National Biogas Programme Ethiopia

Programme Implementation Document

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Acknowledgement

The team responsible for the formulation of the programme implementation documents (PID) for a national biogas programme for Ethiopia wishes to thank the Ethiopian Rural Energy Development and Promotion Centre and SNV/Ethiopia for their support and making resources available. The PID team, composed of Ato Kidane Workneh, Dr. Getachew Esthete and Mr. Willem Boers, consulted potential stakeholders in Tigray, Amhara, Oromia and Southern Nations, Nationalities and Peoples regional states from February till July 2007. Through this extensive consultation process stakeholders identified the preferred institutional arrangement for a national biogas programme. We like to express our gratitude to all stakeholders for their cooperation and for making this step towards a national biogas programme a success.

Executive Summary

Households directly benefit from domestic biogas. These benefits are the reduced use of fuel wood, improved living conditions and improved soil fertility through the use of bio-slurry. Additionally biogas contributes to the reduction of greenhouse gases and to job creation. Experiences in large-scale dissemination of biogas in Asia show that over 200,000 biogas plants have been constructed, with a daily operational rate of 95% and a repayment rate of 98% for micro-credit. Biogas programmes in Nepal and Vietnam received several international awards including the Energy Globe Award and the Ashen Award.

With a population of over 72 million and more than 90% of the energy demand of the country provided by biomass, a dire energy situation exists due to a high rate of depletion of the country's forest cover. Biogas as an alternative to the use of biomass for energy was introduced in Ethiopia in 1979. Since then approximately 1,000 biogas plants have been constructed of which 50% are reported to be in regular use. Due to the renewed interest in biogas and the success of biogas programmes in Asia a feasibility study was commissioned to assess the potential for the dissemination of domestic biogas in Ethiopia.

At least over one million households in Tigray, Amhara, Oromia and Southern Nations, Nationalities and Peoples regional states qualify for the installation of a domestic biogas plant. Cattle are an integrated part of the farming systems and 77% of agricultural holders own cattle. There are many locations where access to water is within 20-30 minutes walking distance. An estimated 500,000 households in the four selected region have an annual income above ETB 4,000 and can theoretically afford to install a biogas plant. For the promotion of biogas in Ethiopia, the standardized *SINIDU* fixed dome model will be introduced with varying sizes of 4 6 8 and 10 m^3, covering the daily energy demand excluding the periodical *injera* baking.

Biogas is widely accepted in Ethiopia as a cooking fuel and will mainly benefit women and children. It is expected that biogas will reduce the overall workload of women by providing the daily energy demand. Gender is not considered a limiting factor as Ethiopia ranks similar to Nepal on an international gender index. The national biogas programme will actively address gender and energy.

The average investment cost[1] for a 6 m^3 biogas plants is ETB 7500 (€ 602). To encourage households to install a biogas plant, an contribution to construction cost of ETB 2400 (€ 193) will be provided, thus increasing the internal rate of return for households to 29%. The investment cost remaining after deduction of the contribution to construction cost and self-help contribution is ETB 4300 (€ 345) and can be financed through either cash or micro-credit. In addition through the household investment in biogas an economic return of 78% is expected.

[1] These cost are at the July 2007 price level and will be adjusted to the January 2008 price level.

To promote the uptake of domestic biogas, a National Biogas Programme (NBP) will be developed to disseminate domestic biogas and develop a commercially viable market biogas sector in four selected regions in Ethiopia. Institutions and organisations with specific roles and responsibilities will be encouraged to participate in the development of a national biogas sector. The number of family-sized domestic biogas plant will increase by 14,000 in selected regions over a period of 5 years.

For the development of a biogas sector, a number of functions are to be implemented. These functions include promotion and marketing, training, quality management, research and development, monitoring and evaluation, institutional support, extension, and gender mainstreaming.

The functions required for a national biogas programme will be executed by multiple stakeholders. Each stakeholder will take on responsibilities best suited to its objectives and in agreement with other programme stakeholders. The Ethiopian Rural Energy Development Centre (EREDPC) at the national level and the Mines and Energy Agencies (MEA) at regional level are identified by stakeholders as the lead institutions with a regulatory responsibility.

To ensure distinct difference between regulatory responsibilities and operational management, a National Biogas Programme Coordination Office (NBPCO) and regional Biogas Programme Coordination Offices (RBPCO) will be established under the overall responsibility of EREDPC and MEA respectively. The BPCOs will operate under separate operational guidelines.

The National Biogas Programme Coordination Office and regional Biogas Programme Coordination Offices will establish partnership for the day-to-day management with national and regional government institutions for training, promotion and extension services, the private sector for the actual construction of biogas plants: (I)NGOs for promotional activities; microfinance institutions for the provision of micro-credit for biogas; and end users for sound operation. The Biogas Programme Coordination Offices (BPCOs) report regularly to EREDPC and MEA and are guided by a national and regional steering committees composed of sector stakeholders.

The programme costs include the investment cost for the rural household (construction cost + financing cost), programme support costs (promotion and training, finance, training, extension, programme management, etc.) and technical assistance (advisory, knowledge brokering, networking and advocacy). For the budget calculation the price level for an average 6 m^3 biogas plant is used.

Proposed contributors to the programme costs are the rural households, the federal government (programme support cost + contribution to construction cost), the regional governments (programme support cost), external donors (Biogas Africa Initiative) and SNV/Ethiopia. The contributions for the contribution to construction cost are borne by the federal government (10%) and external donors (90%). Through the mobilisation of carbon credits through certified emission reductions (CERs) or verified emission reductions (VERs), revenues will be generated that could contribute to the financing of the contribution to construction cost and future up-scaling of the National Biogas Programme.

In this document chapter 1 provides information on the Ethiopia context. Chapter 2 presents an analysis of the biogas sector. In chapter 3 the outline of the National Biogas Programme is introduced, followed by a detailed description of the programme activities. In chapter 4 the roles and responsibilities of the stakeholders are described as well as the desired institutional arrangement. The programme costs and financing strategies are shown in chapter 6. The document concludes with chapter 7 which addresses assumptions and risks.

National Biogas Programme Ethiopia fact sheet

Title of the programme	National Biogas Programme, Ethiopia	
Programme period	2008 – 2012 (5 years)	
Target	14,000 domestic biogas plants of 4 6 8 10 m^3	
Technology	Fixed dome biogas model	
Main objective	To disseminate domestic biogas with the purpose to develop a commercially viable market biogas sector in Tigray, Amhara, Oromia and SNNP regional states.	
Lead organisation (national level)	Ethiopian Rural Energy Development and Promotion Centre	
Coordination (national level)	National Biogas Programme Coordination Office	
Lead organisation (regional level)	Mines and Energy Agency or Department of Energy	
Coordination (regional level)	Regional Biogas Programme Coordination Centres	
Partner organisations	Government agencies, private sector, microfinance institutions, (I)NGOs, *woreda* administrations	
Target group	Households with at least four cattle and 20 kg of dung and having access to water daily	
Expected benefits	- Saving of traditional fuel sources (wood, BLT, dung cakes) - Reduced workload for rural households - Access to clean energy - Utilization of bio-slurry for improved agricultural output - Development of the private sector - Public Private Partnership - Addressing governance issues - Reduction of greenhouse gases and mobilisation of carbon credits	
Average investment cost	- ETB 4310 (€ 346) - *Contribution to construction cost ETB 2400 (Euro 193)*	
Estimated budget	- Total budget - Investment cost (59%) - Technical Assistance (11%) - Programme Support (30%)	€ 16.6 million € 9.6 million € 1.9 million € 5.1 million
Funding sources	- Rural households (42%) - Federal government (4%) - Regional governments (3%) - External donor (39%) - SNV (10%)	€ 7 million € 0.7 million € 0.5 million (0.13 million each) € 6.5 million € 1.9 million

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Glossary

Biogas	A group of gases, consisting of about 60% of combustible methane, produced by the fermentation of organic matter (agricultural residue, animal waste, waste streams) in a anaerobic digester.
Conventional energy	Energy produced from fossil fuels and water resources using familiar technologies, usually in large centralised facilities.
Household	A group of people who live in a confined area or compound; a compound is a confined area where people live in one or several dwellings or houses and use one central place for cooking.
Slurry pit	In case bio-slurry can not be directly applied, collection and storage would be a prime requirement for its proper use. Double slurry pits enable to collect slurry, mix it with other organic material, and leave it for curing for a short period.
Woredas	Administrative regions under regional governments. Hierarchy in administrative structure is: national, regional, zonal, *woreda*, and *kebele*.

Abbreviations and Acronyms

AEMFI	Association of Ethiopian Microfinance Institutions
ANRS	Amhara National Regional State
ASS	After Sales Service
BLT	Branches, leaves and twigs
BoARD	Bureau of Agriculture and Rural Development
BoFED	Bureau of Finance and Economic Development
BPCO	Biogas Programme Coordination Office
CBE	Commercial Bank of Ethiopia
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
Ch	Cattle holding
CSA	Central Statistics Authority
cum	m^3
EIRR	Economic internal rate of return
EREDPC	Ethiopian Rural Energy Development and Promotion Centre
FIRR	Financial internal rate of return
GHG	Greenhouse gases
GIS	Geographic Information System
GPS	Global Positioning System
ha	Ha
hh	Households
IFPRI	International Food Policy Research Institute
(I)NGO	(International) non-governmental organisation
m a.s.l.	meters above sea level
MDG	Millennium Development Goals
MEA	Mines and Energy Agency
MFI	Microfinance institution
MME	Ministry of Mines and Energy
MoFED	Ministry of Finance and Economic Development
Mtonnes	Mega tonnes
NBP	National Biogas Programme
NBPCO	National Biogas Programme Coordination Office
NGO	Non-governmental organisation
NPV	Net present value
(NT)FP	(Non-timber) forest products
ONRS	Oromia National Regional State
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PID	Programme implementation document
PILS	Plant Identification and Location System
R&D	Research and Development
RBPCO	Regional Biogas Programme Coordination Office
RTPC	Regional Technology and Promotion Centre
SACCO	Savings and credit co-operatives
SME	Small and micro enterprises
SNNPRS	Southern Nations, Nationalities and Peoples Regional State
SNNPRG	Southern Nations, Nationalities and Peoples Regional Government

SNV	Netherlands Development Organisation
Tcal	Tera calories
Tera	10^{12} or 1 billion
TJ	Tera joules
TNRS	Tigray National Regional State
TVET	Technical Vocational Education and Training
TWh	Tera Watt hour
VER	Verified Emission Reduction
WSSD	World Summit on Sustainable Development

Currency Conversion Rates Used

Country	National Currency	Rate per Euro
Ethiopia	ETB (ETB)	12.50

1,000.00*	one thousand

* In a number of tables and figures, a period is used to indicate the decimal point, and a comma is used to mark off groups of three digits, starting at the decimal point (1.000,00 = one thousand).

1. INTRODUCTION

Biogas technology was introduced in Ethiopia as early as 1979, when the first batch type digester was constructed at the Ambo Agricultural College. In the last two and half decades around 1000 biogas plants, ranging in size from 2.5 m^3 to 200 m^3, were constructed in households, community and governmental institutions in various parts of the country. Presently, approximately 40% of the biogas plants that were constructed are not operational due to a lack of effective management and follow-up, technical problems, loss of interest, reduced animal holdings, evacuation of ownership, water problems, etc.

Regional governments developed strategic plans for the promotion of renewable energy technologies including domestic biogas. The current approach is to construct demonstration sites with the intent that the technologies will promote themselves. The proposed number of biogas plants to be constructed does not exceed 20 per region.

Due to the renewed interest in biogas and in order to unleash the potential for biogas in Ethiopia, a feasibility study to assess the potential for domestic biogas plant was commissioned. The positive outcome of the feasibility study of a National Biogas Programme (NBP) for Ethiopia resulted in a formal partnership between the Ethiopian Rural Energy Promotion and Development Centre (EREDPC) and SNV/Ethiopia to develop a programme implementation document for mass dissemination of domestic biogas. The expected impact from domestic biogas are time saving and health improvement mainly for women and children, contribution to arrest environmental degradation including reduction of greenhouse gas emission, economic return for the public (economic internal rate of return of 78% for Ethiopia), provision of quality bio-fertilizer, and private sector development. In the first phase of the implementation it is planned to construct 14,000 biogas plants, with a potential to up-scale construction to 100,000 biogas plants in the next phase.

In 2007 a joint team of EREDPC and SNV was established with the responsibility to develop a programme implementation document (PID). The PID team conducted a broad stakeholders' consultation in Tigray, Amhara, Oromia and SNNP regions with the aim to create awareness about the concept of domestic biogas, identify ongoing initiatives related to biogas, roles and responsibilities, and willingness of stakeholders to participate in the National Biogas Programme (NBP). A similar approach was conducted at national level. The stakeholders' consultation was concluded through a national stakeholders' consultation meeting, giving the PID team an input on institutional and financial arrangements to finalize the implementation document. The outcome of this approach is that more than 120 representatives of the government, (I)NGOs and the private and financial sectors gained awareness on the features and functions required for a NBP. Additionally stakeholders provided input for the development of the NBP. At the national stakeholder consultation meeting it was unanimously agreed to establish a semi-autonomous Biogas Programme Coordination Offices for the day-to-day management of the NBP. EREDPC and the regional Mines and Energy Agencies (MEA) are responsible for the overall programme coordination based on the consensus reached at the national and regional stakeholders meetings.

1.1 Country context

Ethiopia, with a total area of 1.1 million km^2, lies in the north-eastern part of the Horn of Africa. The country is landlocked, sharing frontiers with Eritrea (912 km) to the north and northeast, Djibouti (349 km) to the east, Somalia (1600 km) to the east and southeast, Kenya (861 km) to the south, and the Sudan (1606 km) to the west. Ethiopia's topographical diversity encompasses high and rugged mountains, flat-topped plateaus and deep gorges with rivers and rolling plains. Altitudes range from 110 m below sea level in the Denakil Depression in the northeast to over 4600 m above sea level in the Simien Mountains in the north.

A chain of lakes lies in the southern Rift Valley, but the largest inland body of water is lake Tana in the northwest. The diversity of Ethiopia's terrain determines regional variations in climate, natural vegetation, soil composition and settlement patterns. All of Ethiopia's rivers originate in the highlands and drain into the surrounding lowlands.

Climate

Rainfall and temperature patterns vary widely because of Ethiopia's location in the tropics and its diverse topography. In general, the highlands above 1500 m enjoy a pleasant, temperate climate, with daytime temperatures between 16°C and 30°C and cool nights. In areas below 1,500 m, such as large river valleys, the Denakil Depression, the Ogaden in the southeast and parts of the southern and western borderlands, daytime temperatures range from very warm (30°C) to torrid (over 50°C), sometimes accompanied by high humidity. Precipitation is determined by differences in elevation and by seasonal shifts in monsoon winds. The highlands receive by far the most rainfall, most of it between mid-June and mid-September, whereas lower elevations receive much less. In general, relative humidity and rainfall decrease from south to north and vary from scant to negligible in the eastern and south-eastern lowlands.

Population

The country's total population is 72.4 million (2004), of which about 84% is rural. The annual population growth rate is about 2.3%. Population density is 66 inhabitants per km^2, but varies from 7 inhabitants per km^2 in Afar in the northeast to 114 inhabitants per km^2 in SNNPR in the southwest of the country. The urban population is growing rapidly as a result of both natural increase and high rural-urban migration. This is putting more and more strain on urban services and employment. The unemployment rate is 2.9% and under-employment is common, particularly in rural areas. In 2000, 44% of the population lived below the national poverty line. Only about 22% of the population had access to improved drinking water sources in 2002, going from 81% in the urban areas down to only 11% in the rural areas.

Sanitation coverage is only 6%, going from 19% of the urban population to 4% of the rural population. The infant mortality rate was 114 per 1000 live births in 2002 and the under-5 mortality rate was 171 per 1000 children. Life expectancy at birth was 46 years (47 years for females, 45 years for males). According to the United Nations Population Division, Ethiopia's population in 2000 fell into the following age-groups: ages 1-14, 45.9%; ages 15-59, 49.5%; and ages 60 and older, 4.6%, making Ethiopia a typical sub-Saharan country with a large proportion of its population under 15 years of age and a large proportion of women within the reproductive years of 15-49 years of age. For the years 2000-2005, the average number of children per woman was estimated at 6.1.

Administration and governance system

Ethiopia is a federal republic under the 1994 constitution. The executive branch includes a president, Council of State, and Council of Ministers. Executive power resides with the prime minister. There is a bicameral parliament comprising the House of Representatives and House of Federation. The judicial branch consists of national and regional courts. Ethiopia today has nine semi-autonomous administrative regions and two special city administrations (Addis Ababa and Dire Dawa), which have the power to raise their own revenues.

The regional/federal governments have legislative, executive, and judicial power over their administrative areas, except in matters of defence, foreign relations, citizenship, etc., which fall under the jurisdictions of the federal government. These regional administrations are divided into zones (66) that are further divided into *woredas* (556). The *woredas* are considered the key local units of government. Below this level, communities are further subdivided into smaller electoral units, known as *kebele*s.

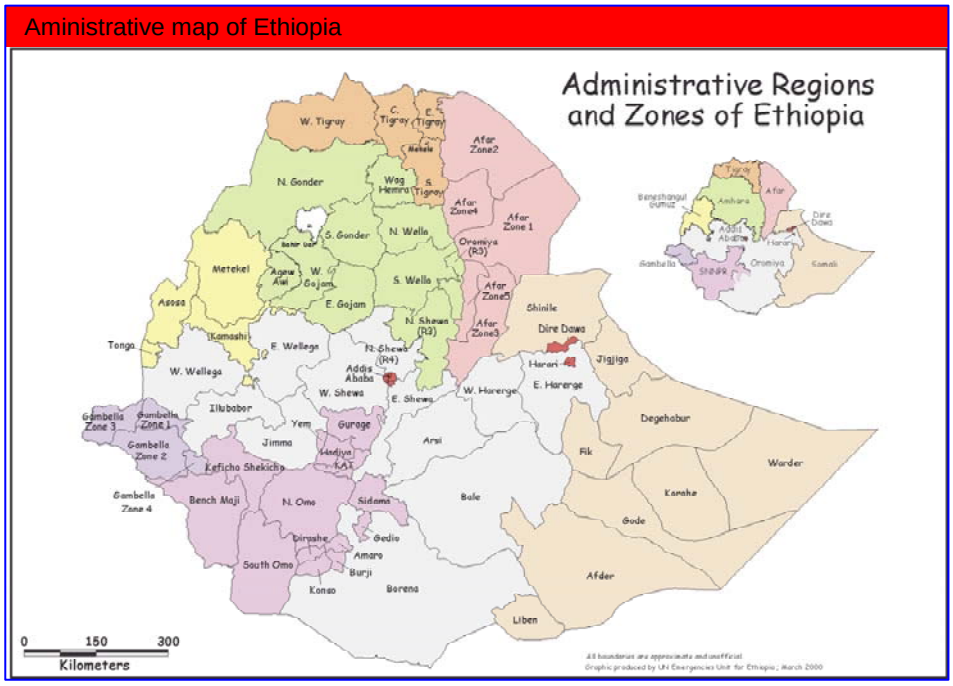


Figure 1 Map of Ethiopia

Economy

Ethiopia is an agrarian country and agriculture makes up for 54% of the gross domestic product (GDP). Agriculture employs about 80% of the population and accounts for about 90% of the exports (CSA, 2000) The major agricultural export crop is coffee, providing 35% of Ethiopia's foreign exchange earnings, down from 65% a decade ago because of the slump in coffee prices since the mid-1990s. Other traditional major agricultural exports are hides and skins, pulses, oilseeds, and the traditional "khat", a leafy shrub that has psychotropic qualities when chewed. Sugar and gold production has also become important, with other agricultural products being introduced on the international market in recent years. Nonetheless, Ethiopia's agriculture is plagued by periodic droughts, soil degradation caused by inappropriate agricultural practices and overgrazing, deforestation, high population density, undeveloped

water resources, and poor transport infrastructure that make it difficult and expensive to get goods to the market. The country is one of the least developed in the world, with a per capita gross national income (GNI) in 2004 of US$110 (Worldbank, 2006). The Ethiopian currency is the ETB, and at present, 1 € is equivalent to about 12.5 ETB.

Environment

Ethiopia has many regions which were once rich in vegetation and are now rocky, barren, and desert areas. Desertification and erosion have further increased in the past decade. Because of the demands for fuel, construction and fencing, at least 77% of the country's tree cover has been cut down in the last 25 years. Forest coverage reaches now 2.7%, down from 40% some 80 years ago. Moreover, the decline in forest coverage, the continuing inefficient use of the soil – including the cultivating of land that is better for grazing or that should be left fallow or unplanted for a while –, the socioeconomic system that does not reward investment in soil protection, and the increasing demands of a rapidly growing population have further aggravated the situation. As a result, in many parts of Ethiopia soil resources suffer from declining fertility and erosion.

In 2002, the Ethiopian Government issued a new policy guideline on rural development and set up a supra-ministry to coordinate activities. The Rural Development Policy guideline regards environmental rehabilitation as an essential factor in increasing productivity.

The Environmental Policy of Ethiopia incorporates a basic principle similar to one adopted in organic agriculture: "Ensure that essential ecological processes and life support systems are sustained, biological diversity is preserved and renewable natural resources are used in such a way that their regenerative and productive capabilities are maintained, and, where possible, enhanced (...); where this capacity is already impaired to seek through appropriate interventions a restoration of that capability."

Key elements of the policy cover soil husbandry and sustainable agriculture, and can support the development of more specific policy and regulations for organic agriculture. These include: promoting the use of appropriate organic matter and nutrient management for improving soil structure, nutrient status and microbiology; maintaining traditional integration of crop and animal husbandry in the highlands, and enhancing the role of pastoralists in the lowlands; promoting water conservation; focusing agricultural research and extension on farming and land use systems as a whole, with attention to peculiarities of local conditions; promoting agro-forestry/farm forestry; ensuring that potential costs of soil degradation through erosion, chemical degradation and pollution are taken into account; shifting the emphasis in crop breeding to composites and multi-lines to increase adaptability to environmental changes and to better resist pests and diseases; using biological and cultural methods, resistant or tolerant varieties or breeds, and integrated pest and disease management in preference to chemical controls; and applying the precautionary principle in making decisions.

1.2 Energy in Ethiopia

Access to modern energy is a key element in rural development. However, despite all attention given to energy issues in Ethiopia in the past, rural communities continue to be deprived of basic energy services. Modern forms of energy are simply not available in rural areas while traditional sources are rapidly being depleted, thereby deepening the rural energy crisis.

Among the principle manifestation of the rural energy crisis is depletion of wood fuel resources. This leads to the decline in household welfare caused by an increased use of inferior fuels, higher wood fuel prices, and a reduction in quality and frequency of cooked meals. Additionally, it leads to a reduction in agricultural productivity as a result of using dung and crop residue as fuel instead of using these as soil nutrients. Due to the use of dung as a source of domestic energy it is estimated that 10% of the annual grain production is lost for the Tigray region (Birhane *et al.*, 2005). Through the biogas programme the utilization of slurry is promoted, thus contributing to increased crop production.

Ethiopia is endowed with various energy resources. The gross hydro-energy potential of the country is about 650 TWh per year, of which 25% could be exploited for power production (CESEN, 1986). This enormous potential ranks Ethiopia as one of the world's leading countries in hydro potential. The most promising hydropower development potential is found in the Blue Nile, Omo, and the Wabi Shebelle river basins (MEDaC, 1999). The energy potential of the country so far discovered comprises between 30 and 50 billion m^3 natural gas, more than 1000 MW geothermal power, and several hundred million tonnes coal and oil shale (Mariam, 1992). The total solar radiation reaching the territory is 2.3 TWh per year while wind energy potential is estimated at 4.8 million Tcal per year (CESEN, 1986). The country's woody biomass energy resources are about 14 million Tcal in standing stock and 0.93 million Tcal in terms of annual yield. The annual agricultural waste available for energy is about 176,000 Tcal per year. Although the country has abundant energy resources, its potential is not yet well developed due to lack of capacity and investment. For example only less than 1% of the total hydropower potential of the country is known to have been utilized so far.

The energy sector in Ethiopia is composed of three main sub-sectors: biomass, petroleum and electricity. Energy consumption is very low, with an estimated total per capita consumption of only about 0.2 tonne oil-equivalent.

Table 1 Energy consumption, Ethiopia

Energy consumption by sector and source (TJ)								
	Woody biomass	Crop residue	Dung	Charcoal	Electricity	Petroleum	Total	**%**
Urban hh	34969	2824	3263	5856	1832	4161	52905	**7.1**
Rural hh	507172	49186	50629	2709		3171	612867	**82.1**
Agriculture						1497	1497	**0.2**
Transport						26743	26743	**3.6**
Industries	17101	1409	1396	112	1864	4573	26455	**3.5**
Services	22110	1031	1046	109	1145	331	25772	**3.5**
Total	**561352**	**54540**	**56334**	**8786**	**4841**	**40476**	**746239**	
%	**77.9**	**7.3**	**7.5**	**1.2**	**0.6**	**5.4**		**100**

Woody biomass represents the principal form of cooking and lighting fuel in the country's rural areas, and an increasing fraction of the population is being confronted with the difficult choice between eating its food poorly cooked or travelling long distances to collect fuel for cooking. The scarcity of fuel wood has led to an increased utilization of dung and agri-residues for cooking, which could otherwise have been used to enhance the nutrient status and texture of the soil and contribute positively to agricultural production. As can be seen in Table 1, the total amount of energy generated from dung directly burned in household stoves is estimated at 56.3 TJ in the year 1998/99 and was about 8% of the total energy consumption in Ethiopia.

1.3 International context

The oil crisis in 1973 prompted many countries to review their energy policies and identify alternatives to fossil fuels. Countries focused on energy efficiency and the substitution by renewable energy technologies (RETs). However, most of the intervention programmes initiated did not succeed in transforming RETs into major alternatives for oil products (Putti, 1998). The switch from traditional use of energy sources to renewable energy technologies is lengthy and has not delivered as expected. In India, for example, biogas plants were installed in only 1.5% of households over a period of 16 years (Putti, 1998).

The renewed interest for renewable energy was boosted in 2000 when the national assembly of the United Nations agreed on eight major goals to address the world's main development challenges and which are know as the Millennium Development Goals (MDGs). Although energy is not explicitly mentioned, the importance of access to energy services to achieve all the MDGs is recognized. UNDP, for example, supports more then 140 countries in integrating energy issues in their national development plans.

At the World Summit for Sustainable Development (WSSD) in Johannesburg, energy was prominent on the agenda and was included in the plan of implementation (UN, 2002). Governments committed themselves to providing one billion people with access to energy over the period 2003 to 2015. In practical terms this translated in, for example, the commitment of the Netherlands Government to serve 10 million poor people in developing countries with appropriate and affordable energy services (DGIS, 2003).

In response to the WSSD, the Conference for Renewable Energies Bonn 2004 addressed the issue of how developing and industrialized countries can pursue the increase of renewable energies, their potential and improved utilization. The outcomes of the conference, again attended by governments, consist of three facts: firstly, a political declaration addressing issues leading to the broader and enhanced utilization of renewable energies; secondly, an international action plan whereby governments, international organisations, and stakeholders from the civil and private sectors pledged commitment towards these goals; and finally, policy recommendations on renewable energies for stakeholders responsible for developing new approaches and strategies.

From the perspective of climate change (Kyoto protocol), sustainability (WSSD and International Conference for Renewable Energies Bonn 2004) and development (the MDGs), the role of renewable energy technologies is increasingly becoming more important. These developments are the driving international forces for up-scaling of renewable energy technologies and for influencing social, cultural, political and economic institutions at the national level.

In May 2007 the "Biogas for Better Live: an African Initiative" was launched in Nairobi. The purpose of this initiative is to provide 2 million households in Africa with domestic biogas plants. The initiative aims to achieve the following by 2020:

- 2 million biogas plants installed (90% operation rate)
- 10 million Africans benefiting in daily life from the plants
- 800 private biogas companies and 200 biogas appliances manufacturing workshops involved or established
- 100,000 new jobs created
- comprehensive quality standards and quality control systems developed and in use
- 1 million toilets constructed and attached to the biogas plants
- 80% of the bio-slurry utilised as organic fertiliser
- agriculture production raised by up to 25%
- health and living conditions of rural household improved and death of rural household reduced by 5000 each year
- drudgery reduced by saving 2 to 3 hours per day per household for fetching wood, cooking and cleaning the pots
- health costs saved by up to US$ 80 to 125 per family per year
- 3 to 4 million tonnes of wood saved per year
- greenhouse gas emissions annually reduced by 10 Mtonnes of CO_2 equivalent.

1.4 About biogas

Biogas offers an attractive option to replace unsustainable utilization of wood and charcoal. Biogas is produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition. Biogas is mainly composed of 50 to 70% methane (CH_4), 30 to 40% carbon dioxide (CO_2) and small amounts of other gases (Lam and Heegde, 2007). Biogas is generated in a biogas plant[2]. The commonly used models are the floating drum, the fixed dome or Chinese model digester, the Deenbandhu model (also a fixed dome model) and the plastic bag digester.

The benefits of domestic biogas are divided over multiple levels (micro, meso and macro) of the society and differ in the extent to which they can be translated in direct economic gains (formal versus informal[3]). As indicated in the benefit matrix (Table 2), the benefits of biogas are not limited to the rural household only, although the rural household is expected to pay for the lion's share of the installation cost. The household will only reap a small part of the benefits, and an even smaller part could actually assist in repaying the investment (micro, formal) (Eshete *et al.*, 2006b).

[2] The terms biogas plant refers to the technical installation to generate biogas.
[3] Formal benefits refer to economic gain and can be attributed a price; informal benefits refer more to benefits in the social and environmental domain.

Table 2 Biogas benefit matrix

Biogas benefit matrix

	Informal	Formal
Micro	– Reduced indoor smoke-induced illnesses – Reduced poor-sanitation induced illnesses – Reduced drudgery from fuel wood collection – Reduced pressure for illegal forest encroachment – Reduced drudgery from weeding fields – Reduced workload for food-preparation – Reduced soil erosion/degradation – Improved opportunity for education	– Reduced direct medical costs – Reduced expenses on conventional energy sources – Reduced chemical fertilizer expenditures – Increased opportunity for (small-scale) organic agriculture – Improved agricultural yields – Increased family income
Meso	– Reduced risk of erosion and landslides in mountainous areas – Improved forest quality and quantity – Reduced pollution of the environment as a result of uncontrolled dumping of animal waste	– Increased employment and income-generating opportunities – Opportunity to develop markets for (organic) agricultural produce
Macro	– Reduction of illness-induced production losses – Improved biodiversity – Increased non-marketable (NT)FP availability – Reduced mortality – Improved human resource base – Reduced risks resulting from global warming	– Reduced (forex) costs on medication – Reduced health system expenses – Reduced (forex) costs on chemical fertilizer – Reduced (forex) costs on fossil fuels – Increased availability of marketable (NT)FP – Increased agricultural production – Increased tax revenues – Generating CDM revenue

Source: Eshete *et al.*, 2006a.

The value depends directly on the value of the substituted fuels. Table 3 provides the calculated value of 1 m^3 of biogas, based on the fuel price, the substitution ratio (biogas stoves have a significant higher efficiency than traditional stoves) and the assumed fuel mix (the share of the substituted fuel in the total energy supply) (Eshete *et al.*, 2004a).

Table 3 Financial and economic value of energy sources

Biogas replacement	Unit	Substitution ratio	Fuel mix (%)	Economic value	Financial share (%)	***Financial value***
Agric. residue + BLT (50% replacement value for wood)	*€/m^3 gas*	*7.06*	*15*	*0.038*	*10*	*0.004*
Dung cake	*€/m^3 gas*	*6.05*	*15*	*0.035*	*30*	*0.010*
Fuel wood	*€/m^3 gas*	*9.79*	*68*	*0.480*	*70*	*0.336*
Charcoal	*€/m^3 gas*	*1.99*	*1*	*0.003*	*80*	*0.002*
Kerosene	*€/m^3 gas*	*0.61*	*1*	*0.002*	*100*	*0.002*
Biogas	*€/m^3 gas*		*100*	*0.56*	*0.35*	*0.35*

Source: Eshete *et al.*, 2006a

Two values are shown in Table 3: the economic value, taking the full market price of the substituted fuel into account, and the financial value, taking only a share of the market price into account. The financial value better allows for the fact that rural rural households often acquire fuel by hard labour rather than by buying it on the market. Striking in the results is not only the significant difference of € 0.21 between the economic and the financial value of biogas, but also that the economic value of biogas in Ethiopia is € 0.56 and the financial value, € 0.35 (Eshete *et al.*, 2006b).

2. ANALYSIS OF THE BIOGAS SECTOR IN ETHIOPIA

2.1 Description of the selected regions

The first phase of the programme will be implemented in selected *woreda*s in Oromia, Amhara, SNNP and Tigray regional states. Although the programme is planned to gradually cover the whole country, it is important to mention the rationale for starting in these four regions during the first programme implementation phase. The main reasons for this include: the presence of most of the human (>70%) and livestock population (~70%); the loss of vegetative cover as a consequence of severe deforestation and resulting in a huge imbalance for the rural household energy; the relatively advanced status of the regions with regard to educated human resources and technology adoption experience; and the availability of relatively well-documented information crucial to start the programme. Up-scaling of the programme to additional regions could be considered on the outcome of the mid-term review. Prior to expansion to additional regions feasibility studies will be conducted to assess the potential for domestic biogas taking into consideration the potential for domestic biogas, possibilities for financing and available capacity.

2.2 The potential of biogas in Ethiopia

Technical potential

Technical resource considerations include the availability of a constant supply of manure, the availability of water with which to dilute the manure, the suitability of the ambient temperature, and the availability of sufficient space for effluent disposal and usage. Table 4 present an overview of the technical data for the four study areas.

Table 4 Overview of technical data

Region	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]	hh with access to water [%]	ch with access to water [# of ch]
Amhara	148509	3194754	2574836	10275527	81%	69	4.0	1587506	1110264	43%	10%	111026
Oromia	328939	4564213	3594072	18575227	79%	56	5.2	799379	2787099	78%	25%	696775
SNNPRS	112217	2688970	2009680	8815689	75%	79	4.4	1213824	758760	38%	20%	151752
Tigray	50182	724964	559334	2665129	77%	53	4.8	284879	290733	52%	10%	29073
Total study area	**639846**	**11172901**	**8737922**	**40331572**	**78%**	**63**	**4.6**	**3885588**	**4946856**	**57%**	**20%**	**988626**

Availability of manure: Cattle are an integrated part of the farming systems in the highlands of Ethiopia. Although on average 77% of agricultural holders in Ethiopia own cattle, the proportion varies widely throughout the country. Cattle-owning smallholders are common in the highlands but ownership varies widely due to household and local resource constraints. In Ethiopia, cattle are used for milk, beef, draft power, and breeding. In view of the low level of mechanization and chemical fertilizer usage, it will be quite impossible for most rural households to farm without cattle. Under the current holding regime, sedentary rural households would need at least 4 cattle stabled during the night to get the minimum 20 kg of fresh animal dung per plant per day required to produce enough gas for cooking or lighting.

Collection of urine and availability of water: Urine can be collected and used for feeding the biogas plant and replaces the daily amount of water required. However, the type of stable floor commonly used in Ethiopia does not allow for urine collection. The collection of urine will however be promoted and rural households will be encouraged to voluntary construct a low-cost stable floor suitable for urine collection. Availability of water is mainly area dependent, and in most parts of Ethiopia, recurrent droughts have to be taken into consideration. Although, a comprehensive national groundwater resources study has not been conducted, some surveys suggest that there is ample groundwater potential in many parts of Ethiopia.

Additionally, there are many locations where permanent rivers and streams flow in the highlands of Ethiopia. Fetching water required to mix with the daily input of 20 kg fresh dung in a 1:1 ratio should not take more than 20 to 30 minutes. There are definitely many farm locations that meet this requirement, but there will also be many that do not. Careful and strict selection of the locations for the installation of the biogas plants should help avoid disappointments.

Conducive temperature: The temperature regime required for biogas production is not a major problem in Ethiopia. Many of the areas in the highlands of Ethiopia have average temperatures in the range of 15-20°C throughout the year. However, night temperatures may drop to 10^{o}C or slightly lower during the rainy season in areas with altitudes of more than 2500 m a.s.l. Provided the plant is properly located and covered with soil, this should not prevent the biogas plants from functioning throughout the year.

Availability of space: Physical space requirement on the farms for the construction of biogas plants is not a limiting factor in Ethiopia. Most rural households have gardens in their backyard. Often these rural households use their manure (or bio-slurry in the case of biogas households) as fertilizer for their vegetables and crops.

Slurry: The burning of dung and plant residue is a considerable waste of plant nutrients. Losses to crop production from burning dung and soil erosion are estimated at over 600,000 tonnes annually, or twice the average yearly request for food aid in Ethiopia (Araya and Edwards, 2006). With more continuous cropping on the increase, organic material and nitrogen are rapidly getting depleted; phosphorous and other nutrients reserves get depleted slowly but steadily (Borlaugh and Dowswell, 1995). The fuel wood deficit is increasingly being made up for by substituting with dung and crop residues, thus leading to a drastic decline in the use of animal manure and crop residues for fertility improvement programmes. With the 10^{th} largest cattle population in the world, Ethiopia can significantly benefit from this organic fertilizer if the energy sector in the rural areas is addressed properly. Biogas technology is a suitable tool for making maximum use of scarce resources. The slurry that is obtained after extraction of the energy content of the dung is still an excellent fertilizer, rich in nitrogen, phosphorous, potassium and humus, supporting general soil quality as well as higher crop yields (Marchain, 1992).

Due to the decomposition and breakdown of parts of its organic content, digested dung provides fast-acting nutrients that easily enter into the soil solution, thus becoming immediately available to the plants. Crop yields are generally acknowledged to be higher following fertilization with slurry. Most vegetable crops such as potatoes, radishes, carrots, cabbage, onions, garlic, etc., and many types of fruit (oranges, apples, guavas, mangos, etc.), sugar cane, rice and jute appear to react favourably to slurry fertilization. Slurry is also a good fertilizer for pastures and meadows. The available data vary widely, because the fertilizing effect is not only plant-specific, but also dependent on the climate and type of soil.

Fertilizer: Traditionally, many of the rural households in the highland parts of Ethiopia use dung as fertilizer. Unfortunately, shortage of energy for cooking increasingly forced many of the households to use dung as energy source. Although chemical fertilizer has been widely promoted, only 32.8% of the rural households in Ethiopia used fertilizer in 1995 (CSA, 1999). Fertilizer utilization increased from 105,000 tonnes in 1990/91 to 346,000 tonnes in 2004/05. This is equivalent to 32.3 kg of nutrient per ha of the crop land estimated at 10.73 million ha (EarthTrends, 2003). However, application rates are mostly well below the recommended rates (200 kg per ha according to the latest recommendations). The fact that most of the visited biogas households used the bio-slurry for fertilizing vegetables and other crops shows that rural households will use the organic fertilizer if their energy needs are covered from other sources.

Fuel wood: Subsistence rural households who depend on firewood for cooking and heating comprise more than 99% of the rural population in Ethiopia. However, there is a visible chronic scarcity of fuel wood in many parts of Ethiopia given rapidly increasing prices. As a result, fuel wood and charcoal are gradually becoming unaffordable goods for rural households. Dung cakes, agricultural residues, and tree branches, twigs and leaves have also become commercial energy sources traded at markets. Fuel collection and cooking are tasks that constitute a large part of the women's daily workload. Time spent on collecting fuel in fuel-scarce areas can range from 1 hour to 5 hours per household per day (Cecelski, 2000). The labour required to maintain traditional energy systems (such as fuel wood collection) can be used in more economically productive activities. The savings in fuel wood due to biogas can help to slow the rate of deforestation. The reduction in the use of kerosene, from which 81.4% (CSA, 1999) of the lighting requirements of rural households in Ethiopia is covered, save valuable foreign exchange. Table 5 shows the percentage of households that use different energy sources for cooking in rural and urban Ethiopia.

Table 5 Distribution of Ethiopian households by type of fuel used for cooking

Type of cooking fuel	***Percentage of households***		
	Country level	***Urban***	***Rural***
Collected firewood	*65.4*	*17.2*	*74.1*
Purchased firewood	*8*	*44.5*	*1.4*
Charcoal	*0.7*	*4.3*	*0.1*
Leaves/Dung cake	*17.4*	*7.6*	*19.1*
Kerosene	*3.0*	*18.9*	*0.2*
Butane gas	*0.2*	*1.0*	*0.0*
Electricity	*0.4*	*2.7*	*0.0*
Others	*5.0*	*3.8*	*5.2*

Source: (Wolde-Ghiorgis, 2001); CSA, 1999

Services

Micro-credit: Credit facilities in Ethiopia are not new. Various institutions provide short and medium term credit to rural households. The Commercial Bank of Ethiopia (CBE) is the largest source of agricultural credit in the country (FAO and WFP, 2006). Currently, more than 2.5 million farmers, accounting for 25% of the total smallholder farmers, obtain credit annually for the purchase of inputs, mainly fertilizer. The bulk of this credit is provided by the commercial banks, with the intervention of the state governments to underwrite the loans. During the cropping year 2005/06, CBE approved a total of ETB 1.2 billion of agricultural input loans based on credit requests submitted by the regional governments of Oromia, Amhara, SNNPR, Tigray and Addis Ababa. The amount of agricultural credit approved by CBE for the cropping year 2005/06 is about 21 % higher than 2004/05 and the highest for the last five cropping years. The credit repayment default rate has been kept under control and it is expected that it will decline in the coming year given the good harvest prospects. Furthermore, the regional governments in their capacity as guarantors of agricultural input loans are implementing measures to reschedule part of the past due loans. The interest rate on these loans is 7.5%, shared between the CBE which receives 5.25% on the disbursed amounts, and regional governments which receive 2.25% for loan disbursement, recovery and administrative charges. Microfinance institutions (MFIs) are the other major source of access to financial credit for smallholders.

Currently, loans are typically used for the purchase of inputs (fertilizer, fungicides, herbicides, and so on), capital acquisition (livestock, machinery, buildings), or other improvements. Nationally, about 19% of smallholders participate in these programmes, although there is a wide variation throughout the country. Especially in the lowlands and more remote areas of the highlands, few holders make use of formal sources of credit. Gojam in Amhara, central and western parts of Oromia, and most of Tigray show higher use of formal credit. With the micro-credit facilities modernizing and extending their services in all regions, MFIs can contribute immensely to the large scale diffusion of biogas. Credit terms are not prohibitive, but it has to be kept in mind that there is no experience with biogas credit yet. Except for the GTZ scheme for fuel saving stoves, energy initiatives have not been funded through MFIs or cooperatives (Teferra, 2001). Hence, whereas there is an apparent willingness of micro-credit institutions to get engaged in the biogas programme, micro-financing organisations may require initial assistance in covering the risk. Through the stakeholder consultation and a national workshop organized by the umbrella organisation for MFIs, the Association of Ethiopian Microfinance Institutions (AEMFI), regional MFIs indicated their willingness to provide credit to biogas rural households. The indicative interest rates are 12% per annum and the repayment period is negotiable with individual MFIs. Providing microfinance for biogas is considered a 'low' risk investment[4].

Extension: Advisory services are organized into "extension packages," which include packages for rain shortage areas, rain abundant areas, and for post-harvest processing. These packages aim to transfer modern and appropriate agricultural technologies to rural households so as to increase productivity. A holder is said to utilize a package if he or she obtains agricultural advice and applies the recommended package of inputs and related services. Use

[4] MFIs consider lending to biogas rural households as 'low risk' because there will be government involvement and provision of an contribution to construction cost.

of advisory services across the country is fragmented, but general patterns of higher usage are observable for Tigray, Amhara, and western Oromia. The extension network of the relevant institutions, especially the Bureaus of Agriculture and Rural Development, reach down to the grassroots level. Development agents (DAs) working close to the rural households at *kebele* level can bring the required impact especially in the utilization of biogas slurry.

Infrastructure: Much of the country is poorly serviced by roads. This is true for a significant part of the highlands in Ethiopia that are still not accessible by all weather roads and where there is a big potential for biogas dissemination. Hence, accessibility can possibly hinder the market opportunities of biogas due to the cost implications associated with industrial goods that must be transported to the site. Holding other factors constant, the further away a rural location is from the nearest town, the less potential interaction residents of that location have with the opportunities available in that town.

Disposable income

Ethiopian rural households greatly engage in subsistence activities. Cereals represent the most important product both in the income and consumption baskets of the households. Therefore, any change in the price of cereals is likely to create substantial income redistribution between producers and consumers. Among other agricultural products, the ones that substantially impact households' income are livestock (Ahmed *et al.*, 2003), coffee, and chat. Labour income is only marginally important and government transfers are negligible.

Household expenditure can broadly be disaggregated into expenditure on food, non-food items, and farm inputs. Theoretically, expenditure on food also includes the value of food produced and consumed by the household. Non-food expenditure includes household expenses such as clothing, health care, education, and social contributions. Expenditure on inputs covers farm inputs such as fertilizer, chemicals, seed, and livestock expenditure such as feed and veterinary supplies. Disposable income is the remaining amount either in cash or in kind that the rural household is willing to spend.

Dependable information on rural households' disposable income is difficult to obtain in Ethiopia as rural households usually are not frank enough to reveal their accurate earrings. A study in Tigray revealed that the mean average income for rural male headed households is ETB 3187 and for female headed households ETB 2207 (Desta *et al.*, 2006).

A study conducted by the Ethiopian Economic Association/Ethiopia Economic Policy Research Institute (EEA/EEPRI) identified that in Tigray, Oromia, Amhara and SNNPRG 3.7% of the rural households have a net income from crop production of ETB 3000–4000 per ha and that 3.7% of rural households have a net income above 4000 ETB per ha (EEA and EEPRI, 2006). More than 63% of all the rural households in Ethiopia have less than 1 ha of land, the national average being 0.8 ha (IFPRI *et al.*, 2006).

With an estimated total of 8.8 million holdings in the four selected regions, it can be assumed that 325,000 rural households have an annual net income above ETB 2400 and another 325,000 rural households have a net annual income above ETB 3200.

Observations from a meeting with dairy cooperative members in Debre Zeit indicated that rural households are interested to invest in biogas technology. The technology can be linked to their dairy farming, on the one hand through provision of energy for milk processing and on the other hand for waste management purposes and commercial use of the bio-slurry. It is also observed that dairy farmers tend to keep their livestock in a well-managed stable whereby urine and dung can regularly be collected. In total, approximately 10,000 dairy farmers are registered in, and are members of, dairy cooperatives in Debre Zeit. In addition, these cooperative have shown interest in biogas technology and appear to be ready to provide extra advantage to their members through financing (Ahmed *et al.*, 2003).

From other observations made during field visits, interviewed rural households showed keen interest to invest in biogas technology as it would address the difficulty in obtaining fuel wood and provide an instant and clean cooking energy source. In locations where existing biogas plants are in operation the users informed the study team that neighbouring rural households are very keen to obtain biogas but did not know where to go for assistance.

Form 2003/04 onwards, there has been a 10.7% growth of the agricultural sector resulting in a real per capita income increase at an annual average of 7% (IMF, 2007). The surge in food prices resulted in a higher disposable income in the agricultural sector.

As shown in Table 6, production of biogas plant targets the “innovators” who are the first to adopt a technology and are willing to take a risk (Rogers, 1962). With 2-3% of the total number of households targeted during the first phase in Amhara, Oromia and SNNP regional states and 11% in Tigray regional state a production of 3,500 biogas plants per region is realistic.

Table 6 Target biogas penetration

Population Biogas regions as at July 2007

Region	Total Pop	Est No. of HH	Pop > 4000 Birr	Target Production	% of hh > 4000 Birr
		[ave 4,8]	*[3,7%]*		
Amhara	19.624.000	4.088.333	151.268	3500	2%
Oromria	27.304.000	5.688.333	210.468	3500	2%
SNNP	15.321.000	3.191.875	118.099	3500	3%
Tigray	4.449.000	926.875	34.294	3500	10%

Despite the lack of accurate and dependable data on disposable income in the four selected regions there is satisfactory indication that 14,000 biogas plants can be financed by rural rural households. The targeted production of 3500 biogas plants per regional state in 5 years is achievable.

2.3 Geographic coverage

Oromia National Regional State (ONRS)

The ONRS (CSA, 2005) covers about 363,136 km^2, forming a broad tract across south-eastern, southern, south-western and western Ethiopia. It is a region of incredible ecological and cultural diversity, ranging from arid to semi-arid deserts in the lowlands inhabited by transhumant pastoralists, to montane forests with high rainfall inhabited by bush fallowing agriculturists. The population was estimated in 2005 by the CSA to be 26,553,000. Some 88% of the population lives in the rural areas.

Agriculture in the highlands comprises mixed cropping and livestock production, with cereals predominating in the eastern and the north-central highlands and the Rift Valley, and mixed enset, root crops and cereals systems in the south-central and south-western highlands. In the Hararghe and southern lowlands extensive pastoralism occurs, whilst in the tsetse-infested Abay and western lowlands shifting cereal cultivation is a common practice.
With a rapidly increasing population, cultivation is expanding. Marginal and steep lands are increasingly being brought under cultivation, leading to accelerated soil erosion and to declining and more variable crop yields. Expanding cultivation is taking place at the expense of communal lands on which most woody biomass resources are located, leading to a decline in these resources. Regionally, biomass fuels provide 99.5% of the total (rural and urban) domestic energy supplies, with 81% derived from woody biomass, 4% from crop residues, 14% from dung and 1% from charcoal. However, these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of declining stocks of wood fuel and the increasing opportunity costs in its collection or purchase.

Given the well-integrated nature of agriculture in the highlands, these changes have important implications for both crop and livestock production, as well for the health and nutrition of the population. Increasing use of dung precludes its use as manure, whilst the use of residues as fuel precludes their use as livestock feed. This leads in turn to breaches in the cycling of soil nutrients, in particular nitrogen and phosphorous, leading in turn to declining soil fertility and so to declining crop yields.

According to (CSA, 2005) , Oromia has over 4.6 million households with a total cattle holding size of 3.6 million. Out of the 79% households that own cattle, 78% keep at least four animals or more. In the region only 25% of the households have reasonably close access to water. Based on the figures in table 7, the technical potential for domestic biogas in Oromia region would amount to approximately 697,000 installations.

Table 7 Data on cattle in Oromia

Oromia Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Arsi	23713	573680	480821	2783892	84%	117	5.8	0	480821	100%
Bale	60805	297018	256654	1614990	86%	27	6.3	0	256654	100%
Borena	70604	321428	227715	1732020	71%	25	7.6	0	227715	100%
East Harerghe	23544	406076	338674	975054	83%	41	2.9	331080	0	0%
East Shewa	13893	353342	264953	1416553	75%	102	5.3	20576	244377	92%
East Wellega	22181	295540	229597	1458188	78%	66	6.4	0	229597	100%
Illubabor	16411	220714	158226	794176	72%	48	5.0	0	158226	100%
Jimma	18486	514489	417041	1805867	81%	98	4.3	148888	268153	64%
North Shewa (K4)	11269	269663	222689	1173542	83%	104	5.3	53721	168968	76%
Oromia Zone	4073	78911	60704	326825	77%	80	5.4	0	60704	100%
West Harerghe	17461	309862	261931	994224	85%	57	3.8	150711	111220	42%
West Shewa	21812	554009	449463	2431375	81%	111	5.4	14667	434796	97%
West Wellega	24316	354436	214316	1034513	60%	43	4.8	68448	145868	68%
Hundene	372	15045	11288	34008	75%	92	3.0	11288	0	0%
Total Oromia	**328939**	**4564213**	**3594072**	**18575227**	**79%**	**56**	**5.2**	**799379**	**2787099**	**78%**
					Access to potable water					25%
					Technical potential domestic biogas Oromia region					**696775**

Amhara National Regional State (ANRS)

The ANRS covers 159,173.66 km^2 across north-western and north-eastern Ethiopia. The National Population and Housing Census estimated the population to be 19.12 million in 2005. Some 90% of the population lives in the rural areas. Agriculture comprises mainly smallholder mixed cereal cropping and livestock production.
Regionally, bio-fuels provide 99% of the total domestic energy supply, with 64% derived from woody biomass, 14% from crop residues, and 21% from dung. However these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of changing stocks of wood fuel and the opportunity costs in its collection or purchase.

With a rapidly increasing population, cultivation is expanding. Marginal and steep lands are increasingly being brought under cultivation, leading to accelerated soil erosion and to declining and more variable crop yields. Expanding cultivation is taking place at the expense of land under communal use rights on which important grazing and woody biomass resources are located, leading to changes in the supply of these resources.

Given the well-integrated nature of agriculture in ANRS these changes have important implications for crop and livestock production and household energy supply, as well as for the health and nutrition of the population. Use of dung as fuel precludes its use as manure, whilst the use of residues as fuel precludes their use as livestock feed. This leads in turn to breaches in the cycling of soil nutrients, in particular nitrogen and phosphorous, resulting in declining soil fertility and thus in declining crop yields.

According to the feasibility study made in 2006 on biogas potential in Ethiopia (Eshete *et al.*, 2006b), in ANRS there are nearly 3.2 million households with a total number of cattle holding estimated at 2.6 million. Nearly 83% of the households in the region own cattle with 43% keeping four or more animals. In the region, only 10% have reasonably close access to water.

Based on the figures in Table 8, the technical potential for domestic biogas in the region is thus estimated at approximately 111,000 installations.

Table 8 Data on cattle in Amhara

Amhara Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Awi	6346	175494	137552	638868	78%	101	4.6	0	137552	100%
East Gojam	14186	406823	333321	1257843	82%	89	3.8	207136	126185	38%
North Gondar	45486	462119	375422	1931400	81%	42	5.1	85427	289995	77%
North Shewa (K3)	16077	369828	287843	1018055	78%	63	3.5	240700	47143	16%
North Wollo	12702	324963	253403	910492	78%	72	3.6	187463	65940	26%
South Gondar	14607	407519	336299	1181472	83%	81	3.5	300694	35605	11%
South Wollo	17212	553574	441555	1582857	80%	92	3.6	415106	26449	6%
Wag Hemira	8479	80546	61467	355056	76%	42	5.8	0	61467	100%
West Gojam	13413	413888	347974	1399484	84%	104	4.0	150980	319928	92%
Total Amhara	**148509**	**3194754**	**2574836**	**10275527**	**81%**	**69**	**4.0**	**1587506**	**1110264**	**43%**
					Access to potable water					10%
					Technical potential domestic biogas Amhara region					**111026**

Southern Nations and Nationalities Regional State (SNNPRS)

Located in southern and south-western Ethiopia, the SNNPRS covers about 112,343,19 km^2. It is a region of incredible ecological and cultural diversity, ranging from arid to semi-arid deserts in the Omo river lowlands inhabited by transhumant pastoralists, to montane forests with high rainfall inhabited by bush fallowing agriculturists. The total population was estimated in 2005 by CSA to be 14.9 million. Rural population growth rates for the period 1995-2000 were projected to be 2.98% per annum and urban rates 5.22%. Some 93% of the population live in the rural areas.

Agriculture in the highlands comprises mixed cropping and livestock production, with cereals predominating in the north-central highlands and the southern Rift Valley, and mixed enset, root crops and cereals cultivation in the south-central and south-western highlands. In the southern lowlands extensive agro-pastoralism and pastoralism occur, whilst in the tsetse-infested Omo lowlands and foothills shifting cereal cultivation is found.

With a rapidly increasing population, cultivation is expanding. Marginal and steep lands are increasingly being brought under cultivation, leading to accelerated soil erosion and to declining and more variable crop yields. Expanding cultivation is taking place at the expense of communal lands on which most woody biomass resources are located, leading to a decline in these resources. Regionally, traditional fuels provide 99.8% of the total (rural and urban) domestic energy supply, with 88% derived from woody biomass, 10% from crop residues, 1% from dung and 0.1% from charcoal. However these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of declining stocks of wood fuel and the increasing opportunity costs in its collection or purchase.

Given the well-integrated nature of agriculture in the highlands these changes have important implications for both crop and livestock production, as well as for the health and nutrition of the population. Increasing use of dung precludes its use as manure, whilst the use of residues as fuel precludes their use as livestock feed. This leads in turn to breaches in the cycling of soil nutrients, in particular nitrogen and phosphorous, leading in turn to declining soil fertility and so to declining crop yields.

SNNPRS counts nearly 2.7 million households, out of which 75% keep cattle. Out of these 2.0 million cattle holdings, 38% are keeping four or more cattle heads. In the region, only 20% has reasonably close access to water. Based on the figures in Table 9, the technical potential for domestic biogas in SNNPRS would amount to approximately 152,000 installations.

Table 9 Data on cattle in SNNPRS

SNNPRS Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Amaro Special Woreda	1557	23714	17374	78473	73%	50	4.5	0	17374	100%
Basketo Special Woreda	419	10348	7509	23611	73%	56	3.1	7509	0	0%
Benchi Maji	23159	102783	81521	319902	79%	14	3.9	72986	8535	10%
Burji Special Woreda	1353	7980	6433	32970	81%	24	5.1	0	6433	100%
Dawuro	4380	81637	65541	292664	80%	67	4.5	0	65541	100%
Derashe Special Woreda	1526	23278	12396	66701	53%	44	5.4	0	12396	100%
Gamo Gofa	12153	257901	205707	850291	80%	70	4.1	93563	112144	55%
Gedeo	1356	141168	41506	117356	29%	87	2.8	41506	0	0%
Guraghe	7914	419708	335151	1353983	80%	171	4.0	130601	204550	61%
Hadiya	4026	253305	199648	733814	79%	182	3.7	199648	0	0%
Kaffa	10539	157734	128591	575024	82%	55	4.5	0	91495	71%
Kembata Alaba Tembaro	2493	193843	144008	472681	74%	190	3.3	144008	0	0%
Konso Special Woreda	2323	36261	22919	103413	63%	45	4.5	0	22919	100%
Konta Special Woreda	2287	17062	13780	52576	81%	23	3.8	13780	0	0%
Shaka	1530	29386	18755	65817	64%	43	3.5	13574	5181	28%
Sidama	6779	528046	404560	1573318	77%	232	3.9	244331	160229	40%
South Omo	23145	91237	60446	1392822	66%	60	23.0	8483	51963	86%
Wolayita	4525	297226	230520	658886	78%	146	2.9	230520	0	0%
Yem Special Woreda	753	16353	13315	51387	81%	68	3.9	13315	0	0%
Total SNNPRS	**112217**	**2688970**	**2009680**	**8815689**	**75%**	**79**	**4.4**	**1213824**	**758760**	**38%**
					Access to potable water					20%
					Technical potential domestic biogas SNNPRS region					**151752**

Tigray National Regional State (TNRS)

The Tigray Regional State covers about 50,078,64 km^2 across north-western and north-eastern Ethiopia. The National Population and Housing Census estimated the population to be 4.33 million in 2005. Some 83% of the population lives in the rural areas. Agriculture comprises mainly smallholder mixed cereal cropping and livestock production.

Regionally, bio-fuels provide 99% of the total (urban plus rural) domestic energy supply, with 62% derived from woody biomass, 2.5% from charcoal, 4.4% from crop residues and 23.0% from dung. However these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of changing stocks of wood fuel and the opportunity costs in its collection or purchase.

With a rapidly increasing population, cultivation is expanding. Marginal and steep lands are increasingly being brought under cultivation, leading to accelerated soil erosion and to declining and more variable crop yields. Expanding cultivation is taking place at the expense of lands under communal use rights on which important grazing and woody biomass resources are located, leading to changes in the supply of these resources.

Given the well-integrated nature of agriculture in TNRS these changes have important implications for crop and livestock production, household energy supply, as well as for the health and nutrition of the population. Use of dung as fuel precludes its use as manure, whilst the use of residues as fuel precludes their use as livestock feed. This leads in turn to breaches in the cycling of soil nutrients, in particular nitrogen and phosphorous, resulting in declining soil fertility and thus to declining crop yields.

Tigray counts nearly 725,000 households, out of which 77% keep cattle. Out of these 559,000 cattle holdings, 52% are keeping four or more cattle heads. In the region only 10% has reasonably close access to water. Based on the figures in Table 10, the technical potential for domestic biogas in TNRS would amount to approximately 29,000 installations.

Table 10 Data on cattle in Tigray

Tigray Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Central Tigray	10327	230761	174810	627831	76%	61	3.6	162010	12800	7%
Southern Tigray	9408	183354	136515	631185	74%	67	4.6	20264	132529	97%
Western Tigray	24652	180952	152793	1081963	84%	44	7.1	20264	132529	87%
Eastern Tigray	5795	129897	95216	324150	73%	56	3.4	82341	12875	14%
Total Tigray	**50182**	**724964**	**559334**	**2665129**	**77%**	**53**	**4.8**	**284879**	**290733**	**52%**
					Access to potable water					10%
					Technical potential domestic biogas Tigray region					**29073**

The potential *woreda*s qualifying for biogas installation (Table 11) were identified by the stakeholders and from the analysis of the observation made by the PID team. However, the first phase programme will be implemented in only two promising *woreda*s per region. The remaining *woreda*s where domestic biogas will be introduced will be selected by the RBPCOs in consultation with stakeholders and *woreda* administration, using elaborate criteria that will include cost-effectiveness and management efficiency to achieve the maximum targets set in the programme.

Table 11 Potential *woreda*s qualifying for biogas

	Woreda	*Reasons for selection*
Oromyia	*Adaà*	▪ *surplus crop producing area* ▪ *presence of dairy cooperatives* ▪ *critical shortage of fuel* ▪ *dung is used as fuel* ▪ *off-farm income*
	Dugda Bora	▪ *major vegetable and onion producing area* ▪ *surplus crop production area* ▪ *households keep a large size of cattle* ▪ *off-farm income*
	Hitosa	▪ *surplus crop producing area* ▪ *critical shortage of fuel* ▪ *dung is used as cooking fuel*
	Ambo	▪ *surplus crop producing area* ▪ *visible shortage of fuel* ▪ *dung and agricultural residues are used as fuel*
	Kuyu	▪ *surplus crop production area* ▪ *critical shortage of fuel* ▪ *dung is used as cooking fuel* ▪ *presence of dairy cooperatives*
Amhara	*Bahir Dar Zuria*	▪ *surplus crop producing area* ▪ *visible shortage of cooking fuel* ▪ *crop residue and dung used for cooking*
	Dembia	▪ *surplus mixed crop and livestock producing area* ▪ *visible deficit of cooking fuel* ▪ *crop residue and dung used for cooking*
	Gondar Zuria	▪ *surplus mixed crop and livestock producing area* ▪ *visible deficit of cooking fuel* ▪ *crop residue and dung used for cooking*
	Fogera	▪ *surplus crop producing area (mainly rice)* ▪ *visible deficit of cooking fuel* ▪ *crop residue and dung used for cooking*
	Dangla	▪ *surplus crop producing area* ▪ *severe cooking fuel shortage* ▪ *crop residue and dung are used as fuel*
	Dale	▪ *excellent coffee and other cash crops and fruit producing area*
	Mareko	▪ *excellent spice and other cash vegetable crops producing area* ▪ *crop residue and dung are used as fuel*
	Meskan	▪ *excellent spice and other cash vegetable crops producing area* ▪ *crop residue and dung are used as fuel*
SNNPRS	*Arba Minch Zuria*	▪ *excellent fruit and banana cash crops producing area* ▪ *critical shortage of cooking fuel*
	Derashe Special Woreda	▪ *excellent fruit and banana cash crops producing area*
Tigray	*Hintalo Wajirat*	▪ *excellent cattle keeping area*
	Raya Azebo	▪ *excellent cattle keeping area*
	Western Tigray	▪ *excellent cattle keeping area*

2.4 Technical issues

The design of biogas plants for rural areas can be based on two main objectives: i) the amount of digestible material available for biogas production at site, and ii) the quantity of biogas required for specific purposes such as cooking, lighting or operating an internal combustion engine. Subsidiary considerations involve the on and off-site conditions, such as availability of adequate space and water within a short distance. There are different types of biogas digester models around the world but only some of them are commonly constructed in Ethiopia, including the floating gasholder, the fixed dome Deenbandhu, the LUPO model, Carmatec, the Chinese hybrid and the plastic type. The construction of a floating metallic drum installation is straightforward with little chance of error. The installation cost for a fixed dome design is lower in comparison to the floating metallic drum. However, fixed dome plants would need a higher level of on-site workmanship and are less forgiving for construction mistakes.

Plant type and size selection

Based on the selection criteria of a biogas digester such as low cost, utilization of locally available material for construction, durability, the modified fixed dome version of the Nepalese model is favoured above the other existing models. Other models can only be constructed using bricks. Due to the high cost of bricks in most rural parts of Ethiopia a biogas design is selected that can be constructed with bricks but also with local availed stones. It is proposed to introduce the fixed dome design (modified version of the Nepalese model with an Ethiopian name – *SINIDU* (meaning "ready", see Figure 2*)*. The Nepalese design is preferred because of its robustness, ease of operation, opportunity to accommodate high shares of local materials, correct sizing and low cost. In addition, as the design has been used intensively over a long period of time, construction and after sales service standards and a variety of training materials can readily be adopted.

For a biogas installation to become interesting for the family, it would have to produce around 1 m^3 of biogas per day. This would require at least 20 kg manure being fed to the installation every day. With most of the livestock roaming around on common grazing lands during the day, the amount of dung that can be obtained in stables per head of cattle per day is likely to be in the range of 5 to 8 kg. Hence, a family would need the manure of at least four heads of cattle. For such "typical" biogas households, a correctly sized installation would have a digester volume of 4 m^3. Since cooking in most Ethiopian rural households starts early in the morning[5], is interrupted during day time, and resumes late in the afternoon, the pattern allows the digester to accumulate enough biogas during the night. Digester sizes of *4 6 8 and 10* m^3 are included to entertain users' demand for cooking energy and lighting. Due to existing farming practices (= kg of available dung) and limitations to large water requirements, biogas plants over 10 m^3 are not included in the programme.

[5] Typical cooking starts between 6.00 and 7.00 a.m. for porridge, coffee or tea till 9.00 in the morning, and resumes at 10.00-12.00 for *wot* and *injera*. In the afternoon between 4.00 and 5.00 light snacks are prepared, followed by *wot* cooking from 6.00 to 7.00 p.m.

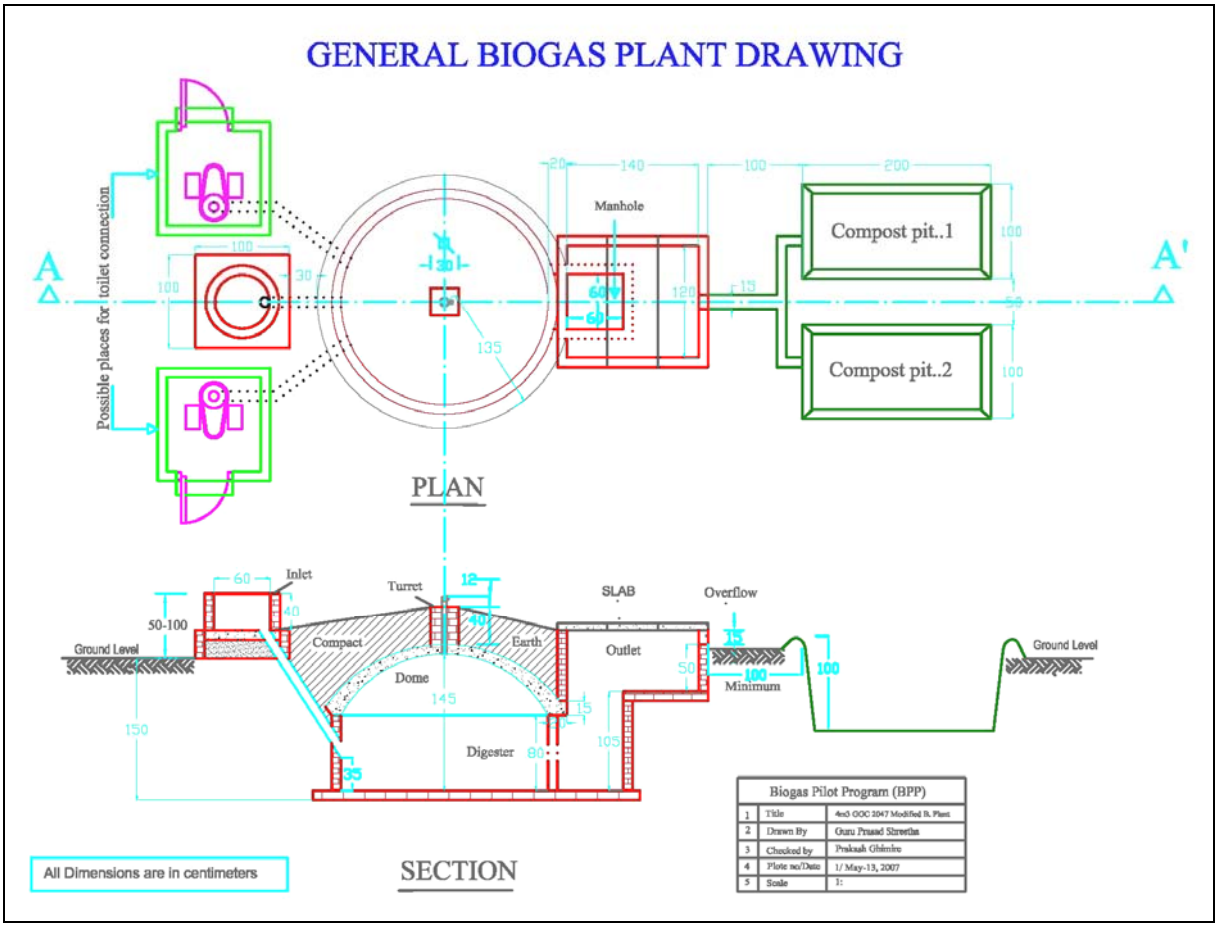


Figure 2 Drawing of the SINIDU Biogas plant for Ethiopia

Toilet connection

Attachment of a toilet to the biogas plant is most advisable to improve the sanitation situation of the households but should be based on willingness. In case the households would refuse to connect a toilet at the present stage, the possibility for making the connection at a later stage will be left open by providing a second inlet pipe during construction. Cooperation will be sought with existing sanitation programmes in popularizing the use of biogas plants for human waste treatment. Currently SNV/Ethiopia is embarking upon a Water, Sanitation and Hygiene programme, thus opening opportunities for cooperation. Anticipating future toilet connection needs, it will be compulsory to install two inlet pipes – one for the main inlet and another for toilet connection, both with a size of 110 mm diameter PVC pipe.

Urine collection

The use of urine improves the fertilizer value of the slurry, enhancing the overall benefits of the biogas plant. Therefore, biogas users are encouraged to construct a simple floor for the collection of urine and be guided into the biogas plant. However, construction of facilities for urine collection remains voluntary.

2.5 Technical and operational issues

Temperature: Climatic issues will hardly limit the potential for large-scale dissemination of domestic biogas. The temperature is sufficiently high enough throughout the year, with possibly some local short cold spells in the highlands. Based on the climatic conditions, different sizes of biogas plants are selected for highland and lowland areas of the country. Even though there are three climatic zones (highland, semi-highland and lowland) in the country, the temperature variation is not significantly altering the production of biogas. The average temperature within the country varies from 20 to 25°C throughout the year due to its geographical location, but night temperature may drop down to 5-9°C or slightly lower during the rainy season in areas with very high altitudes, which does not affect much the daily gas production. Additionally, the temperature fluctuations between day and night are not a great problem for plant built under ground, since the temperature of the earth below a depth of 2 m is almost constant.

Daily feeding: From the technical point of view, a standardized volume digester design is preferred for the programme throughout the country. The daily feeding of the plants is decided by the temperature in the area. Most of the biogas plants will be constructed within a similar temperature zone, resulting in uniform feeding requirements. If the plant is underfed, the gas production becomes very low. It is therefore important to ensure strict enforcement of the correct sizing according to the available collectable dung per day.

Retention time: The size of the digester is determined by the retention time relative to the amount of slurry fed every day. This is also related to the climatic condition of the locality, essentially the temperature. Over 78% of the population lives in the highlands and the average temperature range at these altitudes is 16-30°C—adequate for plants to function throughout the year. In the selected regions most of the population lives in the highlands and therefore only one daily feeding rate is calculated. If the need arises and biogas plants are constructed in the cool and lowland areas adjusted feeding rates will be introduced. At the starting up of the programme this it is not foreseen to happen.
Calculations are based on an average temperature in the highlands of 22.5°C and a rate of gas production per day of 34-37 (l/kg). It is estimated that an average cow produces 10 kg of dung per day and that 50% of the dung can be collected during night stabling. The minimum number of cows required is four. The minimum feeding rate will be 20 kg of dung and 20 litres of water. The active volume of a 4 m^3 digester is 3200 litres, giving a maximum required hydraulic retention time of 80 days. In case feeding exceeds the 20 kg of dung per day, the retention time will reduce accordingly.

Table 12 provides the relation between digester size, feeding, water requirements, cattle holding, and gas production. At this juncture, it should also be noted that actual sizing depends on the actual amount of dung available over a longer period rather than on the number of cattle.

Table 12 Daily rate of feeding, required livestock and estimated stove hours

Plant size in cum	Daily fresh dung (kg)		Daily water (l)		No. of cattle required		Min estimated gas production (l)		Min estimated stove hours (400l/h)	
	min	*max*	*min*	*max*	*min*	*max*	*min*	*max*	*min*	*max*
4	20	40	20	40	4	8	680	1600	1,7	4,0
6	30	60	30	60	6	12	1020	2400	2,6	6,0
8	40	80	40	80	8	16	1360	3200	3,4	8,0
10	50	100	50	100	10	20	1700	4000	4,3	10,0

Quality management

Companies and masons who wish to participate in a national programme and benefit from the contribution to construction cost scheme, promotion, training, etc. will be required to seek recognition from the national and regional programme offices. The pre-qualification is subjected to a series of strict rules, regulations and conditions of the quality standards procedures. An essential part of the biogas promotion strategy will be the quality of the product in combination with adequate rural household support in the form of after sales services that include repair and maintenance as well as feedback on operation to the users.

Appliances

There are about six Regional Technical and Promotions Centres (RTPC) in addition to the Selam Technical Vocational Training School. Two private workshops produce different types of stoves in Ethiopia. Most of them are re-engineering or reverse engineering types and not original designs. The responsibility of selecting biogas appliances that can be included in the programme is mandated to the National Biogas Programme Coordination Office. The office can invite manufacturing companies to participate as manufacturers and suppliers to the programme. Based on their workmanship capacity and commitment on timely delivery, the National Biogas Programme Coordination Office can select the companies and support them to enhance their capacity. The outcome of a research on the performance of biogas appliances[6] will determine the most suitable type of biogas stove and lamp for the Ethiopian NBP.

2.6 Social and cultural issues

Aspects that are often overlooked and should be understood are women's control over household resources and incomes, the influence of men in household decision-making, women's own associations, and how all these issues affect and are affected by rural energy development strategies. It is clear that because of their central role in household energy supply and use, rural women should be at the focus of rural energy development strategies (Goldemberg, 1999). According to Goldemberg *et al.* (Goldemberg et al., 1999), rural energy consumption and production revolves around the household as the basic unit of rural economic activity in almost all developing societies, and the vast majority of household roles, including those relating to energy, fall disproportionately on women.
Women in Ethiopia are marginalized economically, politically and socially. They face multiple forms of deprivation and discrimination including lack of protection of basic human

[6] A research is ongoing whereby the performance of various types of biogas stoves and lamps are studied. Research institutions in India, China and the Netherlands are involved.

rights, violence, lack of access to productive resources, education and training, basics health service and employment (Unknown, 2004). Wives are mainly responsible for child care, food preparation and household management whereby the male dominance is paramount on the use of farm input, hiring of labour, and land allocation. It is however noted that it is not uncommon that decisions are jointly made by both wife and husband (Emirie, 2005). On the issue of financial investment women do not appear to play a major role.

On average women work 13 hours a day and this workload is exacerbated by the scarcity of fuel wood. Girls are often taken out of school to assist their mothers in collecting firewood. To cope with the shortage of fuel wood, households in Tigray use 58,552 metric tonnes of dung for fuel, resulting in an estimated 10% loss in agricultural production (Birhane *et al.*, 2005). Furthermore, the women in the same region spend up to 28% of their labour time for fetching water. As a result of these workloads, women have less time to prepare proper food and often quick meals are consumed, resulting in a loss of nutritional intake. A study on biogas in Al-Habeel village in Yemen (Obaid and Saleh, 1997), revealed that women are the real beneficiaries of biogas through reduction of time spent on colleting firewood, baking, and cooking. Moreover, the gains from the biogas technology in reduced indoor air pollution minimized exposure to open fire and improved health situation. To reduce the amount of water to be collected for operating the biogas plant one option is to collect the urine of the cattle by constructing a concrete floor with collection trough and urine pit. The programme has included the provision of technical advice for urine collection. However, as there is limited experience with the urine collection this option will be kept voluntary.

An encouraging step reinforcing the programme's objective is the Government Policy on Women (NPW) issued in 1993. The NPW recognizes the institutionalization of socio-economic rights of women by creating appropriate structures within the government. Some of the focal areas mentioned in the policy document are poverty reduction and economic empowerment of women and girls, human rights of women, provision of training and education for empowering women in decision making.

From observations, interviews and studies (Eshete *et al.*, 2006b) there is little or no objection to the use of gas generated from animal waste. Any initial objection by prospective plant owners might disappear once the actual use of the gas is experienced at demonstration plants or at plants nearby. More problematic might be the use of biogas and composting of plant effluent when latrines are attached. Therefore, the installation and toilet attachment as indicated earlier remains to be optional.

On the Social Institution and Gender Index[7] Ethiopia ranks similar with Nepal with indexes of 0,368 and 0,39 respectively and higher than Bangladesh whose index is 0,496 (Jütting *et al.*, 2006). With Nepal and Bangladesh being countries with established biogas programmes, it can be assumed that gender should not be a limiting factor in Ethiopia.

[7] Social Institutions and Gender Index (value). A composite index measuring gender inequality in four areas of social institutions: family code, physical integrity, civil liberties, and ownership rights: 0=no, 1=high inequality.

The proportion of female borrowers in the Ethiopian microfinance institutions varies from 19.5% to 76.1%, with an average of 46.3% for 2004—a 3% decline of women borrowers as compared to the 2003 data (Anebo, 2006). As women are the main beneficiaries of biogas, the proportion of women borrowers is expected to increase. The NBP shall therefore cooperate with AEMFI and individual MFIs and SACCOs to improve the lending by women. Additionally SNV will make a part-time MFI advisor available with the main responsibility to develop micro-credit for biogas and particularly focusing on women.

To maximize the benefits of this renewable energy technology for the households and in particular for the women, the national programme will allocate sufficient resources. The NBP will also jointly address the gender divide by identifying activities that include awareness creation of stakeholders and actors, training on gender and energy, conduct gender audit, and capacity development.

2.7 Financial and economic analysis

Finance

One of the main constrains for the dissemination of biogas technology in Ethiopia is the high investment cost associated with the installation of a biogas plant (EREDPC, 2006). In the past large sized biogas digesters (16 m^3 and more) were constructed to accommodate the high energy demand required for baking *injera*. Due to this high energy demand, the cost of construction increased accordingly.

A study on household energy consumption revealed that 31% of the total energy is consumed for *injera* baking while the remaining 69% is used for non-*injera* end-uses (Lulie and Shanko, 1999). On average *injera* baking takes place 2-3 times a week. This requires a high peak demand for energy. In the case of biogas, this would mean that a large storage capacity is required to store biogas for *injera* baking thus adding to the cost of construction. In addition, there are technical constrains related to *injera* baking using biogas. *Injera* is preferred to be baked on a 60 cm clay tray *(metad)*. Large biogas stoves have been produced to provide the required energy for this purpose. However, these biogas stoves did not fulfil the intended purpose due to inability to evenly distribute the heat. As a result, energy from biogas for baking *injera* is not favoured and is not yet considered as a mature technology. It is concluded by the study team that biogas for *injera* baking is still imperfect. Consequently, the size of the biogas plants shall be reduced to meet the energy demand for non-*injera* end-use with substantially lower construction cost.

Investment cost

The average cost[8] of a stone and brick-built biogas plants based on July 2007 market prices[9] is ETB 6,978 and ETB 10,182 respectively (see annexes for detailed cost breakdown) as shown in Figure 3. This is a 20% rise compared to the price level in February 2006 and is mainly associated with the increase in price for cement and fitting materials. It can be expected that the price of cement reduces in the future as new cement factories are expected to open. It is, however, unlikely that the price of cement will return to its 2006 price level. The present

[8] This is the average cost of a 4, 6, 8 and 10 cum biogas plant.
[9] Average price calculation of cement in Mekele, Bahir Dar and Awassa (July 2007).

inflation rate of 18% is the cause for the price increment of fitting materials. It is expected that the inflation level will lower, possibly to a one digit figure (IMF, 2007).

The average cost of a biogas digester based on July 2007 prices is then ETB 8,580. Compared to the price calculation at the time of the feasibility study the average cost of construction of a biogas digester has increased by ETB 1444.

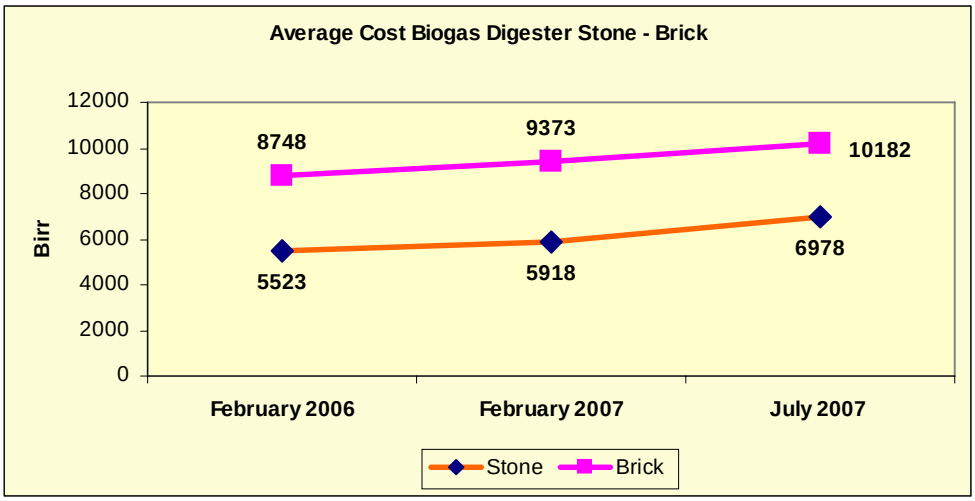


Figure 3 Cost price development of an average biogas plant

The cost of a biogas plant has increased due to the price increment of cement and general inflation, and the assumption that 50% of the biogas plants will be constructed with stone and the other 50% with bricks. Initially it was assumed that 100% of biogas plants could be constructed with stone masonry. This is valid for the Tigray and Amhara regions. However, for the Oromia and SNNP regions it is expected that most of the biogas plants will be constructed with bricks. The exact stones:bricks ratio can only be determined when the actual construction commences. Therefore the assumed stone:brick ratio of 1:1 seems justified for the start-up phase of the programme.

The financial analysis (Table 13) shows the difference between a situation with and without contribution to construction cost on the payback back period, net present value (NPV) and financial internal rate of return (FIRR).

Table 13 Overview financial analysis[10]

	Brick build biogas plant				Stone build biogas plant			
	4 cum	6 cum	8 cum	10 cum	4 cum	6 cum	8 cum	10 cum
Estimated Inv Cost (Birr)	8076	8965	11007	12679	5565	6074	7615	8657
Pay pack period								
Without Investment Incentive	19,5	8,8	7,0	6,0	11,2	5,4	4,5	3,8
Investment Incentive	13,1	6,2	5,6	4,8	5,6	2,9	2,9	2,6
NPV								
Without Investment Incentive	€ 2.544-	€ 328-	€ 604	€ 1.948	€ 251	€ 2.886	€ 4.374	€ 6.418
Investment Incentive	€ 146-	€ 2.069	€ 2.642	€ 4.342	€ 2.648	€ 5.286	€ 6.774	€ 8.818
FIRR								
Without Investment Incentive	3%	11%	13%	16%	13%	23%	25%	29%
Investment Incentive	11%	20%	19%	22%	32%	45%	41%	43%

Despite the high investment cost for the installation of the larger biogas plants (8-10 m^3) the financial indicators show a more favourable situation as compared to the installation of the smaller size biogas plants (4-6 m^3). This is due to the amount of produced biogas in relation to the financial values of 1 m^3 of biogas. The larger the biogas plant, the larger the financial returns. The investment for the 4-6 m^3 biogas brick-made plant shows less favourable financial indicators. Without an contribution to construction cost it is unattractive to invest in biogas in particular for the smaller sized biogas plants.

Based on the experience from countries that implemented national biogas programmes, 6 m^3 biogas plants are the most commonly sizes used in construction. From observations it is identified that an average rural household in Ethiopia would have sufficient dung to feed a 6 m^3 biogas plant, and that there is a demand for cooking energy and lighting. The 6 m^3 biogas plant would fulfil this need.

The average-sized biogas plant[11] of 6 m^3 would require a total investment of ETB 7519. With an own contribution of ETB 810 by the rural household and an contribution to construction cost of ETB 2400 the remaining investment cost is ETB 4,309. Without the contribution to construction cost, the FIRR is 16% and with the FIRR over a 10 year perspective it would be 29% as shown in Figure 4. With an estimated average loan amount of ETB 5000.00 the rural household would qualify for microfinance under the current lending schemes of MFIs. A lower contribution to construction cost would reduce the FIRR to less than 29% and is considered too low for a rural household to invest in biogas. It is therefore justified to introduce a contribution to construction cost of ETB 2,400 (~ € 200). A lower contribution to construction cost would increase the financial benefits for the smaller sized biogas plants. A higher contribution to construction cost would minimize the level of the rural household's own financial contribution and reduce to level of ownership as the technology is offered at a too low cost.

[10] Discount rate 18%; average loan of ETB 5500, two year pay back; value biogas € 0.35 cum gas.
[11] For this calculation the stone/brick of 6 cum biogas plant is referred to.

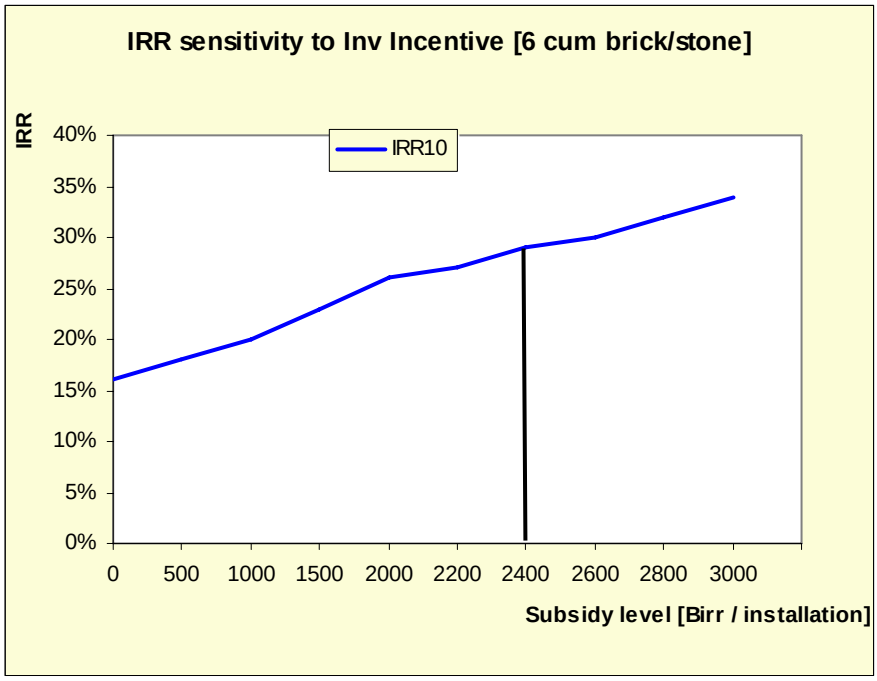


Figure 4 IRR sensitivity

By comparing the average 6 m^3 biogas with the average of 4 6 8 10 m^3 biogas plant it is observed that the financial indicators have similar values, underlining the assumption that a 6 m^3 biogas is representative for financial and economic calculations.

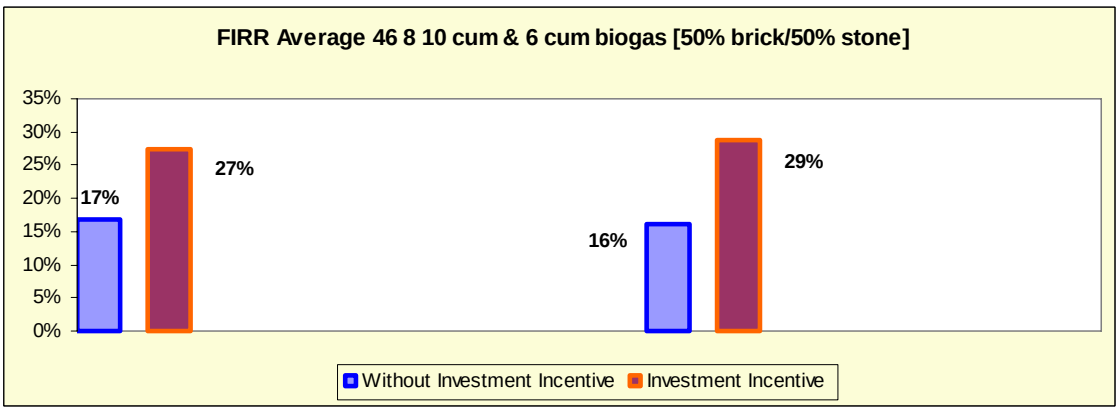


Figure 5 FIRR development

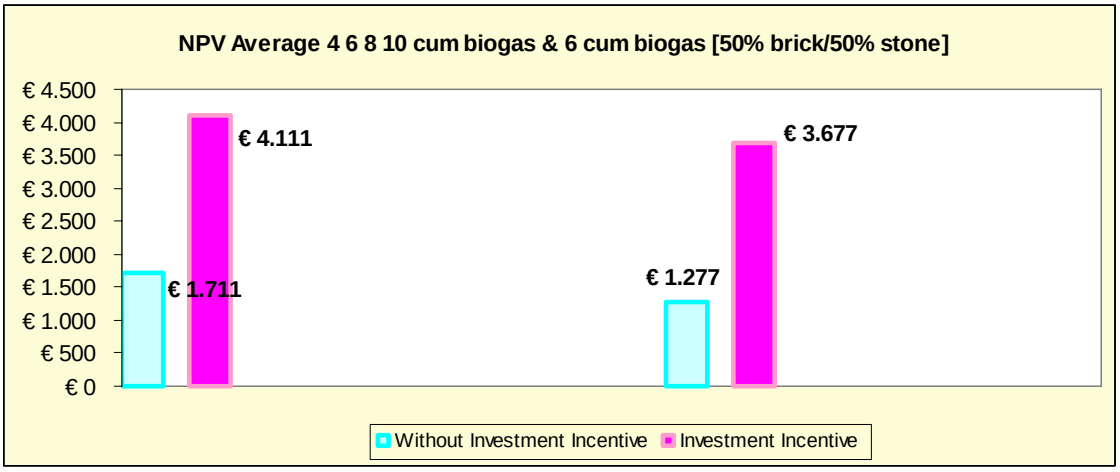


Figure 6 NPV development

Figure 7 presents the financing scheme for the investment for a 6 m^3 biogas plant.

Financing scheme for biogas plant type *Sinidu* 6 m^3		
Average cost brick/stone		
Rural household contribution	810.00	
Supplied materials	4,646.50	
Technical services	630.00	
Company fee	1,332.63	
Programme fee	100.00	
Total investment		**7,519.13**
Own contribution	810.00	
Subsidy	2,400.00	
Remaining investment		**4,309.13**
Annual repayment	**4,826.22** [ETB/annum]	
Monthly repayment	**402.19** [ETB/month]	
Financing costs	517.09 [ETB]	

Figure 7 Overview of a financing scheme for an average biogas plant (6 m^3)

Economic analysis

Based on the findings of the feasibility study for a National Biogas Programme in Ethiopia, other secondary data, and primary data collected from the field, a cost-benefit analysis was conducted for Ethiopia, Rwanda, and Uganda (Renwick *et al.*, 2007). For the financial analysis, calculations were made for an "average household" based on the average cost and benefits of a 6 m^3 biogas plant. Assumptions were also made that 25% of the households would purchase firewood, 75% would collect fire wood, and 50% would adopt a latrine.
The study concluded that, for Ethiopia, with the initiation of phase I of a NBP and the construction of 10,000 biogas plants, the economic internal rate of return (EIRR) would be 78%. In other words, for every ETB invested in the programme the economic return will at least be ETB 40.00 (€ 3.3). According to Mendis and Nes (Mendis and Nes, 1999), it is reported in other studies that the EIRR of a national biogas programme is in the range of 30-50%. It is however noted that the EIRR calculations made by Renswick *et al*. (2007) are based on the February 2006 price level and that with the July 2007 price level the value of the EIRR will be reduced to some extend. Even then, it is concluded that a NBP will yield economic benefits for society as a whole and that a public financial investment is justified. Based on these findings it is concluded that it is justified to encourage rural households to invest in domestic biogas.

2.8 Institutional issues

Based on proclamation No. 256/2001, which provides for the reorganisation of the executive organ of the Federal Democratic Republic of Ethiopia, the Ministry of Mines and Energy is mandated to handle all the energy sector issues in the country. The institutions organized under the Ministry of Mines and Energy are also mandated to execute certain functions related to energy on the basis of their own proclamation.

- The Ethiopian Electric Power Corporation (EEPCO) is a public utility organisation responsible for generating, transmitting, distributing and selling electricity in the country. It is established by Council of Ministers Regulation No. 18/1997 to perform the above mentioned duties. The lion's share of EEPCO's electricity generation is based on hydropower.
- The Ethiopian Petroleum Corporation is mandated to import and distribute to retailers oils and oil related products. This is established by Council of Ministers Regulation No. 210/1987.
- The National Petroleum Reserve Depots Administration established by proclamation No. 82/1997 is mandated to store and administer the petroleum reserve of the country to maintain regular supplies in case of interruption or shortage of petroleum.
- The Ethiopian Electricity Agency is mandated to supervise and ensure that the generation, transmission, distribution and sale of electricity are carried out in accordance to regulations and directives issued. It also mandated to issue professional certificates and licenses for electric generation by proclamation No. 86/1997.
- The Ethiopian Rural Energy Development and Promotion Centre is mandated to make conditions convenient for the development and promotion of rural energy resources, and energy technology development and adoption. These power and duties are given to the Centre by proclamation No. 269/2002. Additionally, the Centre is given a mandate of executive secretariat for off-grid rural electrification by proclamation No. 317/2003.
- The Ministry of Agriculture and Rural development (MoARD) – a ministry established in 2003 – is responsible for initiating rural development policies, ensuring that conducive conditions for development are created, supporting regions in expanding agriculture and rural development as well as monitoring the food security programmes and responding to emergencies through the Disaster Prevention and Preparedness Commission (DPPC).

Efforts have been made to reduce duplication and bridge gaps through clarification of the ministries' mandates and reallocating certain works. The bringing together of rural development and agriculture under one roof has helped both EREDPC and MoARD to concentrate on the demand and supply sides of energy respectively (Eshete *et al.*, 2004b).
The aim of the NBP is to build on and further develop existing institutions and organisations for the continued and sustained viability of the sector beyond the duration of the pilot phase. It will seek the involvement of existing government institutions, (I)NGOs, financial institutions, and the private sector. If there will be a structural and long term involvement of these parties, both financial and advisory support can be provided by the programme to enhance the capacity of the involved parties to continue activities in a more sustainable manner.

2.9 Capacity development

Over the past decades, staff of government line agencies, (I)NGOs, and the private sector have been trained and involved in the promotion and construction of biogas plants. However, due to the low rate of dissemination, the promotion of biogas is for most institutions a marginal activity. Moreover, the dissemination approach was on a demonstration basis and a variety of biogas plant designs were used for construction. The existing experience and knowledge on biogas is diverse and difficult to assess. With an approach to mass dissemination of domestic biogas that has distinct programme functions, including standardization and quality management, there is an immediate demand for capacity development. The NBP will within the first phase of the programme develop sufficient capacity to implement the required programme functions. As much as possible the programme will work with existing capacity development institutions, training centres, consultants, etc. The NBP will be instrumental in developing relevant training materials and coordinate activities related to capacity development. Details on capacity development and training are presented in the next chapters.

2.10 Awareness and promotion

Besides a number of individual projects by government agencies and NGOs, there is currently no uniform national approach to create awareness and promote the benefits of domestic biogas technology. Creating awareness was incorporated in the stakeholders' consultation process with the aim to introduce the concept of sector development for a domestic biogas programme. On the basis of this information respondents were in a better position to assess the relevance of participating in a NBP. However, the outreach of the awareness created during the stakeholders' consultation was limited, and additional activities are required to create a wider awareness about the domestic biogas technology. In the absence of a national strategy to promote biogas amongst potential users, a promotion campaign will be developed at the national level in consultation with the regional states.

3. DESIGN FOR A NATIONAL BIOGAS PROGRAMME

3.1 Main objectives

The overall goal of the NBP is to improve the livelihood and quality of life of rural households in Ethiopia through the exploitation of market and non-market benefits of domestic biogas such as replacement of unsustainable utilization of wood and charcoal for cooking and lighting; use of the high value organic fertilizer from the bio-slurry; and improvement of health and development conditions for rural households.

The **main objective** of the first phase of the Programme is to develop a commercially viable domestic biogas sector in Ethiopia.

3.2 The Specific objectives are to:

- attract and strengthen institutions and organizations for the development of a national biogas sector;
- construct 14,000 biogas plants in the four selected regions over a period of 5 years;
- ensure continued operation of the biogas plants installed under the NBP;
- maximize the benefits of all biogas plants installed.

The direct targets are to ensure that:

1. 90% of all biogas plants installed use indoor cooking facilities.
2. 80% of all biogas plants installed will have double slurry pits.
3. 50% of all biogas plants installed have attached toilets.

3.3 Linkage of programme objectives to government objectives

To improve the energy supply and efficiency of energy utilization, the Government of Ethiopia has formulated a national energy policy in 1994. The national Energy Policy recognizes the importance of energy as a means for sustainable development and is geared towards addressing the basic needs of every household in Ethiopia. The general objectives of the policy are to:

a) ensure a reliable supply of energy at the right time and at affordable price, particularly to support the country's agricultural and industrial development strategies;
b) streamline and remove bottlenecks that are encountered in the development and utilization of energy resources;
c) set general guidelines and strategies for the development and supply of energy resources;
d) give priority to the development of indigenous energy resources with a goal towards attaining self-sufficiency;
e) increase energy utilization efficiency and reduce energy waste;
f) ensure that the development and utilization of energy is environmentally friendly.

The feasibility study on domestic biogas in Ethiopia (Eshete *et al.*, 2006a) identified a link between biogas and the UN-Millennium Development Goals and the Plan for Accelerated and Sustained Development to End Poverty (PASDEP). The findings are presented in the annexes.

3.4 Programme strategy and set-up

Several reasons are identified for the limited penetration of domestic biogas in Ethiopia.

- The use of bricks and metal gas holders and non-local materials increased the cost of construction.
- Biogas plants are oversized in relation to available amounts of dung.
- Rural households' awareness about operation and maintenance of the biogas plants is limited.
- Rural households' awareness of the full range of benefits of biogas is limited.
- Availability of water is inadequate.
- Investment costs are high.

Additionally, the common approach for dissemination is project-based without follow-up structure in place, variation in biogas designs, and absence of a standardized biogas technology.

To overcome these issues a market-oriented approach is proposed wherein the user of the biogas technology is central. The users require information about the benefits of biogas technology, including financial incentives and benefits, installation and maintenance costs, operational issues, guarantee and after-sale service, contribution to construction cost, support structure, quality assurance and durability. Based on transparent information the users will be in a position to make an investment decision. Biogas technology can then be supplied through the private sector. Through competition, the potential users will benefit form reduced cost while the private sector can be ensured of growing business opportunities through an increasing demand for biogas technology.

For the dissemination of biogas, a support structure will be developed to enable the private sector to supply biogas technology to potential users. The support structure will provide an contribution to construction cost to promote biogas technology, enable access to microfinance, support promotional and extension activities, and ensure that a minimum level of quality is maintained related to the product and service delivery so as to safeguard the reputation of the technology.

The dissemination of domestic biogas is through a multiple stakeholders approach whereby institutions and organisations with a link to biogas take up roles and responsibilities based on sound institutional arrangements. Institutions at the national and regional levels will coordinate the activities of multiple stakeholders as shown in Figure 8.

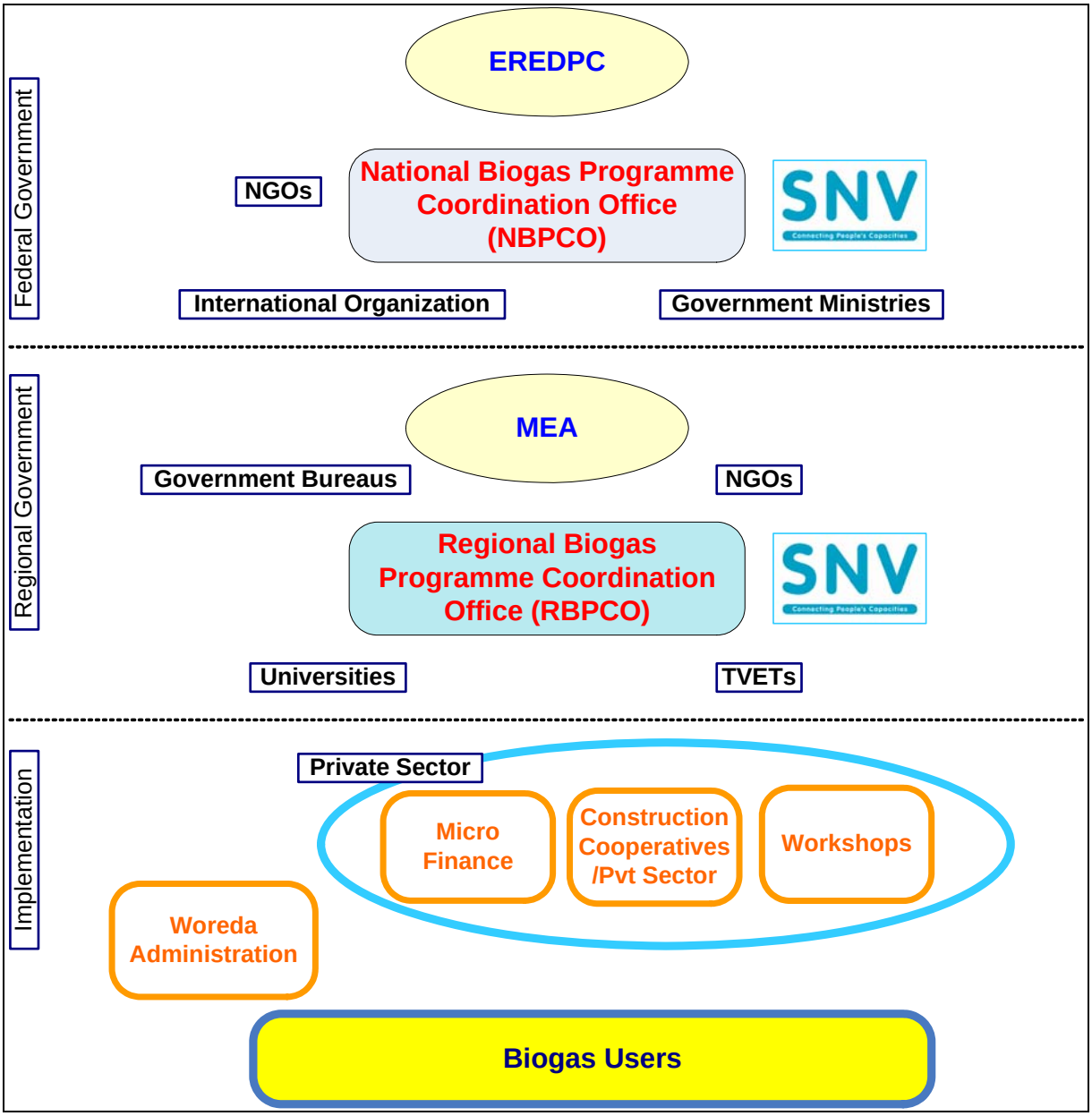


Figure 8 Stakeholders constellation

The expected results of the first phase of a national biogas programme are:

- a significant number of stakeholders involved in the programme; more than 30 stakeholders per region have expressed interest in participating in the programme;
- strengthened institutions and organisations that are devoted to the development of a national biogas sector.

With these it is expected to achieve the following:

- increase the number of families with access to biogas technology by 14,000 in the first phase of the NBP;
- save 2 to 3 hours workload per household per day particularly for women;
- improve the health of rural household as a result of reduced indoor air pollution and attached toilets;
- gain the economic benefits for the country with EIRR of 78%;
- raise agricultural production by up to 40%;
- create new jobs; by the end of phase I, at least 20 private companies will have constructed biogas plants in 28 *woreda*s and it is expected that every company employs at least 10 people;
- reduce the use of fossil fuels;
- save 2190 kg of wood per year per household;
- contribute to the reduction of greenhouse gas emissions by an estimated 4.5 tonnes of CO_2 per household per year per biogas plant.

4. ACTIVITIES

For the development of a biogas sector in close cooperation with multiple stakeholders, a minimum number of functions are to be implemented. The required functions for a National Biogas Programme are presented in Figure 9.

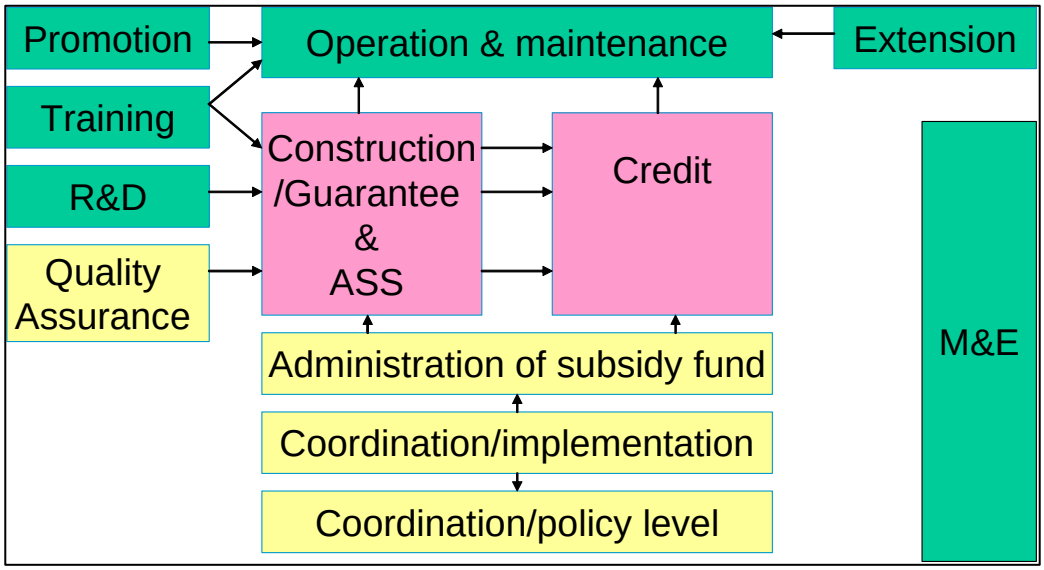


Figure 9 Functions for a National Biogas Programme

To identify the willingness of potential stakeholders in a National Biogas Programme an extensive stakeholders' consultation was undertaken. The outcome of the stakeholders' consultation is used as an input for the institutional framework in the NBP. The findings are presented in chapter 5 under institutional arrangements.

4.1 Promotion and marketing

To increase the number of plants by 14,000 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. However, presently there is a very limited involvement of the private sector towards the construction of domestic biogas. It can therefore not be expected that the private sector can take up this responsibility right from the beginning. Support for the promotion of domestic biogas technology is required during the pilot phase.

For the promotion of biogas a wide network is required. It is estimated that at least double the potential users have to be reached in order to lead to the installation of 10,000 biogas plants. Government institutions, NGOs, the private sector, the mass media, microfinance institutions and cooperatives will be mobilized for the promotion of biogas. Existing biogas users as well as owners of working biogas plants will be approached to assist in the further promotion of biogas.

The national and regional Biogas Programme Coordination Offices will develop and distribute promotional packages like posters, pamphlets, leaflets, etc., highlighting the benefits, cost services and programme arrangements. Other promotional activities like the production of information videos, information through the mass media, organizing orientation training for relevant organisations, participation in exhibitions and production of information booklets. Promotional activities will not only target potential users but also the general public and staff at decision-making level to create a broad awareness on the potential of biogas technology in Ethiopia.

In Ethiopia, approximately 50-60% of the biogas plants that were constructed in the past are non-operational (Centre, 2006), with fixed dome biogas plants functioning better than floating drum models (Eshete *et al.*, 2006a). This implies that potential users may associate biogas technology with a negative image. Promotional activities should therefore integrate quality and benefit concerns.

4.2 Training

Being a new programme that incorporates a new technology and a new approach towards dissemination, training is vital for smooth implementation. Therefore, the programme will invest considerable resources in training. Training will on the one hand focus on the demand side, ensuring that users are capable to operate and maintain a biogas plant. On the other hand, training will focus on the supply side whereby a significant number of masons and supervisors will be trained to make them capable of delivering the correct technology to the users, thus resulting in faultless operation.

Training coordination is the responsibility of the national and regional Biogas Programme Coordination Offices. Users are trained through existing extension networks, and existing training institutions are responsible for training masons and supervisors.

The training costs will be borne by the programme for courses pertaining to the annual programme, user groups and extension trainings. For other courses, where feasible, a contribution will be requested from concerned companies and banks for the training courses. The following training courses and targets are scheduled.

Mason training

Training of masons will have a high priority as masons are the backbone of the programme. Besides the technical part of the training (construction, maintenance and repair), masons will be trained in promotion (how to attract new clients), plant sizing and selection, user extension (how to explain to the user operation and maintenance tasks, including trouble shooting and small repairs) and handling feedback from users. The training is divided in two parts: 10 days training at regionally located TVETs, and a 10-20 days training (the time required to complete two plants) at field level.

Mason refresher training

Trained masons who are active in the biogas construction will receive refresher training. Preferably every mason should get such training one year after completion of his mason training. If the quality of a mason's work is not good enough, additional training can be made compulsory.

Supervisor training

The biogas companies have the final responsibility of the construction of biogas plants while BPCO staff will perform quality control work on sample basis on behalf of the programme. Therefore, both organisations will have supervisors who can inspect the plants on quality and, if necessary, instruct the masons on improvements to be made. The supervisors will be trained at the TVETs in inspection and quality control.

Supervisor refresher training

Like the mason refresher training, also here active supervisors will be invited to attend a refresher course one year after completion of their supervisor training. During this training the participants acquire a more in-depth understanding of the programmatic aspects of biogas plant technology.

Training of quality inspectors

Biogas technicians at the national (NBPCO) and regional (RBPCO) levels will primarily be responsible for technical issues and quality management. Biogas technicians will receive training through a special training programme based on various modules.

Staff of Regional Biogas Programme Coordination Offices

The RBPCOs will be responsible for the planning, implementation and reporting of the programme at regional level. Additional support will be necessary form staff of the Mines and Energy Agencies. Workshops/training will be organised to introduce the programme to the staff and provide training on proceedings and regulations. In addition to regular programme issues, staff of RBPCOs will be trained in database management, plant identification and location system (PILS), quality management and other relevant topics.

Woreda and *kebele* extension workers training

At *woreda* and *kebele* level extension workers will be trained on the promotional aspects of biogas as well as the utilization of bio-slurry. The training will be facilitated by the staff of the RBPCOs.

Managers' training

RBPCOs and company managers of construction cooperatives and private companies will be trained in business management, marketing, promotion, quality management, programme management and related issues. Training in business planning and development will be organized by the RBPCOs in cooperation with the Small Micro Enterprise Development of Bureaus of Trade Tourism and Industry.

Study tours

Study tours in the eastern-African region and beyond will be organised for people working in the sector to learn from experiences elsewhere.

MFIs, banks, (I)NGOs and line agencies extension and promotion training

Extension staff of financial institutions, (I)NGOs and line agencies (agriculture, forestry, health, women affairs) are expected to play a role in the promotion and use of biogas plants. Staff of these organisations will be trained on the basics of biogas, the roles of the different actors, quality standards, and how to promote and extend biogas plants to potential users.

Pre-construction user training (1 day)

During this training, potential users will be explained what the advantages and disadvantages of biogas plants are. A strong focus will be placed on the input requirement for feeding the biogas digesters and on the financial consequences. Also, it will be explained what the procedures are if people want to acquire a plant under the programme.

Post-construction user training (1 day)

The functioning of a biogas plant and its overall efficiency is for a large part determined by the user's operation and maintenance of the plant. Apart from the instructions from masons and supervisors, groups of (mainly) female users will be trained on how the plant works, what output can be expected, how to use the effluent and what maintenance activities are required.

Training of trainers of users

The trainers of the user trainings will be trained on how to extend the users on the operation and maintenance of the plants and on cooking practices and conditions for maximum effectiveness. Training of trainers is provided to staff of TVETs and other vocational training centres.

Gender and energy training

To strengthen gender integration already at the present stage a provision will be made for gender analysis at all stages to verify how gender relations impact on the programme. Gender analysis can be integrated with the energy baseline survey and other studies to be conducted. Gender training will be included training in the programme to ensure that staff and management are gender-sensitive on the one hand, and to avoid putting all the responsibilities of mainstreaming gender on a gender specialist on the other hand. The programme expects and will provide for gender-balanced representation in committees and boards.

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 the usefulness of biogas. In this regard, training related to gender strengthening, dealing with banks for borrowing and repayment of loans, income-generating activities linked to biogas, health and sanitation improvement and plant operation and maintenance will be essential. These training activities will largely be contracted out to appropriate and recognised training institutes and NGOs.

4.3 Quality management

An essential part of the biogas promotion strategy will be the quality of the product in combination with adequate rural household[12] support in the form of after-sale service, repair and maintenance as well as feedback on operation to the user. Furthermore, a well-functioning plant is the best possible promotion and a satisfied user is the best biogas promoter. Additionally, through quality management, the user's investment is safeguarded, enabling full benefit of the investment and ensuring an incentive for timely fulfilling the credit requirements. Therefore control of the quality regarding plant sizing, construction, after-sale service, and user training is important.

Quality management will be the responsibility of the national Biogas Programme Coordination Office whereby responsibilities will be delegated to the RBPCOs. The inspection report will be presented in a format that will then be put in a database for future monitoring. Masons and/or companies showing less than satisfactory performances will be required to upgrade their skills. If the poor performance is persisting they will be eliminated from the programme. During the first year at least 50% of the biogas plants constructed will be controlled on quality of construction and service delivery. Gradually the plants will be controlled based on a random sample. The minimum required random sample size is 5%.
Construction cooperatives and private companies require pre-qualification to participate in the National Biogas Programme. The NBPCO and RBPCOs are responsible for ensuring that the following conditions for pre-qualification are met:

- approval of standard design and sizes of biogas plants
- availability of trained, certified and registered masons for the construction of biogas plants
- construction of biogas plants on the bases of detailed quality standards
- provision of NBPCO approved quality biogas plant appliances (pipes, valve, stove, water tap, lamp)
- proper user training and provision of a user instruction manual
- provision of one year guarantee on appliances and two years guarantee on the civil structure of the biogas plant, including an annual maintenance visit during the guarantee period
- timely visit by a technician to the biogas plant in case of a complaint from the user
- proper administration
- documentation of these conditions in an agreement.

[12] The terms "rural household", "farmers" and "user" are interchangeably used and refer to the family owning a biogas plant.

After-sale service is an integral part of the product. After-sale service includes proper instruction of the user on the operation of the plant and maintenance as well as a guarantee of one year on appliances and two years on the civil structure of the plant. The guarantee provision includes at least two visits with an annual interval, starting six months after the completion of the plant. User instruction will include the following aspects of plant operation and maintenance:

- proper feeding of the plant
- proper use of biogas plant
- simple regular maintenance such as cleaning of the burner, changing the mantle of the lamp, and use of the water tap
- proper use of the plant effluent
- cooking habits and cooking environment.

The above mentioned topics are all equally important for an effective use of the plant and its outputs, and for the overall impact of the biogas plant programme. The training of users, including some simple trouble shooting, will therefore get due attention. This will be a task for biogas plant 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.
Besides training of the users during construction work, commissioning of the plant and maintenance visits, new plant owners will be invited to participate in a one-day post construction user training organised by the RBPCOs. During this training the emphasis will not only be on operation and maintenance but also on financial aspects and owners' rights. Initially users can register complaints with the construction cooperative or private companies, which are responsible for attending to users' complaints. In case a user complaint is not dealt satisfactorily, the RBPCO can be contacted. The RBPCOs will open a complaint register and ensure the users' complaints are duly attended to.

User instruction manuals (user owners' manuals) will be developed and distributed to the users by the construction cooperatives and private companies.

Plant Identification and Locations System (PILS)

To record the position of every biogas plant constructed under the NBP and be able to relocate the position during quality controls, after-sale service or other follow-up visits to the plant, global positioning system (GPS) coordinates of each biogas plant will be registered. Initially, staff of the regional BPCO will record the GPS coordinates and gradually this responsibility will be transferred to the construction cooperatives. The GPS information is also vital for plant verification and promotional purposes. The NBPCO is responsible for the implementation of PILS, with specific tasks delegated to the RBPCOs.

4.4 Research & Development

Applied research is required to improve the programme, further refine biogas benefits and adaptation to changing circumstances. The following activities are identified:

- development and testing of new, and alterations to, biogas designs and applications in co-operation with biogas companies and manufacturers of appliances in order to make them more efficient and better adapted to the rural household;
- solving technical problems related to the construction, operation, maintenance and repair of biogas plants including the appliances;
- standardisation of designs of biogas plants and appliances (gas tap, stove, water taps) as well as construction and manufacturing methods;
- cost reduction of biogas installations;
- improving the efficiency of biogas plants (gas production and utilisation);
- research to support extension (and the development of extension materials) on the optimal use of composted slurry as fertiliser.

In addition to the more technical R&D mentioned above, research on programme activities will be conducted, including:

- a survey of the status of household energy and disposable income
- a survey on the status of existing biogas plants, including assessing rehabilitation prospects
- surveys to analyse willingness and ability to pay and to determine effective demand
- studies on why rural households do not install biogas plants
- a study on the linkages between biogas and deforestation
- a study on the linkages between biogas and health
- user surveys to study field experiences especially in relation to the impact on women
- a study on appropriate micro-financing systems (credit and loan groups)
- evaluation of the performance of financial institutions in credit provision for biogas plants
- evaluation of loan repayments
- evaluation of systems on the quality of after-sale service
- evaluation of trainings such as female biogas users group training and extension activities
- assessment of 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 (wood, dung, crop residues, etc.) and chemical fertilisers and the impact on crop production and the reduction of CO_2 emissions.

Research and monitoring and evaluation activities will be done by capable research institutes, biogas companies, and consulting firms on the basis of project proposals and ToRs developed by the national Biogas Programme Coordination Office.

4.5 Monitoring and evaluation

Monitoring

Overall progress monitoring of the programme is the responsibility of EREDPC. Day-to-day monitoring will be done by the national and regional BPCOs to ensure sound quality of construction and service delivery. Additionally, EREDPC, national and regional BPCOs should ensure that stakeholders perform their roles as per agreement. The RBPCOs regularly (monthly, bi-annually and yearly) report to EREDPC.

For monitoring and evaluation EREDPC, MEAs, and national and regional BPCOs will monitor progress using the indicators presented in Table 14 and as per the logframe presented in annex 7.

Table 14 Indicators for programme monitoring and evaluation

Activities' indicators	*Targets*
Biogas plants constructed according to national standards:	
• *number*	• *minimum 75% achievement*
• *construction defaults*	• *maximum 10%*
Operation and maintenance:	
• *functioning rate*	• *more than 90%*
• *utilization of plant capacity*	• *minimum 80%*
• *users training*	• *minimum 75% (at least 75% female)*
Institutional development:	
• *number of construction cooperatives/ companies*	• *at least 12 companies*
• *number of appliance manufacturers*	• *at least 1 manufacturer per region*
• *number of biogas credit providers*	• *at least 2 credit providers per region*
• *management training*	• *relevant bank and company staff trained*
Maximization of benefits:	
• *improved sanitation*	• *50% of beneficiaries have toilet connection*
• *saving of fuel wood*	• *2190*[13] *kg/household/year*
• *reduction of workload*	• *912 hrs/household/year*
• *proper use of slurry*	• *70% of the biogas users*

The following studies will be required to collect and classify comprehensive information on the impacts and effectiveness of the biogas programme:

- energy baseline survey to identify the current status of household energy
- biogas users surveys to get a clear view of the acceptance and appreciation of biogas plants from the users' perspective (yearly)
- biogas plant cost survey (including access to loans for biogas development) (yearly)
- training evaluation (yearly)
- appraisal of slurry utilization and its effectiveness on crop/vegetable production
- environmental impact study.

[13] Indicative.

Evaluation

An annual internal assessment will be done by the end of the year to review the progress and suggest recommendations for the formulation of the next annual plan. A mid-term evaluation towards the end of the second year of the programme and a final evaluation during the course of the fourth year of the programme are planned for. These evaluations will be carried out by an independent consultant who will provide recommendations for improvement of the programme. The outcome of the final evaluation will provide information for the formulation of the second phase of the national biogas programme.

4.6 Institutional support

The National Biogas Programme will provide support to strengthen partner organisations involved with the dissemination of domestic biogas. These include institutions from the public, civil and private sectors. Both financial and technical support can be provided. Technical support is delivered through the advisory services of existing governmental institutions, local capacity builders and international organisations. Institutional support is based on proposals submitted to the concerned parties.

4.7 Extension

The programme will initiate a slurry extension programme, which will amongst others include sponsoring extension workers to active biogas companies. Follow-up and extension of this programme will be required, as this issue will be important for the economic feasibility of biogas plants, hence for the success of the programme. Use of the biogas plant effluent has to be an integral part of the plant's overall use. Direct use of the bio-slurry is preferred. If this is not possible compost, digging pits will be made compulsory. The programme will conduct research on how effluent use can optimise the benefits of the digester. Extension materials will be developed and distributed, and agricultural extension staff will be trained on the most beneficial effluent use.

4.8 Gender mainstreaming

Since women are primary energy users and managers, 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 them to become empowered and sustain the whole biogas system.

The role of women in the biogas sector in Ethiopia will be enhanced by involving rural women in the programme as decision-makers, as individuals or through existing institutions. Hence, women will be involved in adapting the technology and in selecting the appropriate plant sites. As primary users, women will be familiarized with the function of biogas plants,

proper method of feeding dung and water, the procedure for removing water from the pipeline, methods of cleaning stove components and minor repairs.

Taking the above facts into consideration, a detailed plan for gender mainstreaming will be prepared and put in operation with the assistance of gender specialists. This is likely to be supported by SNV/Ethiopia.

5. INSTITUTIONAL ARRANGEMENTS

The EREDPC is responsible for monitoring and evaluation of the National Biogas Programme. The responsibilities for day-to-day management of the NBP are delegated to the national and regional Biogas Programme Coordination Offices in the four selected regions. SNV-Ethiopia and other local capacity builders provide technical assistance through advisory services, resource mobilisation and knowledge brokering. Figure 10 illustrates the institutional arrangements.

5.1 Role of national stakeholders

5.1.1 ROLE OF THE MINISTRY OF FINANCE AND ECONOMIC DEVELOPMENT (MOFED)

For the financing of the National Biogas Programme the federal government's contribution will be requested from MoFED by EREDPC and the Ministry of Mines and Energy. The expected contribution from the federal government will be towards the contribution to construction cost and programme management for the NBPCO. Additional funds for contribution to construction cost and programme management are expected from an external donor in the framework of the Biogas Africa Initiative. The donor funds will be channelled through MoFED to EREDPC and the National Biogas Programme and Coordination Office. Other responsibilities of MoFED are:

- to include the National Biogas Programme in the regular budget planning
- impact monitoring
- timely disbursement of programme funds.

5.1.2 ROLE OF THE MINISTRY OF MINES AND ENERGY (MME)

The MME is the principal federal government organ established under the Ethiopian law by proclamation No. 41/1993. It is responsible for the formulation of policy, laws, and directives that influence the development of the two main sectors, namely, mines and energy. The energy institutions accountable to MME at present are the Ethiopian Electric Agency, the Ethiopian Rural Energy Development and Promotion Centre and the National Petroleum Depots Administration. According to the proclamation, some of the duties and responsibilities entrusted to MME in relation to the energy sector are to:

- formulate policies and strategies as regards the country's energy development and, upon approval, follow up and supervise their implementation;
- collect and maintain a databank on energy resources and prepare reports;
- undertake studies concerning the development and utilization of energy resources;
- establish research and training centres that can assist in enhancing the development of energy resources;
- monitor and evaluate the National Biogas Programme and coordinate donors, government ministries and stakeholders in renewable energy resources;
- analyse existing policies and policy formulation related to the dissemination of renewable energy technologies, in particular domestic biogas, and act upon accordingly;
- in collaboration with EREDPC, liaise with donors and mobilise the resources required for the implementation of the National Biogas Programme;
- oversee the progress of the programme, analyze reports and inform the parties or stakeholders accordingly.

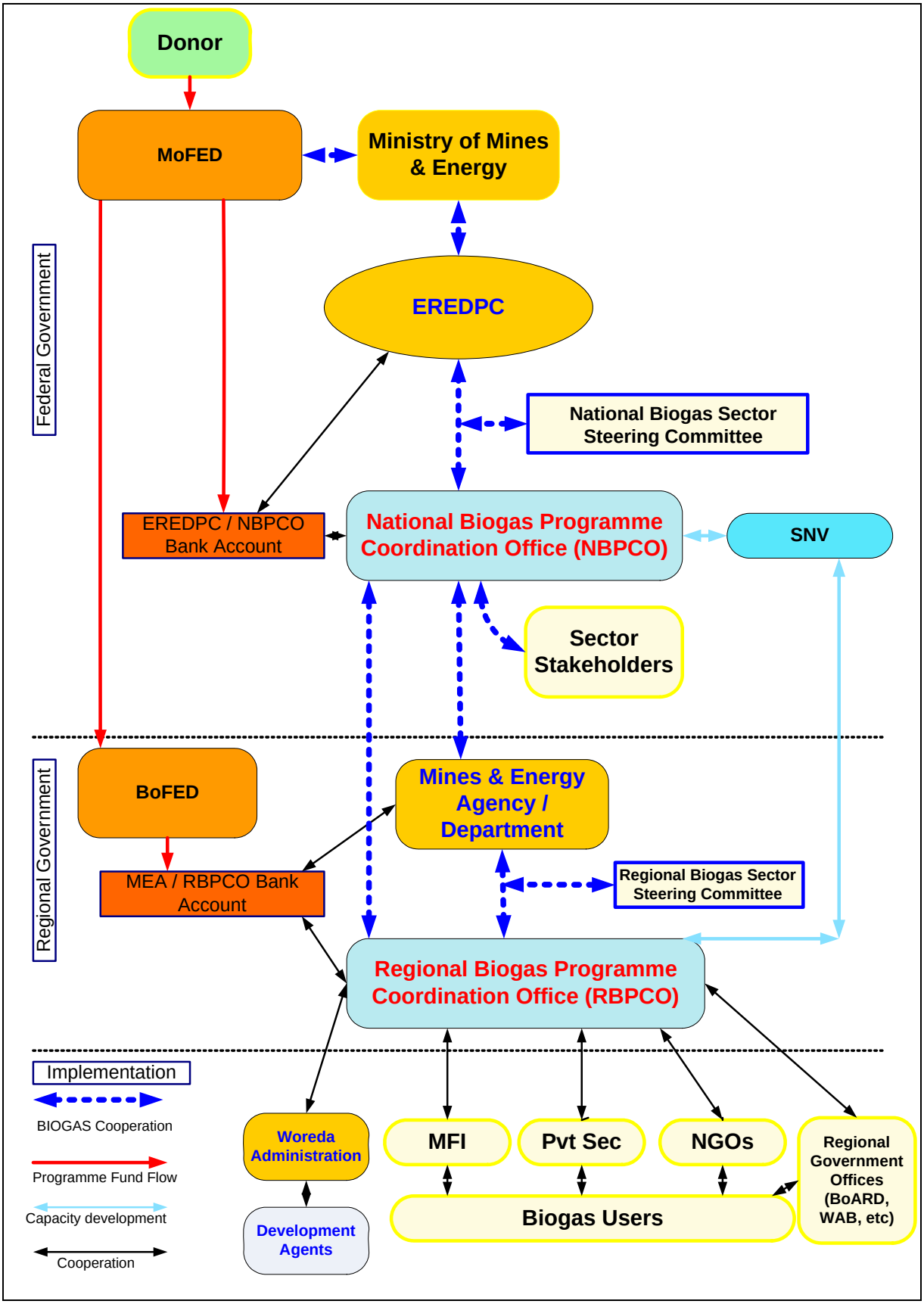


Figure 10 Institutional arrangements

5.1.3 ROLE OF THE ETHIOPIAN RURAL ENERGY AND PROMOTION CENTRE (EREDPC)

For the coordination of activities on renewable energy in Ethiopia, an umbrella organisation is required which represents the interest of the government. The EREDPC is responsible for endorsing the policies relating to the dissemination and promotion of renewable energy technologies and in particular for the biogas sector. As per the protocol issued by the Ministry of Mines and Energy, the Ethiopian Rural Energy Development and Promotion Centre is also responsible for the coordination between various ministries, line agencies and biogas sector stakeholders. Other responsibilities of EREDPC are:

- coordination amongst donors, government ministries, stakeholders in other renewable energy programmes and biogas stakeholders
- liaison with donors for the mobilisation of the resources required for the implementation of the National Biogas Programme
- analysis of existing policies and policy formulation related to the dissemination of renewable energy technologies and in particular domestic biogas
- advice on behalf of the government
- progress reporting to ministries
- promotion of renewable energy technologies and in particular biogas.

For the day-to-day coordination of the National Biogas Programme, EREDPC will delegate responsibilities to a semi-autonomous National Biogas Programme Coordination Office. EREDPC is responsible for the approval of annual plans, reports, monitoring, and evaluation of procedures. EREDPC assumes overall responsibility for the financial management of the National Biogas Programme, and will delegate the operational financial management responsibility to the NBPCO.

The NBPCO is guided by independent operational and financial guidelines acceptable to the government and in line with donor requirements. Additionally, the financial and operational will conform to international standards to allow for independent external monitoring and auditing. The NBPCO will operate an independent bank account in a co-signature with EREDPC.

5.1.4 ROLE OF THE NATIONAL BIOGAS SECTOR STEERING COMMITTEE (NBSSC)

Representatives of the main national level programme actors are responsible for coordinating and guiding developments in the biogas sector, and for overseeing policy and programme matters that relate to programme implementation. The National Steering Committee meets at least twice a year and more often if the need arises. It will also be responsible for:

- advising on the annual plans and reports for the biogas programme;
- endorsing the criteria for the approval of partner organisations;
- promoting the programme among the respective member organisations and (international) partners;
- advising on the set-up and enforcement of sector-wide quality standards and guidelines;
- analysing policy issues and advise on policy matters (contribution to construction cost, price, taxation, R&D);
- advise on any programme-related matters that deviate from the approved plan;
- advise on mobilisation of funds and liaison with donors;
- advise on progress monitoring and programme evaluation.

The proposed members of this committee include:
- two representatives of EREDPC, with one person as the chairperson of the steering committee
- the National Biogas Programme manager (secretary)
- one representative of the Ministry of Agriculture and Rural Development
- one representative of the Ministry of Health
- one representative of the Ethiopian Protection Authority
- one representative form each regional state
- one NGO representative
- one MFI representative
- at least one private sector representative
- one representative from SNV.

5.1.5 ROLE OF THE NATIONAL BIOGAS PRO GRAMME COORDINATION OFFICE (NBPCO)

For the operational management of the National Biogas Programme, a coordination office shall be established under EREDPC. Through the establishment of this coordination office, EREDPC remains accountable with regard to its regulatory responsibility for developments in the rural energy sector. Additionally, trough the national coordination office the focus on mass dissemination of domestic biogas is guaranteed. A situation whereby EREDC would fulfil the role of both regulator and executer of the National Biogas Programme is not desired.

The National Biogas Programme Coordination Office (NBPCO) is responsible for the coordination of the Biogas Programme at the national level. Unless suitable premises are available within EREDPC, the NBPCO will be housed in its own building. The National Biogas Programme manager, who will be recruited on the labour market, manages the office and the other NBPCO staff members. The NBPCO staff is paid by the programme. The proposed main positions for the NBPCO are:
- National Biogas Programme manager
- administrator
- IT/GIS specialist
- promotion and marketing officer
- chief biogas engineer
- biogas technicians
- slurry Extension
- support staff.

The NBPCO is responsible for the day-to-day management and coordination of all programme activities. The running of the office will include accounting, financial procedures and staff management. This will be done according to the programme's rules and regulations. It will also initiate, coordinate, and monitor the activities within the biogas sector. The office will have to work with both private and public sections of the society. It reports to EREDPC.

The main responsibilities of the NBPCO are:
- strengthening the Regional Biogas Programme Coordination Offices
- channelling of the contribution to construction cost
- standardization, quality control and quality management
- internal monitoring of the programme
- promotion and marketing
- analysis of policy issues and proposing modification to the NBSSC and EREDPC
- accreditation of biogas construction cooperatives and private companies
- strengthening the regional Mines and Energy Agencies;
- supporting and strengthening the partner organisations
- coordination of the slurry extension programme, training, capacity building, applied R&D, gender mainstreaming, and surveys and studies.

5.1.6 ROLE OF SNV/ETHIOPIA

SNV/The Netherlands development organisation is operating in 30 countries in Africa, Latin America, Asia and Eastern Europe. In East and Southern Africa, SNV operates in Ethiopia, Kenya, Mozambique, Rwanda, Southern Sudan, Tanzania, Uganda, Zambia and Zimbabwe. In Ethiopia, SNV's core business is capacity-building support to intermediate (meso) level organisations and local capacity builders with the aim of improving governance and reducing poverty. SNV/Ethiopia serves public, private and civil society meso-level organisations and local capacity builders. It provides its services through training and coaching, technical advice, facilitating change processes, support to mechanisms for advocacy, networking and partnership building including intermediation for information, expertise and funds, and knowledge development and dissemination.

The long term strategy of SNV is to support the development of national biogas programmes in a selected number of African countries. SNV implements this support through its four delivery channels to increase the capacity of local organisation, including advisory services, knowledge development and networking, advocacy. Close work with local capacity builders constitutes its delivery channels. In addition, SNV will work in partnership with Biogas for a Better Life, an African initiative that is instrumental for mobilizing resources for national biogas programmes.

SNV's approach to support the development of the NBP/Ethiopia is to develop adequate capacity in the biogas sector within a 5 year period. For the initial phase, SNV will make available the services of two senior (one expatriate) and three junior biogas advisors (one expatriate), a part time energy and gender advisor, and a part-time advisor on micro-credit and general advisory service.

Without excluding other sector stakeholders, SNV will primarily provide support to EREDPC, the National Biogas Programme Coordination Office, the regional Mines and Energy Agencies, and regional Biogas Programme Coordination Offices.

5.2 Role of the regional stakeholders

5.2.1 Role of the Bureaus of Finance and Economic Development (BoFEDs)

For the financing of the National Biogas Programme, regional governments will contribute towards the budget for the BPCOs. The BoFED contribution is mainly allocated to the promotion, training and extension component of the RBPCOs. Additional funds for the National Biogas Programme (regional budget) will be channelled to the BoFEDs through EREDPC/NBPCO using the "channel Ia" procedure. The BoFEDs will then forward these funds to the account jointly operated by the MEAs and the RBPCOs. Other responsibilities of the BoFEDs are:

- integrating the National Biogas Programme in the regular planning
- impact monitoring
- timely disbursement of programme funds.

5.2.2 Role of the Regional Mines and Energy Agencies (MEAs)

At regional level the Mines and Energy Agencies or Energy Departments are mandated for the promotion and development of renewable energy technologies. The role of the regional MEAs is comparable to that of EREDPC.

The main responsibilities of the MEAs are:

- coordination amongst regional bureaus, regionally based (I)NGOs, MFIs and savings and credit cooperatives, the private sector, and construction cooperatives
- analysis of existing policies at regional level and policy formulation related to the dissemination of renewable energy technologies and in particular domestic biogas
- representing the interests of the regional government
- progress reporting to the regional government
- promotion of renewable energy technologies and in particular biogas

5.2.3 Role of the Regional Biogas Programme Coordinating Offices (RBPCOs)

Regional Biogas Programme Coordination Offices are established to coordinate, facilitate and monitor daily programme activities at regional level. RBPCOs are easily accessible entry points for construction cooperatives and private companies, and they are in a position to address geographic and cultural issues. They act as bridging organisations between the government and the private sector, liaise with programme stakeholders and, compared to the national BPCO, are closer to the potential biogas users. A clear focus on dissemination of domestic biogas is guaranteed whereby responsibility for the coordination of the National Biogas Programme at regional level is delegated to the RBPCOs. The RBPCOs will initially have a limited number of full time staff. Depending on the expansion pace of the programme additional staff will be recruited over time.

The RBPCOs identify suitable partners for the different activities and draft working contracts for these partners. Contracts are co-signed by the NBPCO. The RBPCOs are responsible for annual activity plans regarding promotion, training and construction. However, approval for implementation is required from the regional MEAs and the NBPCO. The RBPCOs will produce regular progress reports.

The MEAs and RBPCOs will sign annual co-operation agreements with the NBPCO. In these agreements, the responsibilities of both parties regarding channelling of the funds, quality control and enforcement, production targets, training, promotion and extension will be stipulated.

The regional BPCO will establish partnership with the Bureaus of Agriculture and Rural Development (BoARD) for the promotion of biogas technology through the extension network of BoARD at the Zonal, Woreda and Kebel levels.

The main responsibilities of the RBPCO are:
- strengthening the Zonal and Woreda Administrations
- channelling of the contribution to construction cost
- quality control and quality management
- internal monitoring of the programme
- promotion and marketing
- analysis of policy issues and proposing modification to the RBSSC and MEA
- accreditation of biogas construction cooperatives and private companies
- supporting and strengthening the partner organisations
- coordination of the slurry extension programme, training, capacity building, applied R&D, gender mainstreaming, and surveys and studies.

5.2.4 ROLE OF THE REGIONAL BIOGAS SECTOR STEERING COMMITTEES

As at national level, all biogas activities will be periodically monitored and advised by a regional Biogas Sector Steering Committee (RBSSC). These committees are established after the regional biogas offices are set up and will consist of the main actors in the biogas sector at regional level, including:
- a Mines and Energy Agency (or Energy Department) representative (chair)
- the regional Biogas Programme manager (secretary)
- a Bureau of Finance and Economic Development representative
- a representative of regional NGOs
- a representative of regional MFIs
- a representative of the regional private sector
- a rural households' union representative.

The RBSSC will periodically monitor and advise upon all biogas activities, and will endorse the annual activity plan for the biogas sector in the region.

5.3 Roles at the implementation level

5.3.1 BIOGAS OWNERS

The user is responsible not only for acquiring biogas technology but also for integrating the technology in the day-to-day routine. Any disturbance in the daily routine can affect gas production and cause a negative image of the technology. Another issue is that the technology should perform as expected. The biogas user expects to have an adequate and regular gas production and therefore adheres to the operation and maintenance instructions as stipulated in the owners' manual and to the information disseminated during user training.

5.3.2 ZONAL ADMINISTRATION

The regional BPCOs,where applicable, will develop and implement promotional activities with zonal administration to encourage the uptake of domestic biogas. Where applicable, the role of the Zonal administration can be expanded to additional activities. The exact mode of cooperation between the RBPCOs and the Zonal administration could not be identified at the time of the stakeholders' consultation and the most appropriate mode for cooperation will be identified in the course of phase I.

5.3.3 WOREDA ADMINISTRATION

The regional BPCOs will develop and implement promotional activities with the *woreda* administration to encourage the uptake of domestic biogas. Where applicable, the role of the *woreda* administration can be expanded to additional activities, e.g. quality control. The exact mode of cooperation between the RBPCOs and the *woreda* administration could not be identified at the time of the stakeholders' consultation and the most appropriate mode for cooperation will be identified in the course of phase I.

5.3.4 KEBELE ADMINISTRATION

The regional BPCO will work closely with Development Agents and Kebele representatives on promotional and extension programmes.

5.3.5 NON-GOVERNMENTAL ORGANISATIONS (NGOS)

NGOs can play a significant role in reaching rural households, and promote biogas technology in relation to gender, environment and health aspects of their clients. NGOs can also be involved in the promotion of the utilization of bio-slurry.

5.3.6 MICROFINANCE INSTITUTIONS (MFIS)

The investment costs for biogas technology are prohibitive for most rural households, who would generally be unable to pay in cash at one time. Microfinance can play an important role in making domestic biogas affordable by supplying a long-term credit to rural households who are willing to purchase the technology at a low interest rate.

The regional microfinance institutions will play an important role in a large-scale domestic biogas programme. Regional microfinance institutions show a keen interest to develop a new product line for domestic biogas. At this moment MFIs prefer to determine lending conditions for domestic biogas on an individual basis. MFIs indicated that domestic biogas plants constructed under the umbrella of a NBP are considered low risk investment and the repayment period can be extended to 36 month if required. The required amount for financing

a biogas plant is in the range of ETB 3000-5000 and within the limits of the current lending policies. In view of their large and increasing network, MFIs are an important biogas promotion partner and can be instrumental to create markets for biogas.

In 1999 the Association of Ethiopian Microfinance Institutions (AEMFI) was established with most of the Ethiopian MFIs (27) as members. AEMFI is responsible for training, research, advocacy, networking and funds-raising. In December 2006 the number of loan clients of AEMFI member MFIs was more than one million. AEMFI expressed a keen interest to build a long-term partnership with the National Biogas Programme and develop a credit line for domestic biogas.

5.3.7 THE PRIVATE SECTOR

The private sector biogas companies, cooperatives, and biogas appliance and component manufacturers can play a significant role in supporting the success of the biogas programme, even though they are presently few in number. Private construction companies can play a role in construction and house-to-house promotion of the technology. Past experience shows that once a project is executed, the organisation withdraws from the area without passing on the construction and maintenance knowledge that is crucial to sustain the project. To reduce such eventuality, project organisations should support the local private sector, which can continue to provide services after the construction of the plant is completed. The role of the private sector is crucial for market sustainability.

5.4 Fund channelling

Donor funds are channelled through MoFED. Together with the contribution of the federal government, the funds for the National Biogas Programme are transferred to an account operated by EREDPC and the NBPCO. The NBPCO is responsible for the day-to-day management of the funds, and EREDPC is financially accountable for these funds. Expenditures are on the basis of the Programme Implementation Document, annual plans and reports, and financial and operational procedures. Figure 11 illustrates how funds are channelled.

The funds for the RBPCOs are directly transferred from MoFED to the BoFEDs, who will transfer the funds together with the regional financial contribution to a bank account jointly operated by the MEAs and the RBPCOs.

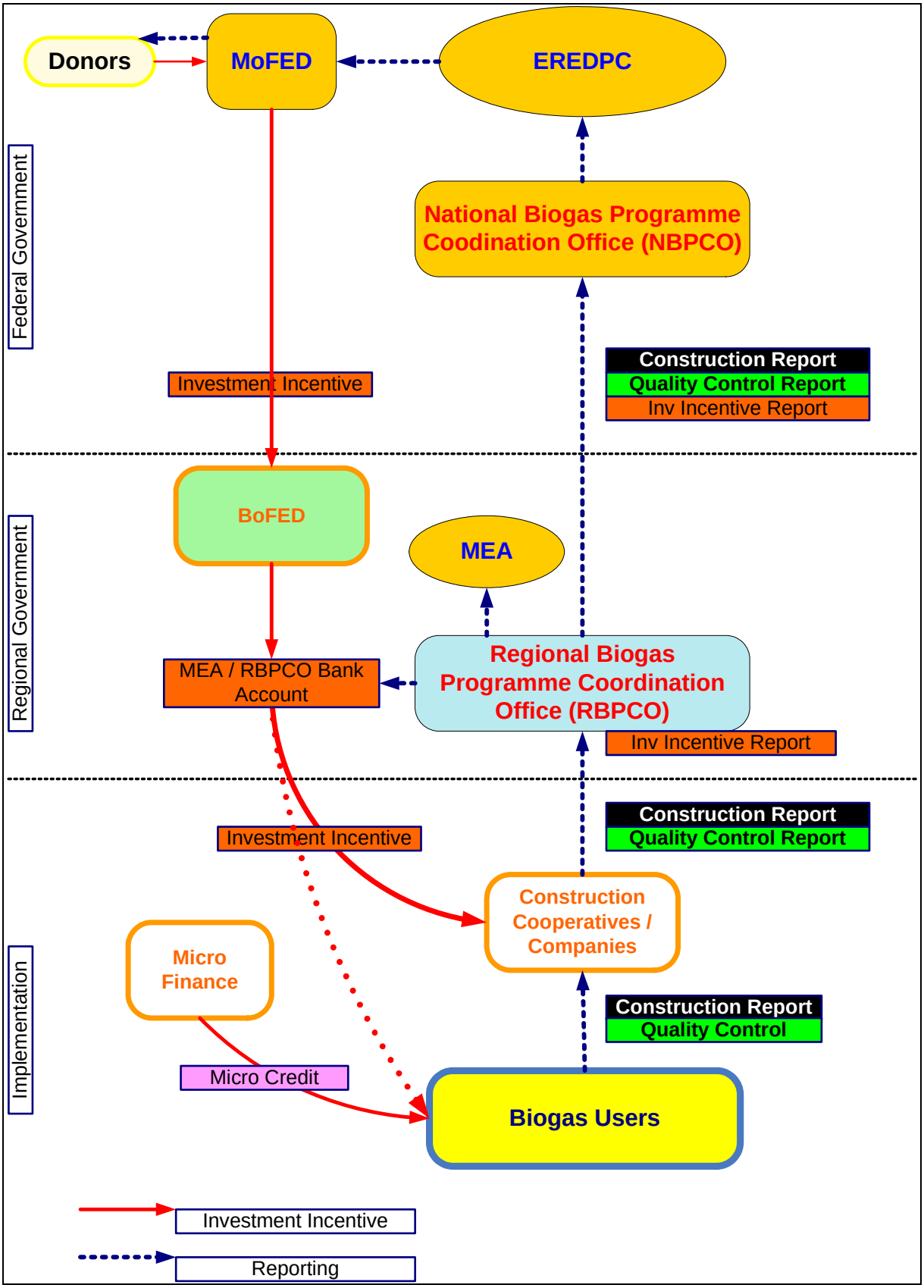


Figure 11 Funds channelling

The contribution to construction cost is transferred to the account of the construction cooperative on the basis of the satisfaction of the users, the construction completion reports and the quality control reports produced by the RBPCOs. The user of the biogas plants will sign for the receipt of the contribution to construction cost. The total amount of the contribution to construction cost will then be deducted from the overall bill for the construction by the construction cooperative.

The required funds for the contribution to construction cost are transferred bi-annually to the account of MEA/RBPCO and are channelled through the BoFEDs.

Micro-credit is directly channelled to the biogas users. NGOs, construction cooperatives and private sector companies can assist the users in acquiring micro-credit. Other options of channelling microfinance funds to the construction cooperative shall be explored with individual MFIs, i.e. the direct channelling of micro-credit to the construction cooperative.

The biogas user will pay the construction cooperative for the construction, maintenance and guarantee either in cash, credit or a combination of the two. The self-help component is deducted from the total cost of the installation of the biogas plants.

6. ESTIMATED COST AND PROPOSED FINANCING

The budget for the National Biogas Programme is stated in euro. Inflation is not taken into consideration as is often the case with public budgets. The 'non-effectuation principle' is also practiced by the BOAM (Business Organisations for Access to Markets) programme in Ethiopia. For the €–ETB conversion, the current[14] exchange rate is applied (1 € = 12.5 ETB).

There is a significant budget increment compared to the initial estimates presented in the feasibility study report. The main reasons are indicated below.

- Price increment of cement increases the average cost of construction, resulting in a higher contribution by the rural household.
- It is assumed that 50% of the biogas plants will be constructed with locally available natural stones and 50% burnt clay bricks. The average cost difference between a stone and a brick biogas digester is 64%.
- Regional Biogas Programme Coordination Offices will be established.
- Technical assistance will be boosted through additional advisors and engagement of local capacity builders.
- The amount for the contribution to construction cost will be increased from € 150 to about € 200.
- The cost estimates for programme management (i.e. salaries and running cost) are higher.

6.1 Estimated costs

The total budget requirement for the implementation of the pilot phase of the National Biogas Programme is € 16.7 million or ETB 208 million over a period of 5 years.

The budget includes the rural households' contribution, the financing cost for credit to be financed by the rural households, contribution to construction cost, programme management cost at national and regional levels, and technical assistance. An overview of the programme budget is presented in Table 15, with budget allocation presented in Figure 12. Detailed budget information for the National Biogas Coordination Programme is presented in a separate document.

Table 15 Summary of the costs of the National Biogas Programme

	Summary project budget *(not corrected for inflation)*						*[Euro]*
		NBP pilot phase summary project budget					
		1	**2**	**3**	**4**	**5**	**total**
1a	Farmer investment	81.967	491.803	1.147.539	1.721.309	2.295.079	**5.737.697**
1b	Credit financing costs	17.907	107.444	250.702	376.052	501.403	**1.253.508**
1c	Investment Incentive	38.433	230.597	538.061	807.091	1.076.121	**2.690.303**
2a	Regional support *(RBPCO)*	433.598	554.694	618.618	758.237	849.408	**3.214.554**
2b	National support *(NBPCO)*	365.630	367.837	366.812	385.337	377.160	**1.862.775**
2c	Technical assistance	412.300	442.300	423.100	335.300	290.500	**1.903.500**
	Total project	**1.349.835**	**2.194.675**	**3.344.832**	**4.383.326**	**5.389.671**	**16.662.337**

[14] Septembre 2007.

6.1.1 ESTIMATED COST OF AN AVERAGE BIOGAS PLANT

The price level of a biogas plant is very important for both households and companies. It is difficult to promote an expensive technology as a commercial product. At the same time, a minimum quality level is required to ensure that user's expectations are met and that a minimum daily gas production is guaranteed. Too small a biogas plant does not meet the daily energy requirements and an oversized biogas plant increases investment unnecessarily. For these reasons, the cost of a biogas plant has to be determined with care.

Contribution to construction cost and rural households contribution are deducted form the overall installation costs. The remaining costs are financed through cash and/or credit. At micro level and particularly in the shorter term, the main benefits of a biogas plant are the direct savings of domestic fuel.

Cost of Sinidu Biogas plant

	4 cum	6 cum	8 cum	10 cum
Brick Masonary	8076	8965	11007	12679
share	50%	50%	50%	50%
Stone	5565	6074	7615	8657
share	50%	50%	50%	50%
Average Cost	6821	7519	9311	10668

Table 16 Cost of 4 6 8 10 m^3 biogas plants

The average investment cost for a 6 m^3 biogas plant after own financial contribution and contribution to construction cost is ETB 4310.

6.1.2 ESTIMATED COST FOR PROGRAMME (SUPPORT) ACTIVITIES

		Budget					
		1	2	3	4	5	total
1	Promotion & marketing	22.000	22.000	22.000	20.000	20.000	**106.000**
2	Finance	7.400	9.400	12.600	15.400	18.200	**63.000**
3	Construction & a.s.s	-	26.000	23.000	23.000	7.000	**79.000**
4	Quality assurance	29.199	33.006	31.885	38.547	39.490	**172.127**
5	Training	46.930	38.650	47.220	46.460	41.680	**220.940**
6	Extension	6.000	1.500	8.250	6.250	11.000	**33.000**
7	Institutional support	32.250	29.250	29.250	29.250	32.250	**152.250**
8	Monitoring & evaluation	18.000	34.500	36.500	26.500	28.500	**144.000**
9	Research & development	24.125	13.500	14.625	20.000	19.500	**91.750**
10	Project management	162.315	142.515	124.015	141.580	141.580	**712.005**
National Support Budget		**348.219**	**350.321**	**349.345**	**366.987**	**359.200**	**1.774.072**
Contingencies	**5%**	17.411	17.516	17.467	18.349	17.960	**88.704**
Total National Support Budget		**365.630**	**367.837**	**366.812**	**385.337**	**377.160**	**1.862.775**

Table 17 National support budget

Summary Regional Support Budget	(per region, not corrected for inflation)					[Euro]
	Budget					
	1	2	3	4	5	total
1 Promotion & marketing	13.650	25.900	44.300	58.650	73.000	**215.500**
2 Quality management	5.268	7.680	11.870	20.993	25.840	**71.650**
3 Training	6.820	4.140	10.820	17.640	24.000	**63.420**
4 Extension	300	1.300	7.800	5.400	6.400	**21.200**
5 Operational expenses	11.200	6.800	5.000	7.600	5.000	**35.600**
6 Institutinal Support	1.500	1.000	1.000	1.000	1.500	**6.000**
7 Programme Management	64.500	85.250	66.500	69.250	66.500	**352.000**
Total regional Support Budget	**103.238**	**132.070**	**147.290**	**180.533**	**202.240**	**765.370**

Table 18 Regional support budget (per region)

6.1.3 COST OF TECHNICAL ASSISTANCE

Summary Technical Assistance	(not corrected for inflation)					[Euro]
	Budget					
Description	1	2	3	4	5	total
1,01 Senior Technical Advisor (EUN)	115.200	115.200	96.000	76.800	57.600	**460.800**
1,01 Junior Technical Advisor (EUN)	84.000	84.000	84.000	70.000	56.000	**378.000**
1,01 MFI Advisor (EUN)	51.000	51.000	51.000	-	-	**153.000**
1,11 Senior Technical Advisor (HCN)	30.000	30.000	30.000	25.000	20.000	**135.000**
1,11 Junior Technical Advisor (HCN) south	19.800	19.800	19.800	16.500	13.200	**89.100**
1,11 Junior Technical Advisor (HCN) north	19.800	19.800	19.800	16.500	13.200	**89.100**
1,11 Gender & Energy Advisor (HCN)	12.000	12.000	12.000	-	-	**36.000**
1,21 Additional advisory services	10.000	10.000	10.000	10.000	10.000	**50.000**
1,22 Local Capacity Builders	30.000	60.000	60.000	90.000	90.000	**330.000**
1,23 Biogas Practice Meetings	3.000	3.000	3.000	3.000	3.000	**15.000**
1,24 Knowledge development	7.500	7.500	7.500	7.500	7.500	**37.500**
1,25 International Training Advisors	15.000	15.000	15.000	5.000	5.000	**55.000**
1,26 Other support expenses	15.000	15.000	15.000	15.000	15.000	**75.000**
Total Technical Assistance	**412.300**	**442.300**	**423.100**	**335.300**	**290.500**	**1.903.500**

Table 19 Technical assistance

6.2 Proposed financing

6.2.1 RURAL HOUSEHOLDS' CONTRIBUTION

The total contribution by the rural households is the average cost of construction minus contribution to construction cost minus contributions in kind plus financing cost.

To finance the costs remaining after contribution to construction cost and self-help component for installing a biogas plant, it is expected that at least 50% of the potential biogas owners will require credit. Gradually the number of credit-financed biogas plants will increase. Microfinance institutions and credit and savings cooperatives have expressed an interest in providing credit for the financing of biogas plants. It is assumed that MFIs have sufficient liquidity to fund the credit requirements. Furthermore, through partnerships with other microfinance networks, 'external' funds can be mobilized for biogas microfinance. Microfinance for biogas is a new product line whose exact modalities the national and regional BPCOs will negotiate with individual MFIs.

6.2.2 CONTRIBUTION FEDERAL GOVERNMENT

The total contribution by the federal government is a 10% contribution to the contribution to construction cost and a 15% contribution to the programme cost in the first year, with a 5% increment annually for the National Biogas Programme Coordination Office. The overall contribution over the first phase will be 4% of the total cost (Table 20).

6.2.3 CONTRIBUTION REGIONAL GOVERNMENTS

The total contribution by the regional governments combined is a 10% contribution to the programme cost for the National Biogas Programme Coordination Office. The contribution of each individual region is less then 1% of the total cost.

6.2.4 CONTRIBUTION EXTERNAL DONOR

The remaining costs for the contribution to construction cost and programme coordination support is expected to be covered by the Biogas Africa Initiative and is equal to 39% of the total cost.

It is expected that the income from carbon trade will significantly contribute to the cost for programme management presently contributed by the Federal, Regional Governments and external donor.

6.2.5 CONTRIBUTION FOR TECHNICAL ASSISTANCE

The technical assistance is expected to be covered by SNV/Netherlands Development Organisation equal to 10%.

Proposed Budget				Proposed Financing			
	Euro	*Euro* per plant	share	*Euro*	Budget total	*[Euro]* / plant	share
Plant Investment cost	9.681.508	*692*	*58%*	Farmers	6.991.205	*499*	*42%*
				National Government	269.030	*19*	*2%*
				Donor	2.421.273	*173*	*15%*
Programme Support	5.077.329	*363*	*30%*	National Government	467.722	*33*	*3%*
				Regional Government	540.885	*39*	*3%*
				Donor (RBPCO)	2.673.669	*191*	*16%*
				Donor (NBPCO)	1.395.053	*100*	*8%*
Technical assistance	1.903.500	*136*	*11%*	Total SNV	1.903.500	*136*	*11%*
Total	€ 16.662.337	*1.190*	*100%*	Total	€ 16.662.337	*1.190*	*100%*

Table 20 Proposed financing

Proposed Financing			
Proposed Financing	Euro	/ plant	[Euro] share
Total Farmers	6.991.205	*499*	*42%*
Total National Government	736.752	*53*	*4%*
Total Regional Government	540.885	*39*	*3%*
Total Donor	6.489.995	*464*	*39%*
Total SNV	1.903.500	*136*	*11%*
Totals	€ 16.662.337	*€ 1.190*	*100%*

Table 21 Proposed financing stakeholder wise

6.2.6 CONTRIBUTION CARBON TRADING ARRANGEMENTS

The fermentation of animal dung in domestic biogas plants, and the subsequent application of biogas and bio-slurry contribute to the global reduction of greenhouse gasses (GHG).

Applying domestic biogas could reduce GHG emissions through substitution of conventional domestic energy sources like fuel wood, modification of the traditional manure management practice, substitution of chemical fertilizer, and where applicable substitution of conventional fuel for cooking or lighting. This is illustrated in Figure 17. However, as observed during the feasibility study, cattle in Ethiopia are largely free grazing and storage of dung under (semi) anaerobic conditions is not customary. Application of chemical fertilizer is hardly practiced. In addition, substitution of chemical fertilizer with bio-slurry will be complicated to monitor. The main contribution to the reduction of GHG would therefore be the substitution of the non-sustainable use of fuel wood.

It is estimated that over a 5-year period a reduction of at least 66 tonnes of CO_2 can be realized through the installation of 10,000 biogas plants. Through the emission trading mechanism, a financial contribution is made to the biogas programme. The reduction of CO_2 emission can be traded through the Clean Development Mechanism (CDM) or Verified Emission Reduction (VER).

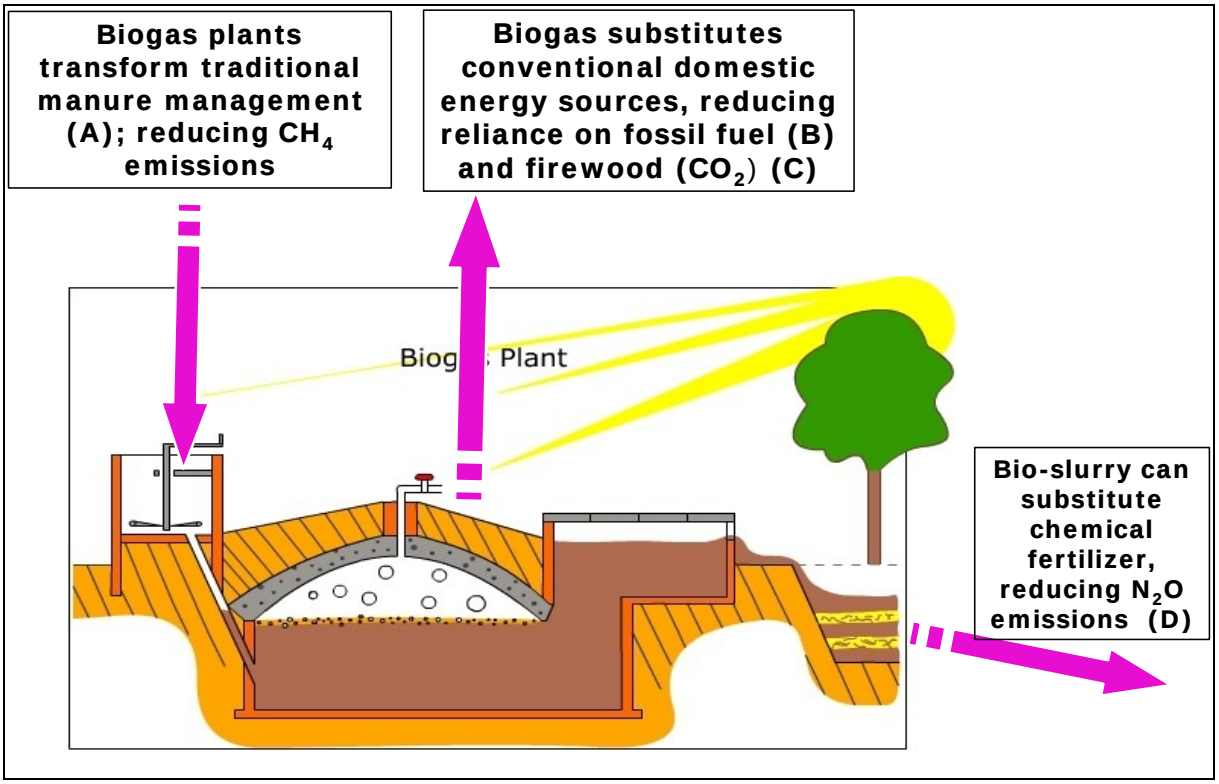


Figure 12 Greenhouse gas reduction

A conservative estimate shows that least € 700,000 can be expected through emission trading. Under more favourable condition a much higher amount can be expected. The funds generated though the emission trading, either through Certified Emission Reduction (CER) or VER, are required to co-finance the contribution to construction cost to encourage rural

households to install a domestic biogas plant. Additionally, these emission revenues contribute to the development of the public sector responsible for the coordination of the National Biogas Programme. It is reasonable to assume that without any financial support the Government of Ethiopia has limited resources to develop the institutional setting for a NBP. The revenues form carbon trading, either through CER or VER, are therefore additional.

When calculating the required feeding regime for a biogas plant, annual zonal average temperatures are used. This implies that during the cold season the gas production will be lower than average and during the hot period the gas production will be higher than average. The higher gas production during the hot season might cause escape of excess methane. As a precautionary measure a gas pressure meter will be installed at every biogas plant. The users in turn will be requested to utilize biogas when the biogas plant is 'full". Excess biogas can be used for boiling drinking water.

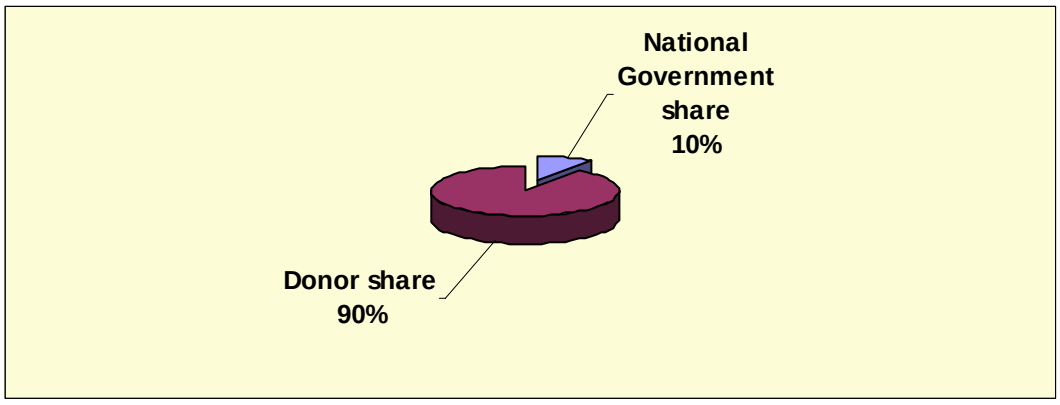
An contribution to construction cost (Table 25, Figure 18) reduces the investment cost for the biogas users and is at the same time a promotional tool. Additionally an contribution to construction cost is an instrument to ensure a minimum level of quality of construction, guarantee and after-sale service. Contribution to construction cost provides leverage over quality; quality relates to:

- safeguarding the rural households' investment
- reputation of the technology
- guarantee for microfinance.

Table 22 Annual contribution to construction cost requirement

Annual Investment Incentive requirement						*[Euro]*
	1	**2**	**3**	**4**	**5**	**Total**
# of plants	*200*	*1200*	*2800*	*4200*	*5600*	*14000*
Investment Incentive requirement	38.433	230.597	538.061	807.091	1.076.121	2.690.303
National Government share	***10%***	***10%***	***10%***	***10%***	***10%***	***10%***
Constibution national government	3.843	23.060	53.806	80.709	107.612	269.030
Donor share	***90%***	***90%***	***90%***	***90%***	***90%***	***90%***
Contribution donor	34.590	207.538	484.255	726.382	968.509	2.421.273

Figure 13 Share contribution to construction cost



7. ASSUMPTIONS AND RISKS

The final programme implementation document for a NBP will be submitted to the Government of Ethiopia and the Biogas African Initiative for resources mobilisation. The contracting period is expected to be completed during the second half of 2007. Depending on the allocation of resources it is assumed that the national and regional BPCOs can be established by the end of 2007 or beginning 2008. For the second half of 2007, starting activities are scheduled which focus on strengthening awareness about the relevance of domestic biogas and initial capacity and knowledge development of the biogas sector in Ethiopia. These starting activities will be financed by the Forum for Environment and SNV/Ethiopia.

The modality to be followed for the dissemination of domestic biogas as identified by stakeholders is the delivery channel through the national and the regional governments. Other options for delivery of domestic biogas through a local NGO, bilateral organisations or direct linkage with regional governments were ruled out by stakeholders. The main risks with the delivery modality through the national and the regional governments is that the flow of fund and programme coordination can be entangled in excessive regulatory procedures. To overcome these risks, national and regional biogas programme coordination offices will be established, which will be guided by independent operational procedures. Through this approach it is expected that a smooth implementation can be guaranteed. Despite the semi-autonomous status of the BPCOs lengthy procedures may hamper progress on the NBP. Despite these risks, the opportunities for having the delivery channels embedded within government are multiple in terms of capacity development and sustainability.

One other risk identified is the collective acceptance by all stakeholders of the contribution to construction cost for domestic biogas. Without an contribution to construction cost it is considered impossible to promote the benefits of domestic biogas within a relatively short period of time. Additionally, without an contribution to construction cost it will be difficult to mobilize CER and VER for the financial sustainability of the programme. In addition CER/VER can also be claimed for financing support activities for the NBP.

In July 2007, the price of cement increased by 45% compared to the price level of January 2007. As a result, the average cost of a biogas plant increased substantially. With the programme implementation document still under scrutiny, it is possible to make a price adjustment of the contribution to construction cost. However, once the price level of the contribution to construction cost is set, no price adjustments are possible. If the price of cement continues to raise sharply this could influence the uptake by rural households of the biogas technology due to too high investment cost subsequently influencing the performance of the whole sector.

The involvement of construction cooperatives for the construction, maintenance and repair of biogas plants is new and there is little experience with construction cooperatives. The NBP will therefore actively cooperate with programmes that promote the development of small and medium scale enterprises.

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Annex 1 Biogas and the MDGs

MDG 1 Eradicate extreme poverty and hunger.

Target 1: To halve extreme poverty

In general, households who install biogas are not amongst the poorest of the poor due to the fact that, for a biogas plant to function, the minimum number of animals a household must have is often more than what 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:

- Construction and installation of biogas creates employment for landless rural people and creates additional income.
- Biogas saving on the use of traditional cooking fuels increases the availability of these fuels for (very) poor members of the community.
- Pollution control and waste management benefit all members of the community.

MDG 3 Promote gender equality and empower women.

Target 4: Eliminate gender disparity in education

It is predominantly women and girls who spend the most time and effort providing traditional energy services and using the domestic energy supply. Biogas directly benefits this group in the following ways:

- Biogas can provide light, thereby helping women and girls to extend the amount of time they can study and gain access to education and information or engage in economic activities.
- Domestic biogas reduces the workload of women by reducing the need to collect firewood, tend fires and clean the soot from cooking utensils. This can save 2-3 hours per household per day on average.
- The reduced smoke resulting from replacing traditional fuel wood stoves with biogas can improve the health of women (and children) who are the most exposed to the dangers of wood smoke.
- The provision of biogas provides an additional or more cost-effective home-based energy source that can enable women to undertake home-based activities to generate additional income or at least generate income in a way that suits their life and obligations.

MDG 4 Reduce child mortality.

Target 5: Reduce by two-thirds the under-five mortality rate

Half of the world's population cooks with traditional (mostly biomass-based) energy fuels. Indoor air pollution from burning these fuels kills over 1.6 million people each year, out of which indoor smoke claims nearly one million children's (< 5) lives per year. Diseases that result from a lack of basic sanitation, and the consequential water contamination, cause an even greater death toll, particularly among small children (< 5 mortality caused by diarrhoea is approximately 1.5 million persons per year).

- Biogas stoves substitute conventional cooking stoves and energy sources, virtually eliminating indoor smoke pollution, hence also the related health risks that particularly affect children who are often heavily exposed to indoor smoke.
- Biogas significantly improves the sanitary condition of the farm yard and its immediate surroundings, thus lowering the exposure of household members to harmful infections, amongst them especially the children who spend extended periods of time

in the farm yard.

- Proper application of bio-slurry will improve agricultural production (e.g. vegetable gardening), thus contributing to food security for the community.

MDG 6: Combat HIV/AIDS, malaria and other diseases.

Target 8: Halt/reverse the incidence of malaria and other major diseases

Indoor air pollution and poor sanitary conditions annually cause millions of premature deaths.

- 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 Ensure environmental sustainability

Domestic biogas can help to achieve sustainable use of natural resources, as well as reducing GHG emissions, thus protecting the local and global environment. Application of bio-slurry increases soil structure and fertility, and reduces the need for application of chemical fertilizer.

Target 9: Integrate the principles of sustainable development into country policies and program and reverse the loss of environmental resources.

- Large-scale domestic biogas programmes positively influence national policies on sustainable development (e.g. agriculture, forestry, poverty reduction).
- Biogas programmes usually comply with and support government policies and programmes that have positive environmental impacts including pollution control, green house gas emission reduction and reafforestation.

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 management of dung.
- Connection of the household toilet to the biogas plant significantly improves the sanitary conditions in the farm yard, thereby reducing the risk of water contamination.

Annex 2 Biogas and PASDEP

Ethiopia's guiding strategic development framework for the period 2005 to 2010 – the **Plan for Accelerated and Sustained Development to End Poverty** – is largely compatible with the MDG requirements. The PASDEP argues that to have a lasting impact on poverty and to finance the necessary social investment for human development, economic growth should be to the tune of 8% per year for the next 10 years, i.e. about double of the country's current economic performance.

The report urges for progress on eight major areas. Hereunder the relevance of domestic biogas regarding improvement in those areas is briefly discussed.

Agriculture – because it still represents the bulk of the economic activity, especially in rural areas, and because the potential to shift to higher-valued crops has not yet been exploited.
Biogas reduces the workload of the farming household (fuel wood collection, cooking, cleaning kitchen utensils, weeding of vegetable fields), thus increasing the labour availability for productive agricultural activity. Bio-slurry, properly applied, is a powerful organic fertilizer, potentially increasing yields by 10 to 40%. Organic produce fits well into a high-value crop policy.

Much more rapid development of the modern private sector – because there is no other sustainable way to generate high growth in the long term, or to create the millions of off-farm jobs that are needed.
A domestic biogas programme is relatively (non-agricultural, skilled) labour intensive, providing good quality employment opportunities (see "expected results", section 5.4).

Exploitation of niche markets and opportunities wherever they present themselves, such as tourism, mining, and production of spices.
Applying bio-slurry, rural households can embark upon growing organic crops, a high value niche market.

A major expansion of exports, and diversification beyond coffee, which has been subject to declining prices; in order to fuel growth, to widen the economic base and reduce susceptibility to shocks, to earn essential foreign exchange, and, in the longer-term, to reduce the dependency on foreign aid.
Organic produce could be an export commodity. Biogas can replace kerosene for lightning, thus reducing foreign exchange expenditure.

Infrastructure: to better link markets and producers, to enable business to take place, to lower the costs of international trade and improve Ethiopia's competitiveness, and to allow people easier access to essential services.
No direct link with domestic biogas.

A continued increase in the education and skill levels of the workforce.
A domestic biogas programme implies a significant investment in training and education of – in particular the rural population (see section 5.4).

Unleashing the potential of Ethiopia's 35 million women – because they represent a major under-used resource, and although they already do much of the country's work, they tend to be trapped in low-productivity occupations, in part due to lower education levels; their potential is held back by poorer health, and repeated and dangerous pregnancies; and much of their time is consumed with low return tasks such as the gathering of water and fuel wood.
Studies in Asia revealed that the households switching to biogas reduce the workload related with fuel wood collection, cooking and cleaning of kitchen utensils with 2 to 3 hours per day. Typically, women and girls are involved in these activities. Hence, biogas improves the development conditions and opportunities for women and girls.

Biogas eliminates indoor smoke pollution and improves on-yard sanitary conditions. Women and children very much benefit from this improvement, further improving the developmental opportunities of women.

Slowing the rate of population growth: because if there continues to be an additional 2 million persons per year, all other interventions will have very limited impact – it will be impossible to produce enough food, provide enough land, create enough jobs, or finance enough health and education services to keep up.
Biogas in general improves the livelihood of households. In the long run, this will reduce the requirement for large families.

Annex 3 Example of quality standards for the construction of a biogas plant

SN	Standards	Tolerances	Type of default
	Standards in household, size and site selection		
1	One biodigester per household	Separate kitchen per biodigester.	Critical
2	Construction site not far from kitchen	Distance from kitchen not more than 20 meters.	Minor
3	Construction site not far from cattle shed or pig sty	Distance from cattle shed or pig sty not more than 20 meters.	Minor
4	Components of the biodigester adequately far from existing structures or trees	Plant components should be at least 2 m away from existing structure or trees.	Major
5	Enough space for biodigester construction as per drawing	Enough space to orient the plant location and slurry pits.	Major
6	Correct size of plant based upon the availability of feeding materials	At lease 5 kg of dung available per cubic meter capacity of biodigester.	Critical
	Standards on construction materials and appliances		
7	Good quality bricks	Best quality locally available. Well baked, regular in size, free from cracks and broken parts.	Major
8	Good quality sand	Not contain more than 3% impurities as determined by bottle test.	Major
9	Good quality cement	Fresh, free from lumps, best locally available.	Major
10	Good quality aggregate	Aggregate should be angular, of regular size not more than 2 mm and free from dust or impurities.	Major
11	Good quality MS rod	The MS rod should be free from heavy rust and at least 8 mm diameter.	Major
12	Good quality acrylic emulsion paint	It should be as approved by the quality control authority.	Major
13	Good quality inlet pipe	The inlet pipe should be of PVC, concrete or Polyethylene 10 cm diameter.	Major

14	Good quality water	Clean and free from organic matter and mud.	Major
15	Good quality dome gas pipe	The size should be bigger than 15 mm diameter with the elbow properly sealed in the workshop. Length should be 60 cm.	Major
16	Good quality main gas valve	As approved by the quality control authority.	Major
17	Good quality pipes and fittings	½" GI or 20 mm PVC pipe of best quality locally available.	Major
18	Good quality water drain	As approved by the quality control authority.	Major
19	Good quality gas tap	As approved by the quality control authority.	Major
20	Good quality connecting pipe	Either neoprene rubber hose or good quality plastic pipe as approved by the quality control authority.	Major
21	Good quality gas stove	As approved by the quality control authority.	Major
22	Good quality gas lamp	As approved by the quality control authority.	Major
23	Good quality mixing device	As approved by the quality control authority.	Minor
	Standards on construction		
24	Only trained masons carry out the construction work	The masons registered in PBPO office after completing training courses in construction	Critical
25	Correct cement, sand, aggregate ratio	For all masonry works the ratio is 1:3 (cement:sand). For plastering works, 1:3 for inner surface and 1:4 for outer surface of the biodigester. Foundation concrete ratio: 1:2:4 (cement:sand:aggregate).	Major
26	Biodigester appropriately placed under the ground	The depth of digging as per drawing. It should not differ by ±5 cm from the standard. If because of high water table or rocky strata the depth is not adequate, proper justification to be provided. In this case stabilisation measures have to be provided around the structure.	Major
27	Correct diameter of the digester	The diameter of the completed biodigester should not differ by ±1% from the standard.	Major
28	Correct height of the curved bottom portion	The height should not differ by ±2% from the standard.	Major

29	Correct height of the position of the bottom of the inlet pipe	The height of bottom of the inlet pipe from the collar should not differ by ±2 cm from the standard.	Major
30	Correct height of the manhole	Height of manhole at the top of the curved opening should not differ by ±2 cm from the standard.	Major
31	Correct height – top of manhole to floor of outlet	The height between top of manhole to the floor of outlet should not differ by ±2 cm from the standard.	Major
32	Correct positioning of the dome gas pipe	The location of the dome gas pipe at centre. Max deviation 2% of the diameter of the digester.	Major
33	Proper plastering outside of the digester	The finished surface properly finished and smooth.	Major
34	Proper plastering inside the gas-holder	Gas holder treated with 5 layers of plastering as indicated in the construction manual. The finished surface smooth and free from cracks.	Critical
35	Plastering outside of digester and dome	The thickness of plaster should be 8 mm.	Minor
36	Proper back-filling in the outside of the wall of digester and gas holder	The space between natural soil and the digester wall filled with soils and compacted well. The height of back-filling at least 45 cm from the top of the dome.	Major
37	Proper length, breadth and height of outlet tank	The length, breadth and height of outlet tank should not differ by ±2% from the standard.	Major
38	Proper volume of outlet tank	The volume of outlet tank differs max. by ±5% from the standard.	Major
39	Proper plumb of the outlet walls	The plumb of the finished surface should not be more than ±0.25 cm ‘in’ or ‘out’.	Major
40	Outlet floor properly finished	The floor is smooth, properly plastered and the level difference should differ by ±0.2%.	Minor
41	Properly casted outlet slabs	The thickness of the outlet slab should not differ by ±0.05 cm. The length and breadth of each panel should not differ by ±0.2 cm from the standard.	Major
42	Proper size of overflow opening	The length and height of overflow opening should not differ by ±2 cm from the standard.	Major
43	Correct positioning of outlet tank	The centre line of outlet, manhole, digester and inlet pipe in one straight line. The deviation max. ±2 cm.	Major

44	Proper backfilling against the outlet walls	The outside of the outlet walls properly compacted with rammed soil to prevent soil erosion.	Major
45	Correct height of inlet tank	The height of inlet tank should not differ by ±5 cm from the standard.	Major
46	Correct positioning of the inlet pipe	The inlet pipe placed at the near end to the digester so that inserting of pipe or pole is possible. It should discharge exactly at the hart line (imaginary line that joins centre of digester, manhole and outlet tank).	Major
47	Proper finishing works of inlet tank	The plaster surface smooth and free from cracks.	Major
48	Positioning of the inlet chamber	Floor of inlet chamber at least 15 cm higher than the bottom overflow opening in the outlet tank.	Major
49	Correct positioning of collection chamber for maturating pig manure	Pig manure and urine flow by gravity to the collection chamber.	Major
50	Positioning of the collection chamber	The floor of the collection chamber should be at least 15 cm higher than the bottom of overflow opening in the outlet tank.	Major
51	Correct positioning of inlet pipe from the latrine attached to biodigester	The inlet pipe should discharge within the location of 30% from the hart line	Major
52	Correct positioning of the pan level	The pan level of the latrine at least 20 cm higher than the bottom of overflow opening in the outlet tank.	Major
53	Correct sizes of turret	The length, breadth and height (diameter in the case of circular turret) of the turret should not differ by ±2 cm from the standard.	Minor
54	Correct fitting of main gas valve	No fittings in between elbow in the dome gas pipe and the main valve. The joint is properly sealed with Teflon tape and good quality adhesive.	Critical
55	No unnecessary fittings in the pipeline	Pipeline contains a minimum of joints. No unions used.	Major
56	Proper burial of pipeline	The pipeline should be buried to at least 30 cm where possible. It should be protected well with clamps and covers where burial is not possible.	Major
57	Water drain able to drain the whole quantity of condensed water	The profile of pipeline should be maintained properly so that the whole quantity of accumulated water is easily drained.	Major

58	Water drain protected in a well maintained chamber	The size of the chamber should be such that it is easy to operate the water drain and rain water does not enter into it. The pit should be provided with a good cover.	Major
59	Correct fitting of gas tap	The gas tap should be placed in a convenient place and the joint should be sealed with Teflon tape and good adhesive.	Major
60	Correct fitting of gas stove	The connecting pipe from gas tap to the stove should be correctly fitted to avoid gas leakage.	Major
61	Correct fitting of gas lamp	The gas lamp should be located in a safe and convenient place. The joint should be sealed with Teflon tape and good adhesive.	Major
62	Proper construction of slurry composting pit	Two compost pits at least equal to the volume of the biodigester to be constructed as per the standard dimensions	Major
63	User's instructed on operation and minor repair works	At least one member from the user's household should be provided with proper orientation on operation and minor maintenance of biodigester	Major
64	Provision of instruction booklet	Instruction booklet should be provided to the users	Critical
65	Guarantee and after-sale service provisions	Guarantee of 2 years in structural part and 1 on pipeline and appliances provided by the installer.	Critical

Source: Implementation document NBP Cambodia

Annex 4 Number of biogas plants to be constructed

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Annex 5 Potential stakeholders per programme function

Oromia Regional State

Function	Organisation/Institution
Promotion	Bureau of Agriculture and Rural Development (BoARD)
	Oromia Mines and Energy Agency (MEA)
	NGOs
	World Vision International (Wvi)
	Mekane Yesus
	Women Affairs Bureau (WAB)
	Rural Training and Research Centre (RTRC)
	Oromia Cooperative Promotion Commission
	Oromia Self Help Organisation (OSHO)
	Farmers unions
	Self Help International
	Oromia Credit and Savings Company (OCSSCO)
	Mass media
Construction and maintenance and ASS	TVET graduates/Construction cooperatives
	Private companies/Biogas builders
	Local masons (previously trained on biogas)
Credit	Oromia Credit and Savings Company (OCSSCO)
	Cooperative Bank of Oromia (CBO)
	Local (private) credit and savings companies
	Italian cooperation
	Wisdom Microfinance Institution S C
	OCSI
Administration of subsidy	Oromia Mines and Energy Agency (MEA)
	BoFED
	Environmental Protection Bureau (EPB)
	Oromia Credit and Savings Company (OCSSCO)
Quality control	Oromia Mines and Energy Agency (MEA)
	Ethiopian Rural Energy Development and Promotion Centre (EREDPC)
	Oromia Agriculture and Research Institute (OARI)
	Quality and Standards Authority
	Urban Development Bureau
Training	TVET
	Bureau of Agriculture and Rural Development
	Oromia Mines and Energy Agency (MEA)
	Rural Training and Research Centre (RTRC)
	Selam VTC
	Bakolate
Extension	Bureau of Agriculture and Rural Development

	Oromia Agriculture Research Institute (ORAI)
	World Vision International (Wvi)
	Oromia Mines and Energy Agency (MEA)
	Rural Training and Research Centre (RTRC)
	Women Affairs Bureau (WAB)
Applied R&D	Oromia Mines and Energy Agency (MEA)
	University of Addis Ababa
	Debre Zeit University
	EREDPC
	Rural Training and Research Centre (RTRC)
	Bureau of Agriculture and Rural Development
	GTZ
	Agricultural research institutions
	Oromia Agriculture and Research Institute (OARI) (+ 4 research centres)
	Oromia Credit and Savings Company (R&D on Credit)
	Selam Vocational Training Centre
Monitoring and evaluation	External evaluator
	Individual stakeholders
Coordination at implementation level	Oromia Mines and Energy Agency (MEA)
Coordination at policy level	Oromia Mines and Energy Agency (MEA)
	Environmental Protection Bureau (EPB)

SNNP Regional State

Function	**Organisation/Institution**
Promotion	Bureau of Agriculture and Rural Development (BoARD)
	SNNPRS Mines and Energy Agency (SMEA)
	Bureau of Transport, Industry and Trade (BoTIT) (also MSED)
	Women Affairs Bureau (WAB)
	Cooperatives
	NGOs
	Environmental Protection Agency (EPA)
	Kembatti Menti Gasni (women self-help association)
	OMO Credit and Savings
	Woreda administration
	Bureau of Information (BoI)
	Women and Children Development Organisation (WCDA)
	World Vision International (Wvi)
	ActionAid
	Construction cooperatives
	Private sector (construction companies)
Construction and maintenance and ASS	TVET graduates/Construction cooperatives

	Private Companies/Biogas Builders
	Selam (Awassa branch)
	Regional Technical and Production Centre (RTPC) = Soddo and Misan
Credit	OMO Credit and Savings (at *woreda* level)
	SIDAMA Credit and Savings
	Wisdom Microfinance Institution S C
	Rural Financial Agency (RFA)
	Credit and savings cooperatives
	MEKLIT
	Commercial banks
	Development Bank of Ethiopia
Administration of subsidy	SNNPRS Mines and Energy Agency (SMEA)
	Rural Financial Agency (RFA)
	Bureau of Transport, Industry and Trade (BoTIT) (also MSED)
Quality control	SNNPRS Mines and Energy Agency (SMEA)
	Urban and Work Bureau
	Ethiopian Rural Energy Development and Promotion Centre (EREDPC)

Training	TVET
	SNNPRS Mines and Energy Agency (SMEA)
	Bureau of Agriculture and Rural Development
	Regional Technical and Production Centre (RTPC) = Soddo and Misan
	Bureau of Transport, Industry and Trade (BoTIT) (also MSED)
	Selam (Awassa Branch)
	Agricultural TVET
Extension	Bureau of Agriculture and Rural Development
	Agri-Service
	World Vision International (Wvi)
	NGOs
	Farm Africa
	Women and Children Development Organisation (WCDO)
	Action Aid
	SelfHelp International
	Goal
Applied R&D	SNNPRS Mines and Energy Agency (SMEA)
	Bureau of Agriculture and Rural Development
	TVET
	University of Hawassa
	Wondo Genet College of Forestry and Natural Resource (WGCF)
	Regional Technical and Production Centre (RTPC)
	Regional Research Institute (+ 4 research centres)
	OMO Credit and Savings (R&D on Credit)
Monitoring and evaluation	Individual stakeholders

	Bureau of Agriculture and Rural Development
	Bureau of Finance and Economic Development (BoFED)
	SNNPRS Mines and Energy Agency (SMEA)
	External evaluator
	Local consultant
	NGOs
Coordination at implementation level	SNNPRS Mines and Energy Agency (SMEA)
	Bureau of Agriculture and Rural Development
	Bureau of Finance and Economic Development (BoFED)
Coordination at policy level	SNNPRS Mines and Energy Agency (SMEA)
	Bureau of Agriculture and Rural Development
	Bureau of Finance and Economic Development (BoFED)
	Bureau of Transport, Industry and Trade (BoTIT) (also MSED)
	Coordinating committee

Amhara Regional State

Function	**Organization/Institution**
Promotion	Bureau of Agriculture and Rural Development (BoARD)
	Amhara Mines & Energy Agency (AMEA)
	Bureau of Transport, Industry and Trade (BoTIT) (also MSED)
	Bureau of Women Affairs
	ORDA
	Amtaho Developmental Association (ADA)
	Environmental Protection and Land Administration (EPLA)
	Media
	Micro, Small, Trade, Industry, Enterprise Promotion Centre (MSTIEPC)
	Private sector (construction companies)
Construction and maintenance and ASS	TVET graduates/Construction cooperatives
	Private companies/Biogas builders
	Regional Training and Research Centre
Credit	Amhara Credit & Savings Institute (ACSI)
	ANRS Cooperative Promotion Agency (CPA)
	Harbu Microfinance S C
	MEKET Microfinance Institution S C
	Wisdom Microfinance Institution S C
Administration of subsidy	Amhara Mines & Energy Agency (AMEA)
	Ethiopian Rural Energy Development & Promotion Centre (EREDPC)
	Micro, Small, Trade, Industry, Enterprise Promotion Centre (MSTIEPC)
	ORDA

Quality control	Amhara Mines & Energy Agency (AMEA)
	University of Bahir Dar
Training	TVET
	Bureau of Agriculture and Rural Development
	Amhara Mines and Energy Agency (AMEA)
	Agricultural TVET
	Private companies
	Biofarm
	Micro, Small, Trade, Industry, Enterprise Promotion Centre (MSTIEPC)
	Rural Technical and Production Centre (RTPC)
	University of Bahir Dar
Extension	Bureau of Agriculture and Rural Development
	NGOs
Applied R&D	Amhara Agricultural Research Institute (ARARI)
	University of Bahir Dar
	Regional Technical and Production Centre (RTPC)
	Agricultural TVET
	Bureau of Agriculture and Rural Development
	Institute of Agricultural Research
	TVET
Monitoring and evaluation	Individual stakeholders
	Amhara Mines and Energy Agency (AMEA)
	Bureau of Agriculture and Rural Development
	Amhara Agricultural Research Institute (ARARI)
	Advisor to the President
	Bureau of Women Affairs
	Programme coordination committee
Coordination at implementation level	Amhara Mines and Energy Agency (AMEA)
	Bureau of Agriculture and Rural Development
	Bureau of Transport, Industry and Trade (BoTIT) (also MSED)
	Coordination committee
Coordination at policy level	BOFED
	Bureau of Agriculture and Rural Development
	Advisor to the State President of Amhara
	Bureau of Transport, Industry and Trade (BoTIT) (also MSED)

Tigray Regional State

Function	Organisation/Institution
Promotion	Bureau of Agriculture and Natural Resource Development (BoARD)
	Tigray Water Resource, Mines and Energy Resources (TWRMED)
	Media
	Woreda Affairs
	Bureau of Transport, Industry and Trade (BoTIT)
	REST
	Bureau of Information
Construction and maintenance and ASS	TVET graduates/Construction cooperatives
	Rural households
	Bureau of Transport, Industry and Trade (BoTIT)
	Local masons
Credit	DECSI
	Cooperatives
Administration of subsidy	Tigray Water Resource, Mines and Energy Resources
	Bureau of Agriculture and Natural Resource Development
	World Vision E
	REST/DECSI
	Regional administration
	MFIs
	Funding agency
	Development Bank of Ethiopia
Quality control	Tigray Water Resource, Mines and Energy Resources
	Mekelle Appropriate Technology Research Centre (MATRC)
	Bureau of Transport, Industry and Trade (BoTIT)
	Independent
	REST
	Private contractor
Training	Mekelle Appropriate Technology Research Centre (MATRC)
	TVET
	Tigray Water Resource, Mines and Energy Resources
	Technical Agriculture College
	Bureau of Agriculture and Natural Resource Development
	DECSI
	Bureau of Transport and Industry
	Urban Development Planning Bureau
Extension	Bureau of Agriculture and Natural Resource Development
	Tigray Water Resource, Mines and Energy Resources
	REST

Applied R&D	MATRC
	Mekelle University
	Bureau of Agriculture and Natural Resource Development
	Tigray Water Resource, Mines and Energy Resources
	Consultant
	Institute of Agricultural Research
	Applied Research institute
	REST
Monitoring and evaluation	Bureau of Agriculture and Natural Resource Development
	MFI
	Tigray Water Resource, Mines and Energy Resources
	Funding agency
	Ethiopian Development Bank
	Zonal and *woreda* administration
	World Vision E
	REST
	Individual stakeholders
	Programme coordination committee
Coordination at implementation level	Tigray Water Resource, Mines and Energy Resources
	Bureau of Agriculture and Natural Resource Development
	Ministry of Agriculture
	Local administration at *kebele* level
	BoFED
Coordination at policy level	BOFED
	Tigray Water Resource, Mines and Energy Resources
	Regional government
	Bureau of Agriculture and Natural Resource Development
	Coordinating Committee
	Disaster Preparedness and Prevention Department
Coordination at federal level	Ministry of Mines and Energy
	Mininstry of Agriculture
	Ethiopian Rural Energy Development and Promotion Centre (EREDPC)

Annex 6 Typical cost breakdown SINIDU biogas plant

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Annex 7 Log frame (draft) National Biogas Programme Ethiopia

	Project description	Key indicators	Means of verification	Assumptions/Risks
	Goal To improve the livelihoods and quality of life of rural rural households in Ethiopia through exploiting the market and non-market benefits of domestic biogas	• 10,000 new biogas plants built nationwide by end of project • 90% of new biogas plants are connected to indoor cooking facilities by end of project • 80% of new biogas household have a slurry pit by end of project • 80% of households with biogas use biogas slurry by end of project • 50% of new biogas plants have domestic toilets attached by end of project	• Project reports • Monitoring reports • Construction records	• Ethiopian Government continues to support biogas at the policy level
	Project purpose To develop a commercially viable domestic biogas sector	• At least 1 biogas construction cooperative working in each *kebele* by end of project • New biogas plants are constructed in clusters of 50 to 100 installations per *kebele* of 5 *woreda*s in 4 regions. • Communities in at least 150 *kebele*s have access to the services of construction cooperative/company • All prospective biogas owners have access to biogas credit and 50% makes use of it	• Project reports • Monitoring reports • Construction records	• Rural households do not begin to show a wholesale preference for other technologies or a whole-sale mistrust for biogas • Labour and material costs do not rise dramatically • Masons are interested in diversifying their businesses
1	**Component 1: Promotion and marketing** **Objective** To stimulate and inform stakeholders on the benefits	• Promotional material distributed to all biogas target areas by end of year 1 • 90% of biogas users accurately report the costs and benefits of domestic biogas in the user survey	• Project reports • Biogas user surveys • Monitoring reports	• Promotional material is officially approved

	Project description	Key indicators	Means of verification	Assumptions/Risks
	and costs of domestic biogas and to publicise the programme itself			
	Outputs			
1.1	Promotional material developed, reproduced and distributed to all biogas target areas	• Promotional material distributed to all biogas target areas by end of year 1 • Ad-hoc 'refresher' promotion conducted in all areas identified as needing further promotion on impact assessments	• Project reports	
1.2	Print and television media coverage regularly initiated and supported	• Television and print coverage reported for all regions, every year of the project	• Project reports • Publication lists	
1.3	Other promotional activities initiated and supported as appropriate, including encouraging word-of-mouth promotion and trade fair displays	• Other promotional activities reported for all regions, every year of the project	• Project reports • 'Traffic' reports at trade fair stalls • Customer feedback surveys at trade fair stalls	
1.4	Special promotional activities developed, targeting groups that may not be reached by other PR activities	• Special promotional activities included • Implementation of special promotional activities reported for all regions, every year of the project	• Project reports • PR materials • Biogas user survey	• Remote rural people are not being reached by current PR activities
2	**Component 2: Financing Objective** To lower the financial threshold, and improve access to credit and repayment assistance, to facilitate access to domestic biogas for all potential clients, with particular emphasis on the poor, women and other disadvantaged groups	• 90% of new biogas plant credit applications are approved • 90% of all new biogas plants are officially owned or co-owned by women • 5% of all new biogas users are classified as poor in their communes	• Project reports • Credit records • Construction records • User surveys	• Financial institutions are willing to negotiate flexible credit products • Special effort is made to reach the poor and disadvantaged groups

	Project description	Key indicators	Means of verification	Assumptions/Risks
	Outputs			
2.1	Eligibility criteria for contribution to construction cost, credit and CER/VER products are established with special attention paid to providing access to the poor and other disadvantaged groups	• 100% of poor or disadvantaged (including women) applicants are eligible for some form of financial assistance during the establishment of their biogas plants • 100% of total approved applicants are eligible for some form of financial assistance during the establishment of their biogas plants	• Project reports • Credit records • Construction records • User surveys	• Development of CER/VER continues at international level and can be implemented at national level
2.2	All prospective biogas users who are eligible for contribution to construction cost arrangements are registered before they commence construction activities	• 100% of prospective biogas users who are eligible for contribution to construction cost arrangements are registered before they commence construction activities	• Project reports • Credit records • Construction records • User surveys	• Information dissemination activities achieve maximum penetration and as many potential biogas uses are reached as possible
2.3	Contribution to construction costs are made available to all eligible prospective biogas users	• 100% of eligible prospective biogas users are given access to contribution to construction costs	• Project reports • Credit records • Construction records • User surveys	
2.4	Targeted biogas credit arrangements identified and facilitated for all eligible prospective biogas users with a special emphasis on products for poor and disadvantaged groups	• 100% of poor or disadvantaged (including women) applicants are eligible for credit products during the establishment of their biogas plants • 70% of total applicants are eligible for project credit products during the establishment of their biogas plants	• Project reports • Credit records • Construction records • User surveys	
2.5	Credit sanctioning costs subsidised for all eligible prospective biogas users with a special emphasis on products for poor and disadvantaged groups	• 100% of poor or disadvantaged applicants (including women) are eligible for credit sanctioning cost assistance during the establishment of their biogas plants • 70% of total applicants are eligible for credit sanctioning cost assistance during the establishment of their biogas plants	• Project reports • Credit records • Construction records • User surveys	

	Project description	Key indicators	Means of verification	Assumptions/Risks
2.6	CER/VER opportunities developed and benefits realised by all eligible prospective biogas users by the end of the project	• 100% of poor or disadvantaged applicants (including women) are eligible for CER/VER finance assistance during the establishment of their biogas plants • 70% of total applicants are eligible for CER/VER finance assistance during the establishment of their biogas plants	• Project reports • Credit records • Construction records • User surveys	• Development of CER/VER continues at international level
2.7	Financing mechanisms developed to assist biogas SMEs in establishment and development	• 100% of eligible biogas SMEs receive support through financing mechanisms	• Project reports • Credit records • Business surveys	• SME owners are interested in finance support
2.8	Contribution to construction costs and other financing mechanisms fairly and effectively managed	• Guidelines for contribution to construction cost allocation and distribution are reviewed and updated • 100% of eligible biogas SMEs receive support through financing mechanisms • Less than 5% of contribution to construction cost recipients lodge formal complaints • Audit reports state that contribution to construction costs and other financing mechanisms are fairly and effectively managed	• Project reports • User surveys • Audit reports	Contribution to construction cost recipients lodge formal complaints when there is an issue Issues are properly recorded by RBPCO and BPCO
3	**Component 3: Construction and after-sale service** **Objective** To facilitate the construction of 14,000 additional biogas plants and their continued operation	• At least 14,000 new plants are constructed nationwide during the project life • After-sale service is available to 100% of new biogas owners	• Project reports • Construction records • User surveys	
	Outputs			
3.1	At least 14,000 new plants are constructed by the end of the project	• At least 14,000 new plants are constructed nationwide during the project life	• Project reports • Construction records	
3.2	90% of all plants receive an	• 90% of all plants receive an annual check-	• Project reports	

	Project description	Key indicators	Means of verification	Assumptions/Risks
	annual check-up in their first two years	up in their first two years • 100% of all plants receive at least one follow-up check-up • 100% of biogas households have access to after-sale service	• Construction records • User surveys	
3.3	At least 20 biogas SMEs are established per region	• At least 20 biogas SMEs are established per region by the end of the project	• Project reports • Construction records • User surveys	
4	**Component 4: Quality management** **Objective** To maximise the effectiveness of the investment made by the biogas owners and to maintain consumer confidence in domestic biogas technology	• 90% of all tested biogas plants pass quality assurance testing at time of testing • 90% of all tested after-sale service providers pass quality assurance testing at time of testing	• Monitoring records • User surveys	
	Outputs			
4.1	Construction and maintenance of domestic biogas plants quality guidelines are developed and accepted	• Construction and maintenance of domestic biogas plants quality guidelines are developed and accepted by development deadline	• Monitoring records • User surveys • Construction records	
4.2	10,000 new biogas plants are commissioned tested and accepted	• 14,000 new biogas plants are commissioned, accepted by the end of the project	• Monitoring records • User surveys • Construction records	
4.3	Random quality check controls conducted on commissioned biogas plants	• At least 5% of all new domestic biogas plants have been given random quality control checks by the end of the project by RBPCO technicians • 0.5% of all new domestic biogas plants are given random quality control checks by the end of the project by BPCO technicians	• Monitoring records • User surveys • Construction records	

	Project description	Key indicators	Means of verification	Assumptions/Risks
4.4	90% of quality checked biogas plants pass	• 90% of all new domestic biogas plants that are given random quality control checks pass	• Monitoring records • User surveys • Construction records	
4.5	Random quality checks are conducted on after-sale service	• 100% of all after-sale service providers are given random quality control checks after their certification by the end of the project	• Monitoring records • User surveys • Construction records	
4.6	90% of quality checked after-sale service pass	• 100% of all after-sale service providers that are given random quality control checks pass	• Monitoring records • User surveys • Construction records	
4.7	National sector quality standards developed and implemented	• Official national sector quality standards developed and accepted by the government • Official national sector quality standards implemented throughout the project	• National standards accreditation • Project reports • Construction records • Quality control reports	
4.8	International sector quality standards (ISO) investigated and adopted	• Investigation conducted into appropriateness of adopting ISO standards in the third year of the project • ISO standards adopted by the end of the project if appropriate	• Project reports • Construction records • Quality control reports	
5	**Component 5: Training** **Objective** To provide the skills for business people to run biogas SMEs and for biogas users to be able to operate their plants effectively	• 90% of biogas SME owners participate in training by the end of the project • 100% of new biogas users receive training by the end of the project	• Training reports • Project reports • User surveys	
	Outputs			
5.1	Training needs analyses conducted for all stakeholders including partners, current and potential masons, biogas construction cooperatives/ companies and users	• Training needs analysis conducted and report approved during the first 6 months of the project • Ad-hoc training needs analyses conducted and approved as commissioned	• Training needs assessment document • Training reports • Project reports • User surveys	

	Project description	Key indicators	Means of verification	Assumptions/Risks
5.2	Regional partner training developed and conducted	• All training plans approved and implemented • Representatives from all regional partners attend training in year 1 of the project	• Training reports • Project reports • User surveys	
5.3	Biogas technician training developed and conducted for all technicians	• All training plans approved and implemented • 15 - 20 biogas technicians trained in each region by end of year 2	• Training reports • Project reports • User surveys	
5.4	Skills upgrading for new biogas masons developed and implemented	• All training plans approved and implemented • 100% of masons requiring refresher training as identified in the Training needs analysis receive training by the end of the project	• Training reports • Project reports • User surveys	
5.5	Refresher training for established biogas masons	• All training plans approved and implemented • 100% of masons requiring refresher training as identified in the Training needs analysis receive training by the end of the project	• Training reports • Project reports • User surveys	
5.6	Biogas user training for men and women developed and implemented for all new biogas users	• All training plans approved and implemented • 100% of new biogas users receive training during construction and immediately afterwards	• Training reports • Project reports • User surveys	
5.7	Biogas construction cooperatives/companies training developed and implemented for all participating enterprises	• All training plans approved and implemented • 100% of new biogas construction cooperatives/companies owners and employees receive training before being certified	• Training reports • Project reports	
5.8	Other appropriate training developed and implemented where needed	• All ad-hoc training conducted as per requirements in the training needs analysis in a timely fashion, by the end of the project	• Training reports • Project reports • User surveys	
5.9	Establish relationships with higher education institutions to	• At least one partnership is established and active	• Project reports	

	Project description	Key indicators	Means of verification	Assumptions/Risks
	provide training and to include biogas in their curriculum and research portfolios	• At least one PhD research position is sponsored by NBP and is active before the end of the project		
5.10	Three regional training and resource centres established within existing vocational training institutions	• Three regional training and resource centres established buy the end of year 1	• Project reports	• Partnerships can be developed with existing institutions or centres
6	**Component 6: Extension** **Objective:** To provide the information to allow biogas users to effectively exploit all the benefits of biogas	• Trials are conducted on effective use of biogas slurry, chicken incubation and other biogas value-adding topics and results are published and utilised progressively throughout the project		
	Outputs			
6.1	Proper extension material is available to rural households and biogas users	• Extension material developed and approved by end of year 1	• Training reports • Project reports • User surveys	
6.2	Rural households receive direct support from extension workers	• 100% of new biogas users receive at least one visit from extension workers within 6 months of the commissioning of their new biogas plants • 70% of new biogas users receive multiple visits from extension workers over the duration of the project	• Project reports	
6.3	Biogas user representative visits to demonstration plots supported	• At least one representative from every biogas users group to visit demonstration plots by the end of year 2	• Project reports • User surveys	
6.4	Comprehensive demonstration sites established in every region	• One comprehensive demonstration site established in each region by the end of year one • Every comprehensive demonstration site contains a range of uses for biogas and biogas slurry for commercial and	• Project reports • Quality control reports	

	Project description	Key indicators	Means of verification	Assumptions/Risks
		household use and meets the technical standards of the project		
6.5	District level demonstration farms tailored to local conditions established	• At least one demonstration farm established in each district • Support is provided to all demonstration farms	• Project reports • Quality control reports	
7	**Component 7: Institutional support** **Objective** To maximise the ability of key biogas related institutions to be able to provide the services and support required by the biogas sector to facilitate access to domestic biogas and the development of quality biogas products	• Each region has at least one regional biogas technician properly trained and certified by the end of the project • Each region has a regional biogas programme coordination office	• Project reports	• Each region is independently motivated to take part in the programme
	Outputs			
7.1	Fifty-one regional biogas programme coordination offices established and supported	• One regional biogas programme coordination office is established in each region as per the establishment schedule • In monitoring reports, every RBPCO reports having received support from the National Office when requested	• Project reports • Monitoring reports	
7.2	A national biogas advisory board is established	• One national advisory board is established as per the establishment schedule	• Project reports	
7.3	Biogas advisory boards established in the regions	• One national level biogas steering committee is established in the first 6 months of the project • One regional level biogas steering committee is established within the first 3 months of a region committing to being part of the programme	• Project reports • Monitoring report	

	Project description	Key indicators	Means of verification	Assumptions/Risks
7.4	Establishment of local biogas user groups that want them	• Every participating commune is given assistance to establish a biogas user group within 4 months of the commune joining the programme if required • 90% of user groups are still active at the end of the programme	• Project reports • Monitoring reports • User surveys • Participation records	
7.5	Establishment of biogas association	• All biogas construction cooperatives/ companies given opportunity to join national or regional association during the period of the project • Support is provided to biogas construction cooperative/company associations throughout the project by BPCO and RBPCO	• Project reports	
7.6	Provision of ad hoc support to external institutions and individuals requiring assistance for biogas implementation purposes	• All external parties approaching NBP receive a response • Site visits and other support is provided to external institutions who may benefit from it	• Project reports	• NBP is not overwhelmed with requests that take time away from core functions • There is mutual benefit in information sharing and possible future partnering
8	**Component 8: Monitoring and evaluation** **Objective** To identify project progress and impact on stakeholders/ other aspects in order to facilitate knowledge transfer	• Annual project monitoring reports are submitted and approved • Periodic impact assessments are submitted and approved • Monitoring and impact data is included in annual reports and ad hoc publications	• Project reports • Monitoring reports • Impact assessment reports	• Good records are kept throughout the project • Good quality baseline data is collected • Gender disaggregated data is collected and kept
	Outputs			
8.1	Annual project monitoring reports completed and accepted	• 100% of annual reports are approved	• Annual reports	
8.2	Periodic assessment (including	• At least two impact assessments are	• Impact assessment	

	Project description	Key indicators	Means of verification	Assumptions/Risks
	user surveys) on all beneficiaries including the poor, women and other disadvantaged groups is completed and reports are accepted	conducted during the life of the project: one at half-way point and one at the end of the project • All impact assessment reports are approved • Biannual gender surveys undertaken • Monitoring of strategies conducted	reports • User surveys • Gender surveys	
8.3	External surveys, studies and evaluations commissioned and completed	• Ad hoc surveys, studies and evaluations are approved	• Project reports • Study and evaluation reports	
8.4	Programme improvement is progressively carried out based on the information from the monitoring reports and impact assessments	• Programme improvement plans are developed after all major monitoring reports and impact assessments are submitted • Implementation of improvement plans is included in annual plans and reports	• Project reports • Programme improvement plans • Annual plans	
8.5	PILS developed and implemented for information gathering, monitoring and analysis purposes	• RFID devices placed in all new plants according to roll-out plan • GIS system integrated into project database according to rollout plan • Training provided to all staff members who will use PILS technology • GPS coordinates included in GIS system	• Project reports • Procedural audit	
9	**Component 9: Research and Development** **Objective** To increase knowledge about domestic biogas issues and maximise effectiveness, quality and service delivery of the biogas programme	• Reports and/or publications are produced at the completion of all research • Examples of how research results are implemented in the programme are contained in annual plans and reports	• Project reports • Publications/publications lists • Annual plans	
	Outputs			
9.1	Trials and trial plots set up with participating rural households	• Reports and/or publications are produced at the completion of research	• Project reports • User surveys	

	Project description	Key indicators	Means of verification	Assumptions/Risks
		• At least one demonstration plot is established in each district by the end of year 1 • Results published and implemented within first two years of project	• Trial reports • Publications/publications lists	
9.2	Partnerships established with research and higher education institutes to conduct trials	• At least one partnership is established and active	• Project reports	
9.3	Technical research and design conducted	• At least one improved household-scale biogas plant designed by the first quarter of the project • Contextually appropriate large-scale biogas plants researched and designed by year 3 of the project • Improved household level biogas accessories researched and designed by year 3 of the project • Improved income-generation biogas accessories researched and designed by year 3 of the project	• Project reports • Research documents	• Large-scale biogas is relevant and interesting for the changing needs of Ethiopia's animal husbandry industry • There is commercial demand for improved household and income-generating technology
9.4	Improved and new technical design concepts implemented	• At least one improved household-scale biogas plant adopted as project standard by end of first year of project • At least one contextually appropriate large-scale biogas plant design adopted as project standard by the end of year 2 of the project • Partnerships or commercial arrangements are developed to ensure the manufacture and distribution of improved household level biogas accessories (including improved burners) by end of year 3 • Partnerships or commercial arrangements are developed to ensure the manufacture and distribution of improved income-	• Project reports • Research documents • Partnership arrangements	• Large-scale biogas is relevant and interesting for the changing needs of Ethiopia's animal husbandry industry • There is commercial demand for improved household and income-generating technology

	Project description	Key indicators	Means of verification	Assumptions/Risks
		generation accessories (including incubators for poultry eggs)		
9.5	Research conducted into social aspects of biogas use and results disseminated	• Reports and/or publications are produced at the completion of research • In-depth research conducted into at least one significant social aspect of biogas in Ethiopia by the end of year 2 • Results published and implemented within first two years of project	• Publications • Project reports	
10	**Component 10: Project management** **National/Regional Objective** To support the activities driving the development of a commercially viable biogas sector	• All annual plans submitted and approved • All regular reports submitted and approved • All periodic audit reports yield positive feedback	• Annual plans • Project reports • Audit reports	
	Outputs			
10.1	Project operational documents updated and developed	• Project handbook produced during first six months of project • Project guidelines produced during first six months of project • Project operational documents reviewed annually	• Handbooks • Project reports	
10.2	Annual plans submitted and accepted	• All annual plans submitted and approved	• Annual plans	
10.3	Regular reports submitted and accepted	• All regular reports submitted and approved	• Project reports	
10.4	Workshops conducted	• All regular reports contain information about workshops held • Participant feedback forms yield positive feedback after each workshop	• Project reports • Workshop reports • Participant surveys	
10.5	Periodic audit reports submitted and accepted	• Results of all periodic audits contained in periodic reporting	• Project reports • Audit reports	

	Project description	Key indicators	Means of verification	Assumptions/Risks
10.6	BPCO maintained	• Procedural and organisational reviews conducted and implemented • Process audits conducted and acted upon	• Project reports • Audit reports	
10.7	RBPCO established and maintained	• All participating regions establish and maintain a RBPCO • Procedural and organisational reviews conducted and implemented • Process audits conducted and acted upon	• Project reports • Audit reports	All interested regions continue to be interested in the programme All interested regions are recommended for participation in the programme
10.8	The implementation plan for roll-out of project activities developed and implemented	• Implementation plan finalised and approved in first three months of project • Implementation plan milestones met as per schedule	• Project reports • Audit reports	

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