Cost	#	Cost	#	Cost
Programme staff National BO			6 000		6 000		6 000		6 000		24 000
Study visit main stakeholders Nepal	lumpsum		12 000								12 000
Mason	25	120	3 000	220	5 500	360	9 000	640	16 000	1 340	33 500
Mason refresher	25	24	600	120	3 000	220	5 500	360	9 000	724	18 100
Supervisor	60	24	1 440	44	2 640	72	4 320	128	7 680	276	16 080
Supervisor refresher	30	4	120	24	720	44	1 320	72	2 160	144	4 320
Appliance manufacturing	100	2	200	2	200	2	200	2	200	8	800
Management companies	60	3	180	6	360	10	600	18	1 080	37	2 220
Technical instructors	150	5	750	10	1 500	15	2 250	25	3 750	55	8 250
Extension (NGOs, banks, government)	25	30	750	30	750	30	750	30	750	120	3 000
User training	3	1 150	3 450	2 300	6 900	4 200	12 600	7 200	21 600	14 850	44 550
Curriculum Development	lumpsum		5 000		3 000		3000		3 000		14 000
Subtotal in US$			**33 490**		**30 570**		**45 540**		**71 220**		**180 820**

Programme management National Biogas Programme Office budget breakdown

Year	2007	2008	2009	2010	Total
Salary national director	2 400	2 400	2 400	2 400	9 600
Salary programme coordinator	21 595	21 595	21 595	21 595	86 380
Salary administrator	14 855	14 855	14 855	14 855	59 420
Salary sen. technician	14 855	14 855	14 855	14 855	59 420
Salary effluent specialist	14 855	14 855	14 855	14 855	59 420
Salary QM officers (2)	26 990	26 990	26 990	26 990	107 960
Salary data officer	10 805	10 805	10 805	10 805	43 220
Data entry	6 755	6 755	6 755	6 755	27 020
Salary office assistant	4 050	4 050	4 050	4 050	16 200
Salary driver	6 755	6 755	6 755	5 000	27 020
Purchase computer	7 500	1 500	1 500	1 500	12 000
Purchase car	25 000	0	0	0	25 000
Vehicle running cost	10 000	10 000	10 000	10 000	40 000
Purchase motorbikes	9 000	0	0	0	9 000
Motor bike running cost	6 000	6 000	6 000	6 000	24 000
Office utilities	3 000	3 000	3 000	3 000	12 000
Furniture	2 000	2 000	2 000	2 000	8 000
Office rent	12 000	12 000	12 000	12 000	48 000
Communication	6 000	6 000	6 000	6 000	24 000
Other office cost	4 000	4 000	4 000	4 000	16 000
Computer consultant	1 500	1 500	1 500	1 500	6 000
NBPO staff	20 000	20 000	20 000	20 000	80 000
Annual audit	4 000	4 000	4 000	4 000	16 000
Subtotal in US$	**233 915**	**193 915**	**193 915**	**193 915**	**815 660**

Salaries include 35 % taxes

ANNEX 5 Technical assistance budget details

Year	2007	2008	2009	2010	Total
International TA SNV	160 000	160 000	160 000	160 000	640 000
Flex SNV Advisors	25 000	25 000	25 000	25 000	100 000
Subtotal in US$	**185 000**	**185 000**	**185 000**	**185 000**	**740 000**