Report on
the feasibility study on a national programme for domestic biogas in Senegal.

Pic 1

For
Agence Senegalais d'Electification Rurale (ASER)
and
SNV-Netherlands Development Organization – West Africa (SNV-WA)

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0.1 Summary.

There is a substantial need for the services of domestic biogas installations in Senegal. The currently used domestic fuels are scarce, expensive and –to a large extent- commercialized, and cooking practices are quite energy intensive. Increasingly farmers are aware of the importance to maintain soil fertility and structure. Indoor air pollution and its health consequences, resulting from cooking with biomass on simple stoves, is for many women and children a serious problem. The observed farm-yard hygiene, especially due to littering of animal manure, is far from optimal. At country level, deforestation and desertification are grave environmental issues.

The technical conditions for operation a biogas installation are met in many households. Most of the visited households have sufficient dung available on a daily basis; households often keep significant numbers of cattle and “zero grazing” practice is gaining popularity. Although for nearly all households water comes at high price, households typically do have access to water within a radius of –say- 1 km from their yard.

Mainly due to the dens agricultural population and the high incidence of integrated farming, the socio-economic and technical potential for domestic biogas appears most promising in the *Basin Arachidier*, (regions Fatick and Kaolack). Pocket areas in Northern Senegal (Louga, St. Louis) and Southern Senegal (Casamance) certainly qualify as well, but active demand may be insufficient and too dispersed to justify a programme start.

As Senegal’s track record regarding domestic biogas is limited to a few demonstration plants, active, commercial demand is difficult to gauge. The technical potential, however, is estimated between 175,000 and 400,000 installations. Of this potential, the Bassin Arachidier should be good for some 50,000 plants.

A complicating factor regarding a proper estimate of the potential for domestic biogas proved to be the absence of reliable data on the share of “pastoral cattle herds” in the total cattle population. SNV-West Africa allowed for a second, shorter mission to verify the impressions of the earlier mission.

To test the active, commercial demand for biogas, but also to allow time to develop a model for both the biogas installation as well as dissemination programme that fits well in the Senegalese situation, the mission recommends to start with a one year pilot phase. To that extent, the report details activities, success criteria and budget for such a pilot. As a pilot should be in the perspective of an “anticipated follow-up”, the report also provides an outline of a full-scale dissemination programme. It should be noted, however, that a programme-proper can only be justified with successful results of the pilot.

The investment cost of a typical biogas plant in Senegal is high; financial support structures –a combination of subsidy and credit is proposed- are crucial if the technology is to be adopted swiftly. The report advises a market-oriented introduction of the technology, where Biogas Construction Companies will be responsible for marketing, construction and after sales service of domestic biogas. As such companies are currently none-existent in Senegal and as biogas construction and after sales service requires high standards of workmanship and quality awareness, the programme will have to deal with a significant training and supervision effort. It will be important for these Biogas Construction Companies to make use of the existing extension network (agriculture & livestock, rural development, health & sanitation, water).

Although ASER seems well placed to assume overall responsibility and coordination of a national biogas programme, the mission advises a more detailed stakeholder analysis before a final choice is made. Similarly, with this report in hand the mission would like to advise SNV to clarify its position in view of supporting biogas activities in Senegal.

The report is divided in 4 sections.

Section 1 addresses the background of the Country, Senegal's main geographic, climatic, demographic and agricultural characteristics and provides an outline of the energy situation. The section concludes with a brief explanation on domestic biogas and its status in the country.

Section 2 starts with the study set-up. It furthers with the study's main findings on 6 feasibility factors: technical, economic, socio-cultural, environmental, programmatic and political.

Section 3 assesses the main conditions for large-scale dissemination of domestic biogas and subsequently presents the mission's conclusions and recommendations. The section closes with an assessment of the main opportunities and risks.

Section 4 proposes the outline of a domestic biogas programme for Senegal. After presenting the main features it details objectives, scope and indicators for a pilot programme. Thereafter, a proposal is presented for a succeeding full scale domestic biogas programme, including a tentative activity schedule and programme budget.

0.2 Acknowledgement.

The Agence Senegalais d'Electrification Rurale, by the persistence of its Director Mr. Aliou Niang and his staff, planted and followed-through the idea for a feasibility study on domestic biogas. Mr. Wade of ASER has been of tremendous help during field preparations.

Together with similar endurance from the side of SNV-West Africa, most notably by its Director Guinea Bissau Mr. Marc Steen, this mission was made possible by providing financial and logistical support and guidance. The effort, and the trust invested in the team is highly appreciated. Members of the Biogas Practice Team, most notably Mr. Wim van Nes, were invaluable in their assistance to shape this report.

Mr Jan de Witte, Director SNV West Africa deserves in particular our gratitude for allowing a second mission to collect additional information. In this regard, Mr. Raoul Snelder should be thanked as well for carrying out the second mission swiftly and very professionally.

Mr. Kanouté of the Directorate of Energy deserves our thanks for test-reading the draft of this document and for providing us a wealth of information on Senegal's national energy situation. Information that otherwise proofed very hard to obtain.

The team is further indebted to all persons and organizations that took time to assist us during field visits and interviews. The privilege of meeting this many knowledgeable and experienced people was entirely ours. Especially the officials of the regional Departments of Livestock and PAPEL offices deserve our gratitude.

The contributions of household members, local and national organizations and colleagues provided the study with meaning and made doing the study a pleasure. Despite all input and feedback, the report will likely have errors. Obviously these will be entirely the team's responsibility.

The Hague,
September 2007

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0.5 Abbreviations.

(F/E/M) IRR	(Financial / Economic / Modified) Internal Rate of Return
(SNV) BPT	(SNV) Biogas Practice Team
(Solar) pV	(Solar) photo Voltaic
€	Euro
AfDB	African Development Bank
AFME	l'Agence Francaise pour la Maitrise de l'Energie
ASER	Agence Senegalais d'Electification Rurale
BAB	Biogas Advisory Board
BCC	Biogas Construction Company
BFI	Biogas Feasibility Index
BPO	Biogas Programme Office
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CERER	le Centre d"Etudes et de Recherches sur les Energies Renouvables
CIRAD	le Centre de Cooperation Internationale de Recherche Agronomique
CNRA	le Centre National de Recherches Agronomiques de Bambey
CRAT	le Centre Regional Africain de Technologie
DIREL	Direction de l' Elevage
ECOWAS	
ENDA	Environnement et Developpement du Tiers Monde
ENSUT	l' Ecole Superieure Universitaire de Technologie
fCFA	Franc de Communaute Financiere Africaine
GDI	Gender-related Development Index
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GTZ	Organization for Technical Cooperation, Germany
HDI	Human Development Index
hh	Household
HPI	Human Poverty Index
ICS	Improved Cooking Stove
IPCC	Inter-governmental Panel an Climate Change
ISRA	l'Institut Senegalais en Recherches Agricoles
LVIA	Associazione di cooperazione e Volontariato Internazionale
M&E	Monitoring and Evaluation
MDG	Millennium Development Goals
MFI	Micro Finance institute
MJ, GJ, TJ	Mega (10^6)-, Giga(10^9)-, Tera(10^{12}) Joule
NGO	Non-Governmental Organization
NPV	Net Present Value
NTFP	Non-Timber Forest Products
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
PAPEL	Project d'Appui a l'Elevage
PERICOD	
PROGEDE	Programme de Gestion Durable et participative des Energies traditionelle et de substitution
PRSP	Poverty Reduction Strategy Paper
PRSP	Poverty Reduction Strategy Paper
R&D	Research and Development
RNE	Royal Netherlands Embassy
SHS	Solar Home Systems
SNV	SNV / Netherlands Development Organization
SWOT	Strong – Weak – Opportunity – Threat
TLU	Tropical Livestock Unit
ToT	Training of Trainers
UEMOA	Union Economique et Monetaire de l'Afrique de l'Ouest
UN-FAO	United Nations Food and Agriculture Organization
US-DoE	United States Department of Environment
VER	Verified Emission Reduction
VEV	Vent et Eau pour la Vie

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0.7 Exchange rates.

1 Euro	656 francs CFA

Section 1
Introduction and background


Pic 2

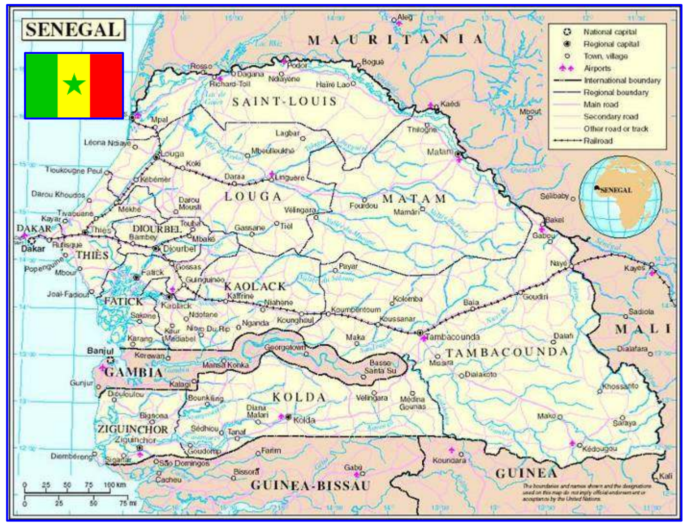

Pic 3


Pic 5


Pic 4

1 Introduction.

1.1 History in brief.



Archaeological findings throughout the area indicate that Senegal was inhabited in prehistoric times. Islam established itself in the Senegal River valley in the 11th century; 95% of Senegalese today are Muslims. In the 13th and 14th centuries, the area came under the influence of the Mandingo empires to the east; the Jolof Empire of Senegal also was founded during this time. In the 16th century, the Jolof Empire split into four competing kingdoms: the Jolof, Waalo, Cayor and Baol kingdoms.

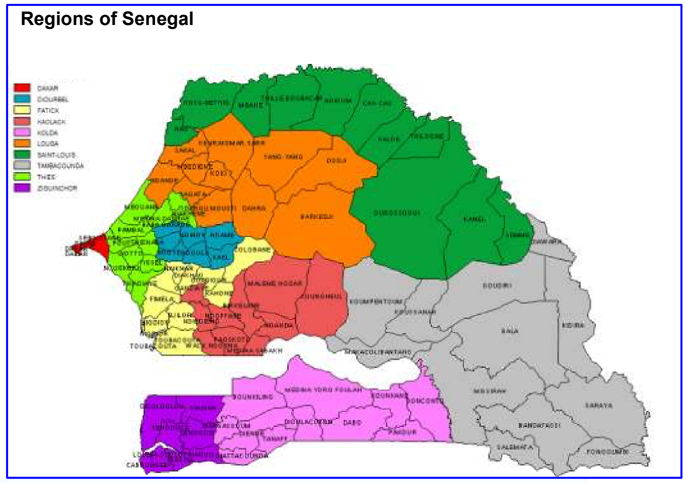
Various European powers - Portugal, the Netherlands, and England - competed for trade in the area from the 15th century onward until, in 1677, France ended up in possession of what had become an important slave trade departure point - the infamous island of Goree next to modern Dakar. It was only in the 1850s that the French began to expand their foothold onto the Senegalese mainland.

In January 1959, Senegal and the “French Soudan” merged to form the Mali Federation, which became fully independent on June 20, 1960. Due to internal political difficulties, the Federation broke up on August 20, 1960; Senegal and Soudan both proclaimed independence. Léopold Sédar Senghor was elected Senegal's first president in August 1960. In 1980, President Senghor retired from politics, and handed power over to Abdou Diouf in 1981. Abdou Diouf served four terms as President. In the presidential election of 2000 Abdoulaye Wade was elected. Senegal joined with The Gambia to form the nominal confederation of Senegambia on February 1 1982. However, the envisaged integration of the two countries was never carried out, and the union was dissolved in 1989.

1.2 Government and administration.

Senegal is a secular republic with a strong, independent judiciary and multiple (~65) political parties. The unicameral National Assembly has 120 members, elected separately from the president. The Socialist Party dominated the National Assembly until April 2001 after which president Wade’s coalition own a majority. The principal political parties constitute a true multiparty democratic political structure, and they have contributed to one of the most successful democratic transitions; Senegal is one of the few African states that never experienced a coup d’etat[1]. The country’s tolerant culture, largely free from ethnic or religious tensions, together with the flourishing independent media contributes to the resilient democratic politics of the country.

Regions of Senegal



Senegal is divided in 11 regions subdivided in 34 departments, 94 arrondissements and 320 commune rurals and 13,212 villages. The regional governors, prefects and sous-prefects of the regions, departments and arrondissements respectively are appointed by the government. The “presidents de commune rural” and the “chefs de village” are elected by the local population.

[1] In contradiction with Senegal’s general political stability and despite peace talks resulting in a peace treaty in 2000, southern separatists in the Casamance clash sporadically with government forces since 1982.

1.3 Population.

Senegal features a wide ethnic variety with the Wolof (43%) as the largest single ethnic group. Other groups include the Fula –traditionally a nomadic, pastoral community herding cattle and Tukulor –differing from the Fula only by the sedentary nature of their society (24%), the Serer (15%), Lebou (10%), Jola (4%), Mandika (3%) and many smaller communities. The official language, French, is only regularly practiced by a literate minority, whereas Wolof can be considered as Senegal's “lingua franca”.

Senegal's population amounts to nearly 12 million (est 2006). Over the period 1988 – 2004 the population growth amounted to 2.7 % per annum[2]. A similar calculation for the period 2002 – 2004 indicates the population growth is actually increasing[3], at current rates Senegal's population would double every 25 years.

The spatial distribution of the population is unbalanced; in 1999 65% of the population was concentrated on 14% of the national territory. Regional population density varies from 11 persons per km^2 in the southwest to over 200 persons per km^2 in the central-western regions (Dakar region: 4363 persons per km^2).

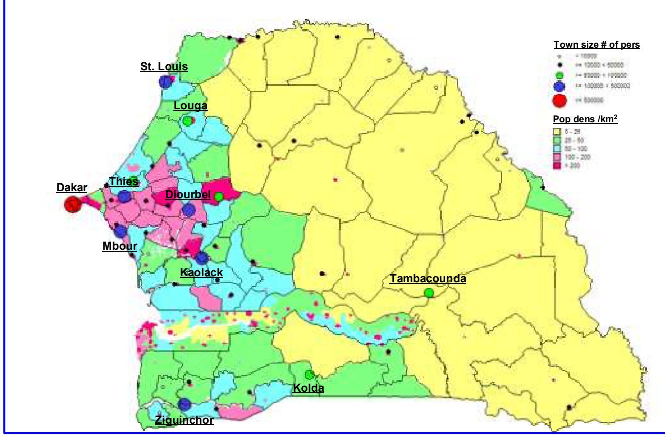
For 2005, the population of the Dakar metropolitan area was estimated at 2.4 million people (~ 22% of the total population and 53% of Senegal's urban population). Other main cities include Touba, Thies, Rufisque, Kaolack, Mbour, St.Louis and Ziguinchor. The urban population increases with ~ 4% pa.

According to the 2004 data, 56% of Senegal's lives in the rural areas. The rural population growth decreased from 2.2% pa in the 80s to 1.1% in the 90s.

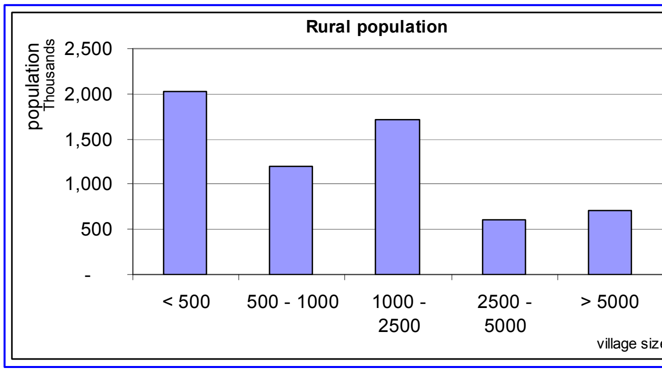
Whereas 75% of the rural villages have a population smaller than 500 persons, nearly half of the rural population -of over 6.4 million people- live in villages with more then 1000 inhabitants

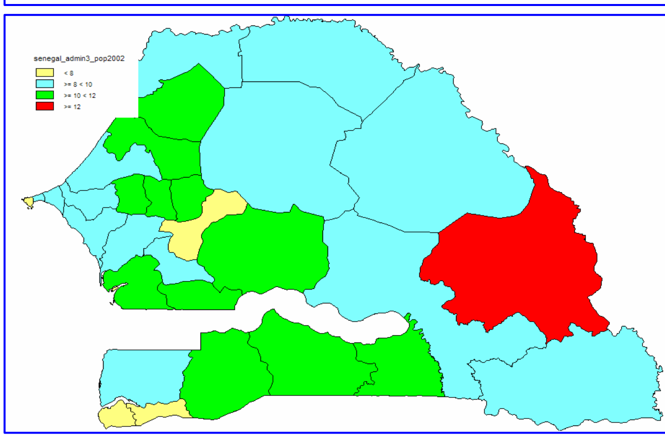
Households in Senegal typically are large. Especially in more rural areas families of over 10 members are no exception.

Major towns and population density of Senegal



Main population characteristics				[2004]
Region	population [pers]	density pers/km^2	growth [avg/year]	rural [%]
Dakar	2,399,451	4363	3.0%	3%
Diourbel	1,144,009	262	3.9%	45%
Fatick	643,505	81	1.5%	91%
Kaolack	1,114,292	70	2.0%	79%
Kolda	893,867	43	2.6%	88%
Louga	714,732	24	2.4%	81%
Matam	461,836	18	3.9%	94%
Saint-Louis	738,724	39	3.7%	66%
Tambacounda	650,399	11	3.3%	84%
Thiès	1,358,658	206	2.3%	56%
Ziguinchor	444,830	61	0.7%	60%
Senegal	**10,564,303**	**54**	**2.7%**	**56%**





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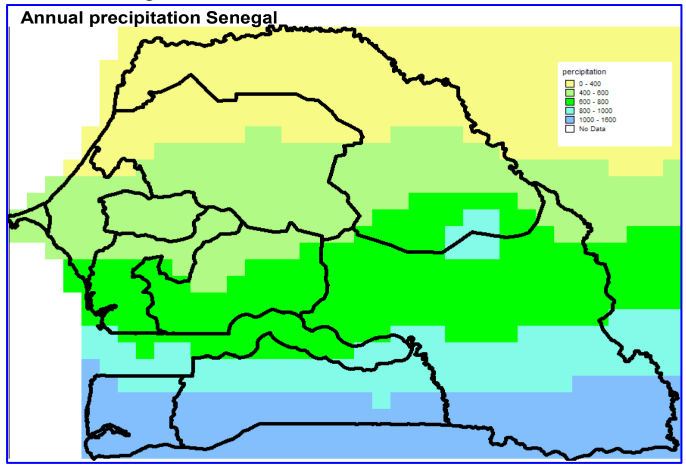
[2] Source: http://www.citypopulation.de/Senegal.html#Land, population growth calculated as average annual increase.

[3] The world fact book estimates population growth for 2006 at 2.34%

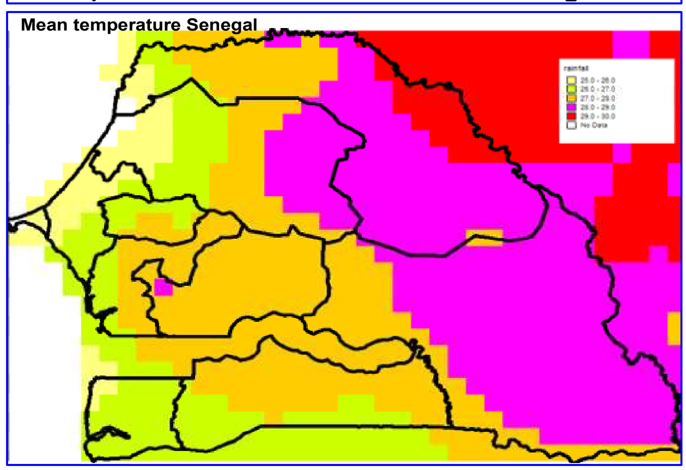
1.4 Geography, climate and vegetation.

Senegal is a coastal West African country (14° N, 14° W) with a total area of 196,190 km^2 including 4,190 km^2 water area. On land, the nation borders with Mauritania to the north and Mali to the west along the Senegal River. In the south east and south, more or less following the Casamance River, Senegal borders Guinea and Guinea –Bissau respectively, The Gambia, as a near enclave, penetrates into the country for more than 320 km from the Atlantic coast eastwards along the river with the same name.



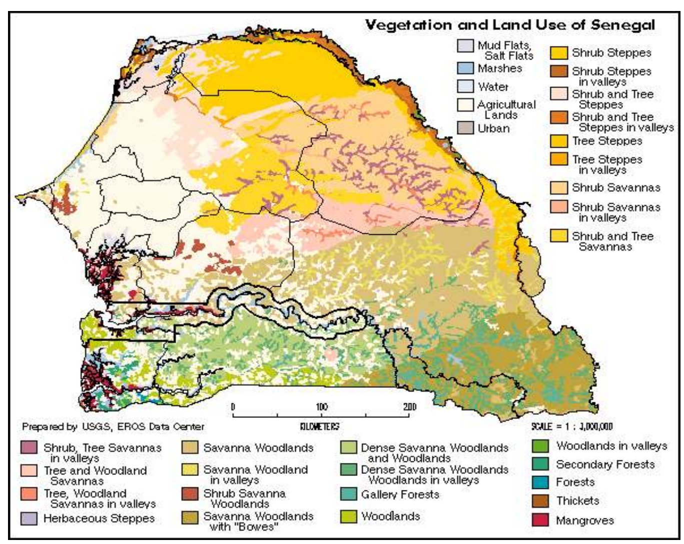
The local climate is tropical with well defined dry and humid seasons result from northeast winter winds and southwest summer winds.

Current annual precipitation[4] ranges from just under 300 mm in the northwest to over 1500 mm in the south of the country and falls between June and October. Important to note is that over the period 1950 – 1995 the “< 400 mm” isohyets moved southwards some 200 km from just under St. Louis to well south of Dakar in the mid 90s. Clearly, this climate change contributed to the increasing desertification. Over the past decade, however, this development seems to reverse.



Temperatures range from minimum 15 °C in January in the northwest up to maximum 42 °C in May along the eastern border with Mauritania. The mean temperature roughly increases from west to east from 25 °C to 30 °C.

The seasonal vegetation growth patterns of Senegal are triggered by the annual monsoon. Accordingly, the vegetation of Senegal –from north to south- can be divided into the Sahelian, Sudanian and Guinean Region.



The **Sahelian Region** occurs between rainfall isohyets of 150 and 700 mm in northern Senegal. The early seasonal rains, which usually begin in July, transform the landscapes into green, lush rangelands, drying out quickly after the last rains in late September. During the long dry season of 8 to 10 months, the herbaceous cover disappears as livestock and termites devour it, exposing bare soil to wind erosion. The primary land use is animal raising which has been a traditional activity for centuries. Woody plants are usually associated with the vast expanses of seasonal grass cover, together forming the dominant vegetation types of the Sahelian Region. The woody cover rarely exceeds 6 to 8 meters in height.

The **Sudanian Region** lies to the south of the Sahel, covering about two-thirds of central and southern Senegal. It is the domain of the savannah. The typical vegetation types include the savannah woodland and

[4] Source: Worldclim dataset, version 1.3 October 2004.

the dry woodland. The area is placed between the 700 and 1500 mm isohyets. It is characterized by rainfall spread over 5 to 6 months, of which July, August and September are nearly certain to have rain. Like the Sahelian Region, the rains occur during the high sun, summer months. A distinct dry season of 6 to 7 months is transformed into a wet, green season by the first rains, triggering vigorous vegetation growth. While the Sudanian Region is often defined by average annual rainfall, other criteria are also considered. Some 80 woodland species have been identified as being specific to this region. Human occupation has greatly modified the vegetation composition and structure, particularly in the Bassin Arachidier ("Peanut Bassin"). To the east, including much of the Tambacounda Region, human pressure is less intense, and the vegetation formations approximate the climax vegetation that once blanketed the Sudanian Region. Annual bush fires continue to play an important role in maintaining more or less open woody vegetation types.

The **Guinean Region** proper can only be found in the extreme southwest corner of Senegal, although characteristics of this zone begin to manifest themselves in the southern Sudanian Region. This is the region of the semi-evergreen dense forest; its extent has been reduced by widespread deforestation for the cultivation of rice, manioc and peanuts. The Guinean Region predominates in the areas of average annual rainfall exceeding 1500 mm. Despite the high rainfall, this region has a distinctly dry season of 7 to 8 months, distinguishing it from the Equatorial Region of Africa.

2 Development and economy.

A household survey in 1994 revealed that nearly 58% of Senegal's population was living below the poverty line (< 2400 kJ pp pd). Despite the improvement due to economic reforms –GDP growth increased from 2.7% in 1994 to 5% in 2001- the share of the population living below the poverty line in the latter year remained as high as nearly 54%.

For that reason, Senegal formulated its first **Poverty Reduction Strategy Paper** (PRSP) in 1997, aiming to increase income, improve access to basic services, promote the position of women in society and reinforce the capacity of grass root organizations. The PRSP provides a framework for all interventions and actors in the socio-economic domain. The current PRSP is in line with Senegal's 10th five year development plan, and is integrated in sectoral plans in the areas of education and training, health, infrastructure, rural development, decentralisation and poverty reduction. The Ministry of Economy and Finance is responsible for the overall coordination of the implementation of the PRSP, with focal point established at each ministerial department.

Parallel to the development of the PRSP, the international community initiated and adopted the **Millennium Development Goals** (MDGs), offering a framework to translate Senegal's PRSP in sector programmes and projects in operational terms. Follow-up of the MDGs is assured by a national committee under the Ministry of Planning. The committee consists of working groups on the fields of infrastructure (including energy), environment, health, water, gender and income generation.

The current PRSP document places energy as an important dimension in development. For families access to clean, safe and sustainable energy is a precondition to improve the quality of life. Economically, energy is a main resource for production and its costs directly affects the competitiveness of products.

Millennium Development Goals

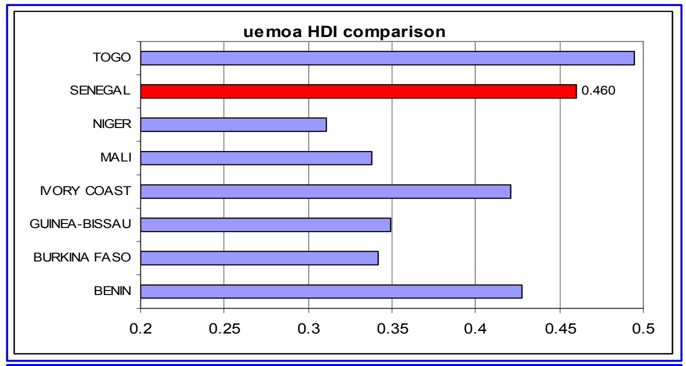
1. Eradicate extreme hunger and poverty
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

Energy poverty in Senegal

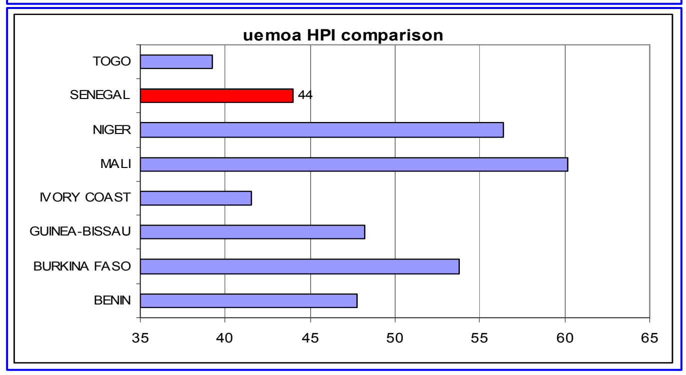
- Senegal's primary energy consumption of 0.34 toe per capita annually equals half of the that of India and only one fifth of the global primary energy consumption.
- Very low electric energy consumption of 450kWh per year per person compared with a global average of 2500 kWh per capita per year (developing countries 900kWh, industrialized countries 9000 kWh)
- Only 13% of the rural population (2004) having access to electricity.

2.1 Main Human Development indicators.

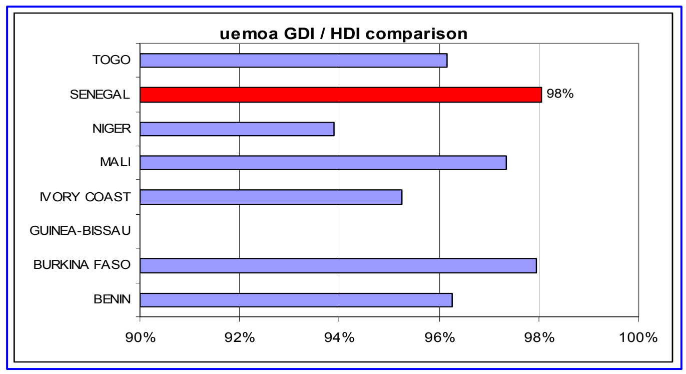
The **Human Development Index** (HDI) [5] provides a composite measure of 3 dimensions of human development: living a long and healthy live, being educated and having a decent standard of living. Senegal scored 156th out of 177 on the HDI ranking. Senegal's HDI progress exceeds the average of sub-Saharan Africa. In the "UEMOA perspective" Senegal scores second-best after Togo with an HDI value of 0.460.



Similar to the HDI, the **Human Poverty Index** (HPI-1) measures human development. As the HPI-1 focuses on the proportion of people living below a threshold it provides a multi-dimensional alternative to the 1$ per day measure. The HPI-1 value for Senegal, 44, ranks 84th among 102 developing countries and 3rd in the UEMOA perspective, following Togo and Ivory Coast.



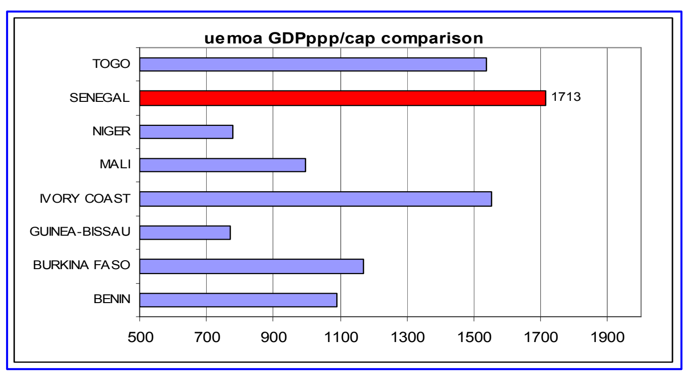
The **Gender-related Development Index** (GDI) measures a country's achievements in the same way as the HDI but captures inequalities in achievement between women and men. Senegal's GDI value, 0.451, should be compared with its HDI value of 0.460. The country's GDI value reaches 98% of its HDI value. Out of 136 countries for which both HDI and GDI was calculated, 111 have a better score than Senegal. In the UEMOA region, Senegal scores best.



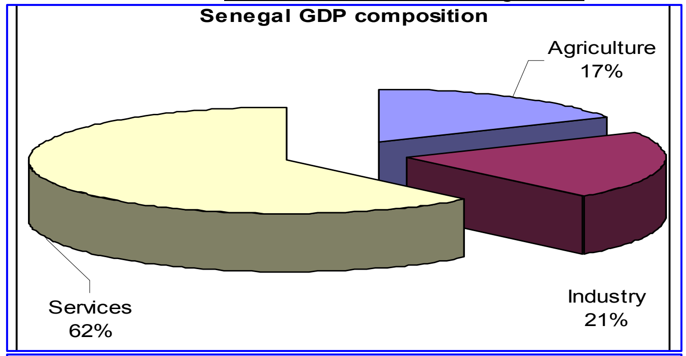
2.2 Main economic indicators.

Over the period 1960 – 1993, Senegal's economic growth, then at a rate of 2.7 % per annum, used to lack behind population growth.

From 1994, after the devaluation of the currency, Senegal's economy shows a more rapid and robust development, maintaining annual economic growth figures of 5 to 6% per annum between 1999 and 2005. The country's 2005 national product amounted to $ 20.57 billion$_{ppp}$ or $ 1800 $_{ppp}$ per capita. In the UEMOA region, GDP$_{ppp}$ variance is large, with Senegal's per capita product over two times higher than its southern neighbour Guinea Bissau.

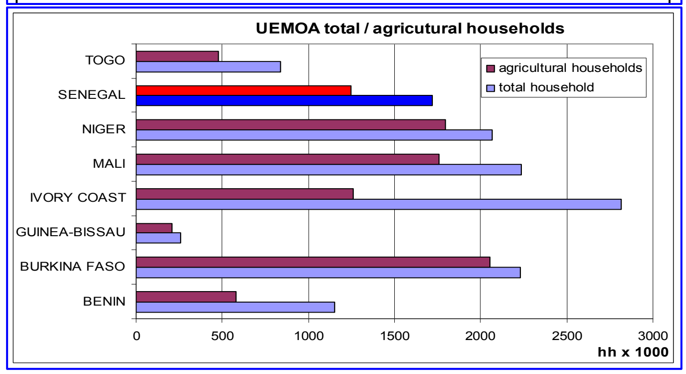


[5] Data from the 2006 UN-Human Development Report, using data from 2004.



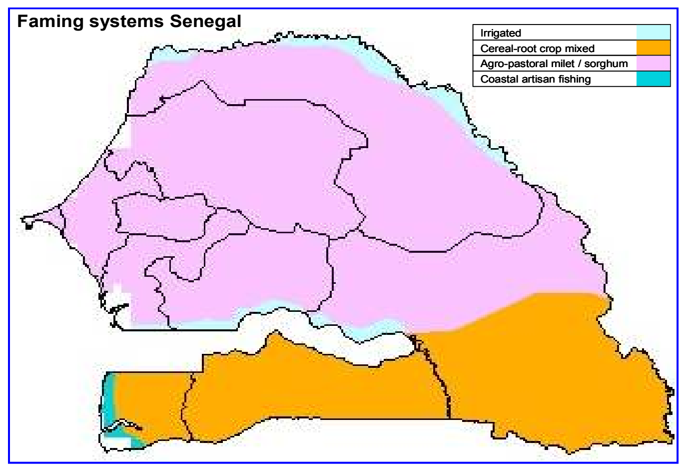
The economy is dominated by the tertiary sector; services (transport, communication, business) supporting over 62% of the national production. In 2005 the industrial sector contributed to nearly 21% of the national product. Both primary and secondary sector have shown steady growth over the past decade.

The contribution of agriculture to the gross domestic product is reducing. While in 1990 the primary sector still provided over 21% of the GDP, its significance reduced to 17% for 2005. Even so, the agricultural sector still creates 50% of national[6] and over 70% of the rural employment.

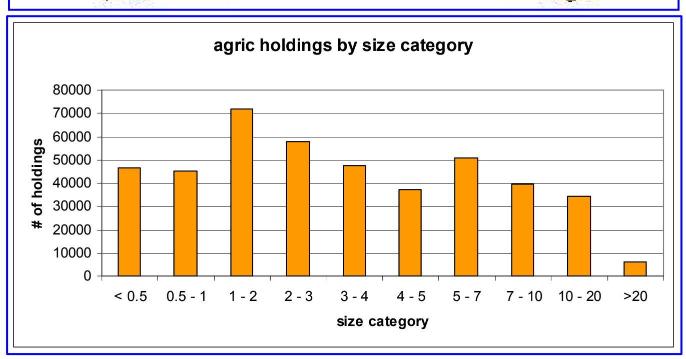


2.3 Agriculture and livestock.

The total agricultural area of Senegal amounts to 81,560 km^2 (42% of the total land area), out of which 56,500 km^2 (69.3% of total agricultural land) is under pasture. Mainly along the larger rivers, irrigated agriculture is developing resulting in 710 ha of irrigated land. The amount of agricultural land as well as the ratio cultivated / pastoral land have hardly changed over the past 20 years. Senegal's soils are dry and sandy in the north, ferrous in the central regions and lateritic in the south. In general, soil fertility is very poor and extremely vulnerable to wind and other forms of erosion. According to IPCC's Conventional Development Scenario[8], cropland degraded at a rate of 227,000 ha per year in 1995, and will still deteriorate with 87,000 ha per year in 2025.

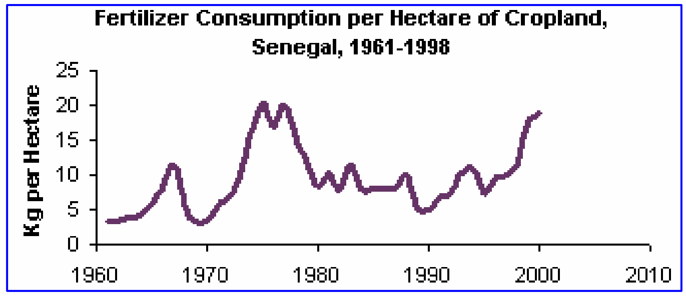


Agriculture: Farming is done mainly on small family farms (< 3ha). On average, a farm would have 4.3 ha of cultivated land, whereby 70% of the agricultural holdings work 33% of the cultivated land[7]. Some 437,000 agricultural holdings have 17,777 km^2 agricultural land in ownership, about 23% of the total agricultural area.



Agricultural families are typically large, with an average of 12 persons per family (7 of them involved in agricultural activities), 0.21 persons hired permanently and 0.45 persons hired temporarily. Agriculture is further characterized by (very) low levels of mechanization and agricultural input consumption.

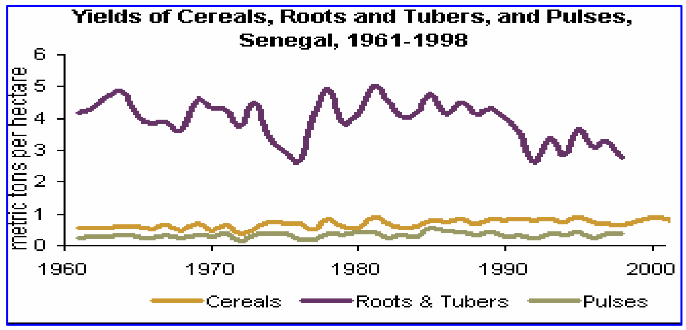
6 The FAO Livestock Sector Brief 2005 mentions 73.1% of the population involved in agriculture
7 Senegal agricultural census 1998-1999



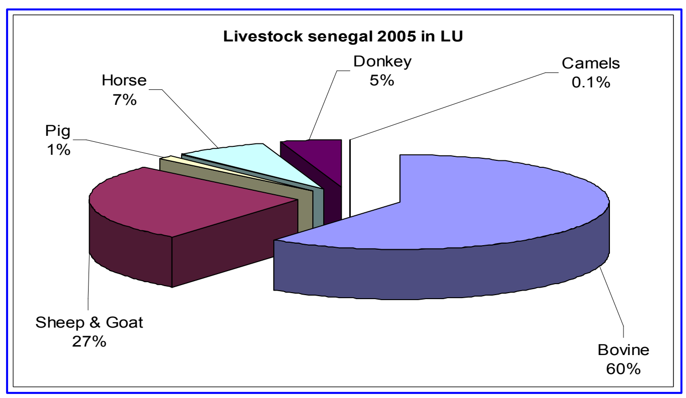
Agriculture being mainly rain-fed, (cereal) production is subject to strong variations (avg > 10%). Farming systems include irrigated crop farming along the rivers the Senegal and the Gambia; agro-pastoral millet / sorghum farming in the northern and central part of the country and mixed cereal / root crops in the south.

With a yield of 854 kg/ha, the average production (1999-2001) of cereals amounted to 1061 kilo tonnes per annum. Over this period roots and tubes yielded 3037 kg/ha, producing 51000 tons per annum and pulses produced 165000 tonnes per annum on a yield of 330 kg/ha.

Senegal's main agricultural areas are situated in regions Thiès, Diourbel, Fatick and Kaolack. The agricultural area in the latter two regions is often referred to as the "Bassin Arachidier". Agricultural produce includes mainly peanuts, millet, corn, sorghum, rice, cotton, tomatoes and green vegetables.

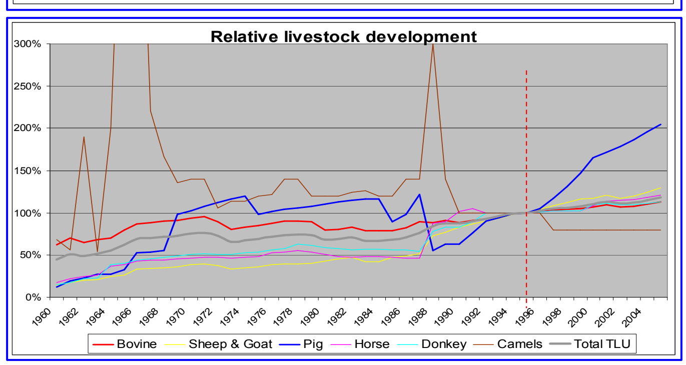


Over the past 40 years Senegal's food production -in absolute terms- showed very little growth; the yield of roots and tubers shows great variation in a declining trend, yields of cereals and pulses stayed at the same level. With the growth of the population, the per capita food production situation actually worsened significantly. The reduction of food production contrasts with the gradual increase of chemical fertilizer use, possibly indicating in increasing nutrient depletion of the cultivated soils (in combination with a period of decreasing rainfall (see chapter 1.4). The combination of stagnant -or even reducing- agricultural production with an increasing population pressure results for Senegal in a net food shortage. The country depends for more than 50% of its food security on imports (including a small share -2.7%- of food aid).



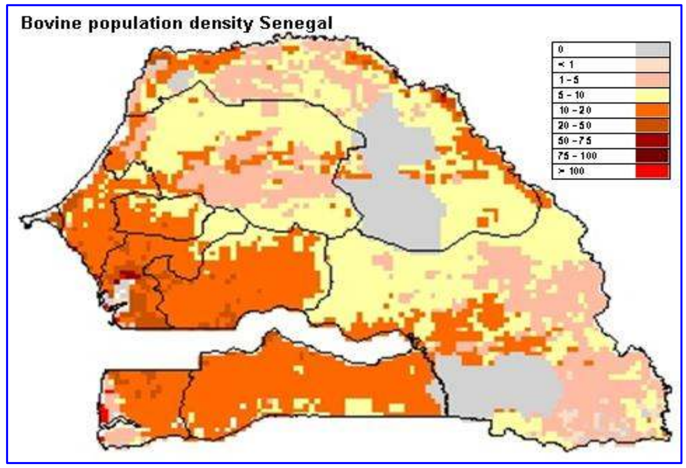
Livestock: Livestock in Senegal includes 3.2 million heads of cattle, 9.3 million sheep and goat (about 50-50%), 330,000 pigs, 525,000 horses, 412,000 donkeys and 4,000, camels and 21.8 million poultry (mainly chicken). Measured in Tropical Livestock Units[8], cattle constitute 60% of Senegal's livestock, and sheep and goat just over one quarter.

Senegal's cattle herd has shown a steady growth – from 1.7 to 3.2 million heads-over the past 45 years. Most other livestock – sheep and goat, horse, donkey- show a similar development. Pig holding, although still modest in absolute terms, has grown disproportional, particularly over the past decade (> 100%). The camel population shows strong fluctuations, the average seems to decrease. The total livestock population, in terms of TLUs, increased with nearly 20% over the past decade. Senegal's livestock density (2005 data) results in 0.36 TLU per ha agricultural land and just over 12 TLU per agricultural holding.



[8] TLU conversion factors: cattle (1.00), sheep & goat (0.15), pigs (0.20) horses (0.80), donkeys (0.70), camels (1.40)

Livestock contribute to the livelihood of ~ 30% of Senegalese households. Pastoralists and agro-pastoralists mainly raise cattle, sheep and goats and marginally participate in the meat market. Most of the Senegalese rural households are involved in traditional –small scale- poultry raising.



Cattle density decreases to the north, east and southeast. The highest densities are found in the Casamance, south of The Gambia, and in the area roughly marked by the cities Thiès – Louga – Kaolack – Mbour (the Bassin Arachidier).

Three cattle raising systems can be distinguished[9]:

1. The traditional extensive "transhumance" system. Pastoralists are located in the northern Ferlo region and in the extreme southeast of the country. They are amongst the poorest groups of the country and livestock is their main source of wealth. In comparison with the other systems, the "transhumance" is increasingly becoming a marginal activity as it is competing with the semi extensive system for pastures.
2. The traditional semi-extensive system as practiced e.g. by the Serere agro-pastoralists. Here cattle is grazed on pastures in the area of the village, and brought home (in large pens just outside the village or on the farmyard) every evening. Agro-pastoralists in the "Bassin Arachidier" are better placed to benefit from commercial, intensified livestock farming than pastoralists. They are physically closer to markets (Dakar, Thiès, Diourbel, etc) and have sufficient availability of feed supply from crop residue. Semi-extensive farming expanded in the past but, according to many, has reached its limits.
3. The more recently adopted "zero-grazing system". Stimulated by environmental and economic considerations, this system has been steadily on the increase, and is getting significant support from various government and non-government agencies. Zero-grazing farms are largely found in peri-urban areas and larger settlements. These cattle farmers are increasingly getting organized to promote their interests and to get access to modern methods (artificial insemination, veterinary services, dairy storage, transport and production, credit)

Overall, meat and milk production steadily increased over the last decades, almost entirely as a result of the increased number of animals. Productivity of the animals has remained stagnant at a –even for developing countries- very low level (avg cattle carcass weight / animal only 125 kg, milk yield under 300 kg/year, percentage milked ~ 10%)[10]. Cattle development is constrained by the persistence of certain epizootic diseases, shortage of pasture and functioning water points, low meat and milk yields of local breeds. These constrains are compounded by the limited public investment for the livestock sector and insufficient credit facilities for livestock producers[11].

As the majority of Senegal's population is Islamic, pig raising is uncommon and limited to areas in Le Saloum, just north of The Gambia, and the Casamance. Although pig raising increased significantly over the past 10 years, absolute numbers are still modest in view of a biogas programme and observations would indicate pig raising to be very much in a "free ranging" modality.

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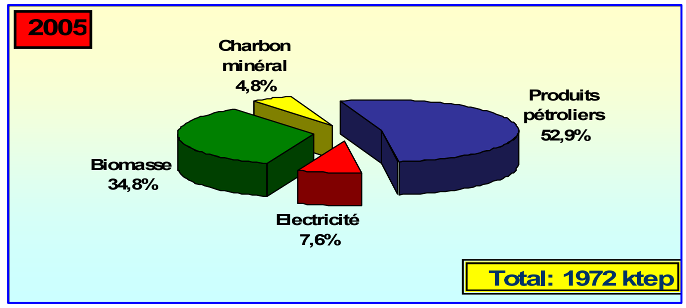
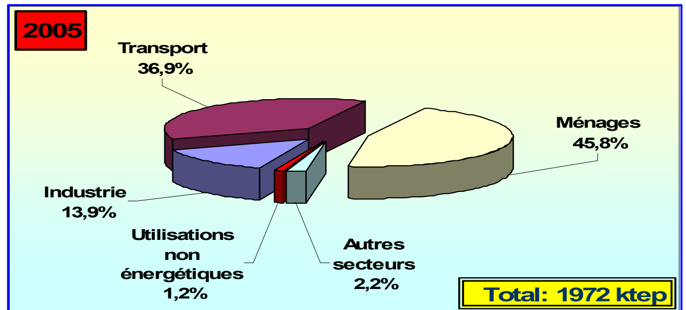
[9] Report of a mission to collect additional information for the feasibility study on a national programme for domestic biogas in Senegal, August 2007 by Raoul Snelder.
[10] FAO Senegal Livestock Sector Brief, March 2005.
[11] Observations of the mission in 2007 would indicate that both health and financial barriers to livestock development are reducing.

3 Energy demand and supply.

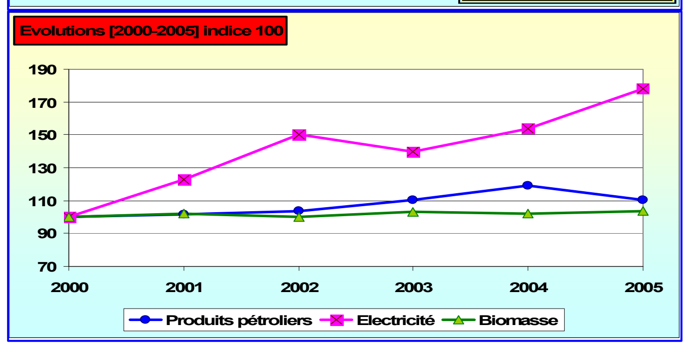
The energy sector can be divided in the two sub-sectors of traditional energy and “modern” energy. The main source of traditional energy is biomass. Biomass energy in Senegal includes mainly fuelwood and charcoal, but probably (not captured in the statistics) in rural areas dung and agricultural residue is used to some extent as cooking fuel as well. In the IPCC’s Conventional Development Scenario[12] for the period 1995 - 2025, biomass energy use is projected to nearly triple from 444 PJ to 1121 PJ. Modern energy includes petroleum products and electricity (mainly of thermal origin). Not unlike other West African countries, the relation between energy and environment is evident. In Senegal in particular, ecosystem degradation as a result of natural (rainfall deficit, drought) and anthropogenic factors (over-exploitation of forests, extensive agriculture, overgrazing, etc) is reaching levels that, for many regions of the country, threatens the very survival of its population[13].



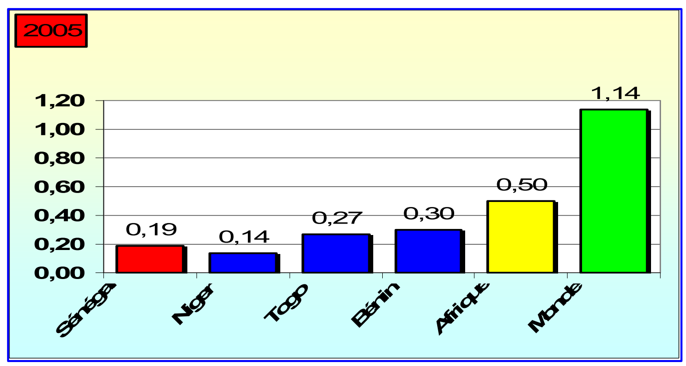


3.1 National energy consumption.

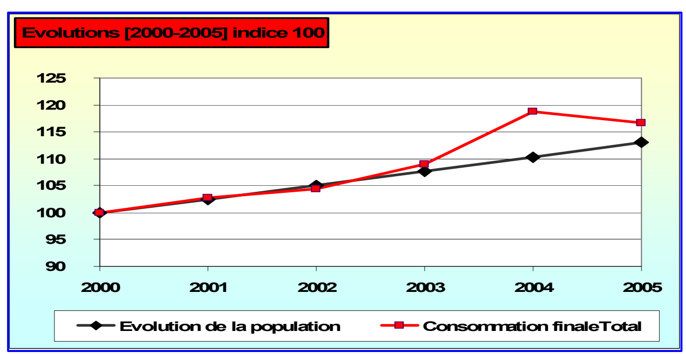
The total energy consumption is in the range of 20 to 30 million GWh per year, with estimates showing a considerable variance. For this report, data obtained from the Directorate of Energy of Senegal, providing the most recent information (2005)[14] is used.



Over the past decade, the contribution of biomass in the country’s energy provision shows a gradual decline, the gap mainly being filled by increasing consumption of electricity and –to a lesser extent- petrol products. In absolute terms, however, biomass consumption (mainly fire wood and charcoal) remained on the same level. Households are the largest consumer of energy, although their share reduced over the past decade, accommodating a significant increase in the energy consumption by the transport sector.



Documents show a wide range for estimates for the per capita energy consumption; from less than 2 to 4 MWh / cap / year. Per capita consumption of Senegal is low in both a global as well as a regional perspective[15].



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[12] Youba Socona, Tomas J. P., Toure, O; October 2003, Development and Climate, Country Study Senegal, 4th draft

[13] Bocar Sada Sy, May 2005, Republique du Senegal, Monographie Pays, prepare pour CEDEAO, PNUD & PREP

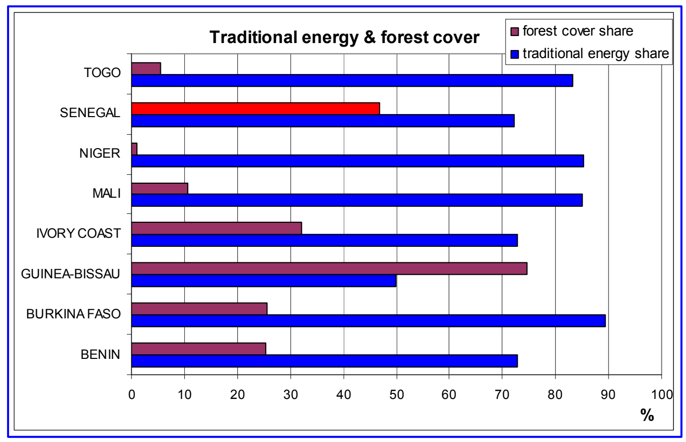
[14] Energy information for this chapter provided by Mr. Kanouté of the Directorate of Energy of Senegal

[15] SIE-Livre Blanc CEDEAO 2004 – Enerdata

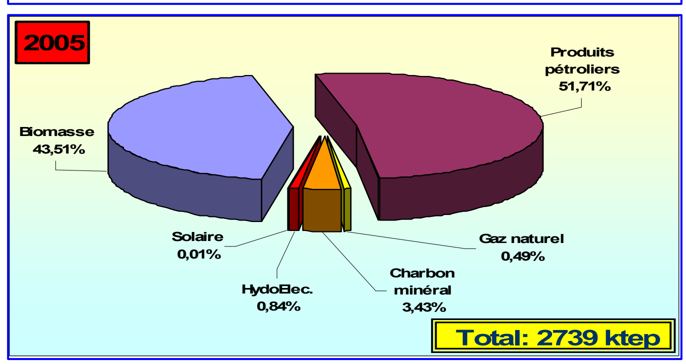
Over the past 25 years, both the energy consumption per capita as well as the energy / GDP intensity show little development. In view of the significant urbanization, with corresponding growing energy requirements, the stagnant energy per capita consumption indicates that the energy situation for the rural population is actually deteriorating. The stagnant energy / GDP intensity points at little change in the productive use of energy.

3.2 Energy resources.

Wood fuels: Wood fuels play the main role in supplying domestic and small industry energy. Despite this role, the forestry sector officially only contributes to 1% of the country's GDP and 5% of the agricultural GDP; it is estimated that 75% of the wood production does not end up in the official statistics. Forest exploitation is estimated (unofficially) at having a turnover of 20 billion FCFA per year, employing 20,000 persons. There is no updated forest resource inventory. For 1995, 11.5 million ha was estimated to be covered with woody biomass which would equal to ~ 60% of the country's land area. However, the area includes 38% of dense forests and forested savannah, the remaining is classified as savannah with "bush" coverage, having a considerably lower wood yield. According to FAOSTAT, Senegal's current forest cover is 45%.



The total productivity is estimated at 8.6 million m^3 per annum, total standing wood resources are in the tune of 331.3 million m^3, 90% of which in the Tambacounda and Kolda regions. Although in the UEMOA setting Senegal seems relatively well-off, the current trend in consumption and production (4.7 million m^3 wood per year for the year 2000 with estimates of accessible wood volumes between 3 and 6 million m^3 per year) suggests that without a shift in energy policy an acceleration in the deterioration of ecosystems[7] (forests, agricultural land, water management etc) is likely. Estimates of deforestation rates vary significantly from 45,000 ha per year (FAO) to an average of 400,000 ha per year (IPCC Conventional Development Scenario)



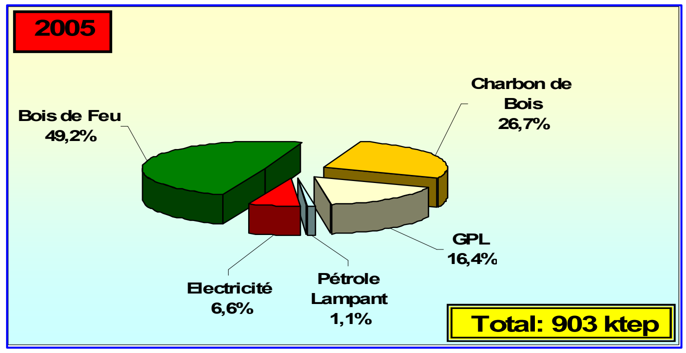
Fossil fuels: The existence of fossil energy resources, in particular oil and natural gas, was proven in the 50s and 60s of the previous century. Reserves of heavy oil, assessed on 100 million tonnes, were discovered in the Casamance. Natural gas and light oil were discovered in Diamniadio / Kabor in the Dakar region; between 1987 and 1992 61,000 barrels of oil and 31 million m^3 of natural gas have been produced from these fields. In 1991 new gas deposits have been discovered in Diamniadio with an estimated capacity of 400 million m^3.

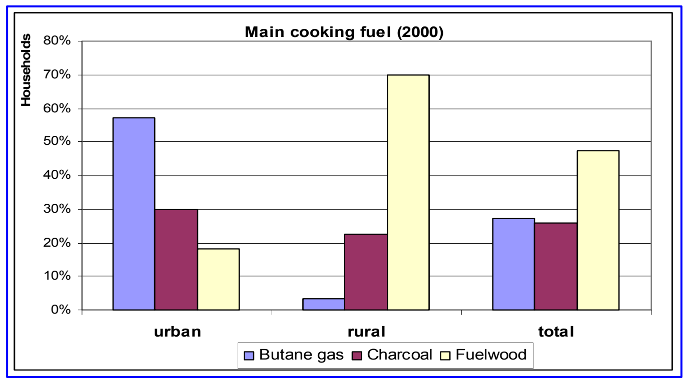
Hydro-power: The hydro-electric energy potential of the country, from its two large rivers the Senegal and the Gambia, is 1000 MW. The hydro-electrical plant in the Manantali dam upstream the Senegal has an installed capacity of 200 MW and provided Senegal with 290 GWh of energy in 2004.

Solar: The solar energy potential of Senegal, with an average insolation of 6 kWh/m^2 and over 3000 hours of effective sun radiation per year, is significant. Solar energy can certainly play an important role in rural electrification, drainage, refrigeration, water heating and drying of produce and cost-wise competes in some areas with more traditional solutions (e.g. Saloum islands).

Wind: Wind energy would seem to have a favourable potential in Senegal as well. The strip of 50 km along the Atlantic coast in the west measures average wind speeds of 2 to 5 m/s, sufficient to power smaller pumping equipment. More recently, wind measurements between 20 and 40 meters in the Saint Louis area would indicate that economic electricity generation in wind mill parks could be potentially viable.

3.3 Domestic fuels.





Country-wide, households depend for over 75% (fuelwood and charcoal) on biomass for their energy supply. The urban cooking fuel mix differs significantly from rural customs. In an attempt to check deforestation (fuel wood, charcoal production), the Government started stimulating the use of butane gas in the 70s. Particularly in the urban areas, promotion (and subsidies) had a good effect, resulting in butane gas being the main cooking fuel for 57% of the urban population in 2000. In rural areas adoption of butane gas as main cooking fuel is far less pronounced. Not only is the availability of butane gas limited but also the possibility for the rural population to switch to a commercial cooking fuel is smaller. Hence, butane gas is only for 3% of the rural population the main cooking fuel. Despite the increase of butane gas consumption (from 15,000 tons in 1987 to 100,000 tons per annum at the end of the previous century), the share of forest-based cooking fuel is still significant, providing the main cooking energy 73% of all households and 93% of the rural households[16].

Parallel to the introduction of butane gas, to regulate production of wood-based fuels, the Government of Senegal pursued a policy to rationalize wood resource management. Measures include introducing fuelwood plantations, raising wood cutting fees, revision of extraction quotas and the revision of land allocation system for charcoal production. As a result, the official sales price for charcoal shows a gradual increasing trend.

Despite the above, urban charcoal consumption is still significant. For 1992 the total consumption was estimated at 330,000 tons (equivalent to 1.8 million tons of fuelwood), out of which the Dakar metropolitan area consumed 150,000 tons[17]. The same document estimates for the year 2000 that Dakar, with 25% of the population, would be burning 80% of the national charcoal consumption. Current estimates mention a charcoal trade with an annual value of 20 billion fCFA (out of which ~ 1 billion fCFA arrives into the Government's coffins) of which 90% is consumed in the urban areas. Clearly, charcoal consumption is not yet to disappear. There are many reasons for this; people still prefer to use charcoal for certain purposes (special dishes, ironing) while lower–income households must still break down their purchases in small amounts, a need that can be served by the local charcoal vendor.

The total fuelwood consumption for 1992 was estimated at 1.5 million tons, of which 86% was consumed in the rural areas. Traditionally, a key feature of fuelwood consumption for the rural areas is that most villagers themselves collect deadwood lying around. Hence, villagers are not directly implicated in deforestation, but they suffer its consequences after charcoal producers pass through their village surroundings, picking up and cutting wood. Subsequently, villagers need to foray further out to collect would and –eventually- resort to cutting live trees to meet their energy demands for cooking.

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[16] Data from PROGEDE

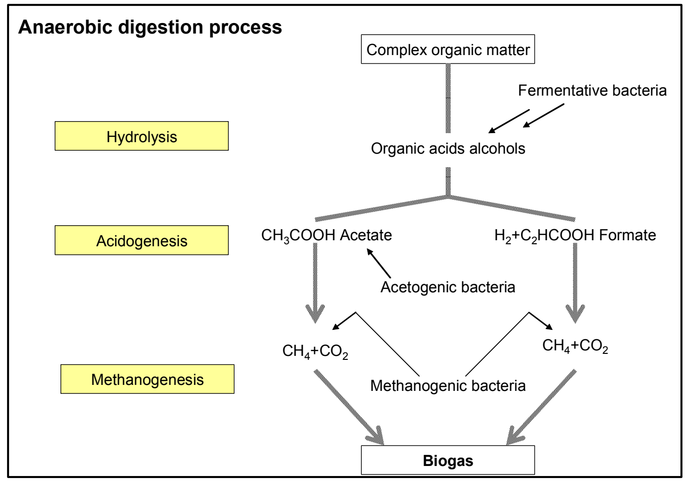
[17] Youba Sokona, Deme P.A. undated; LPG introduction in Senegal, paper by ENDA TM and PROGEDE

4 Biogas.

Substance	Symbol	%
Methane	CH_4	50 – 70
Carbon dioxide	CO_2	30 – 40
Hydrogen	H_2	5 – 10
Water vapour	H_2O	0.3
Hydrogen Sulphide	H_2S	Traces

Source: biogas handbook Nepal

When any organic matter such as animal dung, crop residue or kitchen waste is fermented in the absence of oxygen, biogas is generated. Biogas contains combustible methane (~ 60%) along with carbon dioxide and traces of other gasses. This gas can serve as a convenient fuel for a variety of applications such as cooking, lighting and motive power. The bio-slurry that comes out of the plant after the gas is produced can be used –directly or as a composting agent- as organic manure to augment soil fertility. Thus, biogas technology produces fuel without impairing the fertilizer value of the dung.



Biogas production is a bio-chemical process occurring in three stages: hydrolysis; acidogenesis and methanogenesis, during which different bacteria act upon the organic matter resulting in the formation of methane and acids. The main factors influencing biogas production are the level of acidity of the feedstock and the temperature. It is well established that biogas plants work best with a near to neutral substrate and a temperature of around 35^0C.

4.1 Benefits of domestic biogas.

The benefits of biogas in energy supply, agriculture, health, sanitation, gender and environment are well documented. There are a number of aspects of biogas production that have multiple benefits:

Animal dung and night soil is collected regularly and fed into the biogas plant, this:

- reduces pollution: leading to a cleaner farm environment;
- reduces human and animal disease: by improving sanitary conditions related to bad sanitation and polluted surface water for both the household its environment, and;
- reduces greenhouse gas emissions: depending on the traditional manure handling, the improved manure management system can significantly reduce GHG emissions.

The generated gas substitutes conventional fuels. In doing so, biogas:

- reduces indoor air pollution: the incomplete combustion of conventional fuels is minimized, resulting in a reduction of eye and respiratory illnesses particularly of those most heavily exposed to smoke namely women and children;
- reduces workload: especially in regards to fetching firewood, maintaining the fire and cleaning cooking pots. The use of biogas can reduce workload by 2 to 3 hours per day, particularly the workload of women and children;
- reduces fuel expenses: traditional domestic fuels increasingly become part of the formal economy. Biogas significantly decreases consumption of these traditional sources;
- increases opportunities to use appliances: such as gas lamps and water heaters;
- reduces greenhouse gas emissions emitted by the conventional energy sources;
- reduces deforestation: by reducing the demand for firewood;
- provides income generation opportunities: by providing an energy source activities (incubators, kilns, lanterns etc) as a new or more efficient resource.

The residue of the process - bio-slurry-, is a potent organic fertilizer. When used in this way it can:

- provide a superior organic fertilizer: in terms of available nutrients and soil texture, increasing agricultural yields with 20-40%.
- provide a catalyser for composting other agricultural waste: Applying this practice increases the amount and quality of organic fertilizer;
- improve handling safety: of residue due to the fact that the process of digestion followed by composting makes handling of the residue much safer from a hygienic point of view;

- reduce chemical fertilizer costs of farmers: by reducing the amount of synthetic fertilizer used;
- reduce greenhouse gas emissions through avoiding the application of synthetic fertiliser
- enables farmers to participate in animal husbandry in areas in which discharge regulations would otherwise have been prohibitive: anaerobic digestion reduces odour and environmental load resulting from livestock holding.

These benefits, although not all equally tangible, do not only profit the investor, but have an impact on the community at meso and macro levels as well. For a more elaborate explanation of impacts of domestic biogas, please refer to:

Annex 1: Biogas and sustainable development
Annex 2: Biogas and the UN Millennium Development Goals
Annex 3: Biogas tangibility matrix

4.2 History of biogas in Senegal[18].

Although Senegal's history in biogas technology tracks back to the 50's of the previous century, it took until 1977 until a revival of the interest in biogas resulted in the construction of two Indian model (floating drum) biogas digesters by CARITAS Senegal at Ndiouk Fissel, arrondissement of Thiadaye. Most digesters were installed for demonstration and or research purposes, still efforts have not resulted in a wide acceptance of the technology;.

The main actors in the development of biogas technology in Senegal include:
- l' Ecole Supérieure Universitaire de Technologie (ENSUT);
- le Centre National de Recherches Agronomiques de Bambey (CNRA);
- le Centre d"Etudes et de Recherches sur les Energies Renouvelables (CERER);
- le Centre Régional Africain de Technologie (CRAT);
- le Centre de Coopération Internationale de Recherche Agronomique (CIRAD);
- l'Institut Sénégalais en Recherches Agricoles (ISRA) and;
- l'ENDA (Environnement et Développement du Tiers Monde).

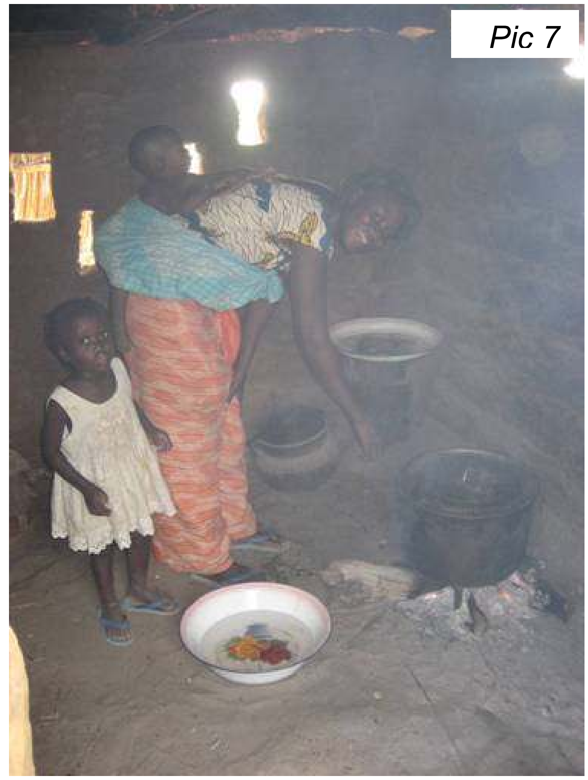
Initially (ISRA) introduction attempts focussed on the floating drum technology with as main substrate a mix of agricultural waste and animal dung. The objective was two pronged: production of a high quality organic fertilizer and generation of renewable energy. However, the investment costs of this type of installation in combination with high maintenance requirement (corrosion of the steel gas holder) prohibited popular dissemination.

For that reason, ISRA –in cooperation with IRAT and financed by l'Agence Française pour la Maîtrise de l'Energie (AFME) proposed the introduction of the Transpaille biogas digester[19]. This type of installation is constructed entirely out of sheet metal and typically connected with a dual fuel engine (20% diesel / 80% biogas) for electricity generation. The first prototype was constructed in Bambey in 1980 (?) at the ISRA compound. Other Transpailles followed in Cap Vert, Dakar, for a dairy farm in 1983. CRAT and CERER constructed two installations in 1999; the first one in Dakar (10 m^3) and the latter one in Sassal (30 m^3). In 1989 a large Transpaille installation was installed in Thiès, treating the slaughter waste of the slaughterhouse.

In 1989 POYAUD constructed two large biogas installations (2000 and 3000 m^3) in Cambérène for waste water treatment. The generated biogas (1500 to 2000 m^3 daily) is used for electricity generation (200 kW) and hot water production. In total some 42 installations have been constructed in Senegal; 2 large industrial installations, some 7 smaller fixed dome plants, 11 Transpaille installations and 22 Sanigaz (floating drum?) installations. Most of the constructed installations are currently not in operation.

[18] Most of the information of this chapter origin from Mr. Lamine Diop, Senior Researcher at CERER.
[19] For a detailed description of the Transpaille installation please refer to www.cirad.fr/en/prest_produit/materiel/page.php?id=63.

Pic 6



Pic 7

Pic 9

Pic 8

1 A national programme for domestic biogas in Senegal.
Following initial contact at the Renewable Energy 2004 conference in Bonn, Mr. Aliou Niang, Directeur General of ASER (Agence Senegalais d'Electrification Rurale) expressed hisinterest in studying the opportunities for a national domestic biogas programme in Senegal. Further meetings between Mr. Niang and Mr. Marc Steen, Director of SNV Guinea Bissau, resulted in Jan Lam, Biogas Advisor of SNV's Biogas Practice Team, conducting a pre-feasibility study on this subject. The report was submitted to ASER and SNV in September 2004. On September the 19th 2005 ASER representatives met with Mr. Jan de Witte, regional Director SNV-West Africa and Marc Steen. At this meeting, ASER and SNV decided that the pre-feasibility study sufficiently justified a full feasibility study, for which ASER requested further assistance from SNV.

ASER and SNV agreed on the Terms of Reference[20], proposed by SNV's Biogas Practice Team, and the logistical details for the study, and a 3-member study team was composed as follows:
- Mr. Lamine Diop, Engineer / Researcher at the Centre d'Etudes et de Recherches sur les Energies Renouvables (CERER) de l'Universite Cheikh Diop de Dakar.
- Mr. Rob Ukkerman, Natural Resources Officer SNV-Netherlands Development Organization.
- Mr. Felix ter Heegde, Senior Advisor Biogas Practice Team, SNV-Netherlands Development Organization (team leader).

1.1 Study objective.
The objective of the study is to thoroughly assess the feasibility to set-up and implement a national biogas programme in the Republic of Senegal. More specifically, the study will address the following areas;
- Country background including agricultural & livestock sector, energy demand and supply, energy policy and plans, safety situation;
- History of domestic biogas;
- Potential demand for domestic biogas;
- Possible supply of services for domestic biogas; and
- Outline for a national programme on domestic biogas.

1.2 Methodology
The study applied the following activities and methodologies:

A. Preparation of a mission to Senegal by using the pre-feasibility desk study report, collecting secondary information, contacting key respondents and informants in Senegal and abroad, and drafting checklists for biogas plant visits and interviews;

B. Mission to Senegal to visit domestic biogas plants constructed in the past, to meet with key respondents and informants for interview and discussion. The mission shall included debriefing workshops to discuss with the main stakeholders the roles of the different actors in Senegal and the outline of a possible national biogas programme;

C. Formulation of the draft study report and submission for comment to SNV/Guinea Bissau, ASER and members of the Biogas Practice Team (BPT) of SNV;

D. Submission of the final study report by incorporating the comment from SNV/Guinea Bissau, ASER and members of the BPT.

1.4 Limitations.
In addition to the typical restrictions of a short-term mission, the following should be noted:

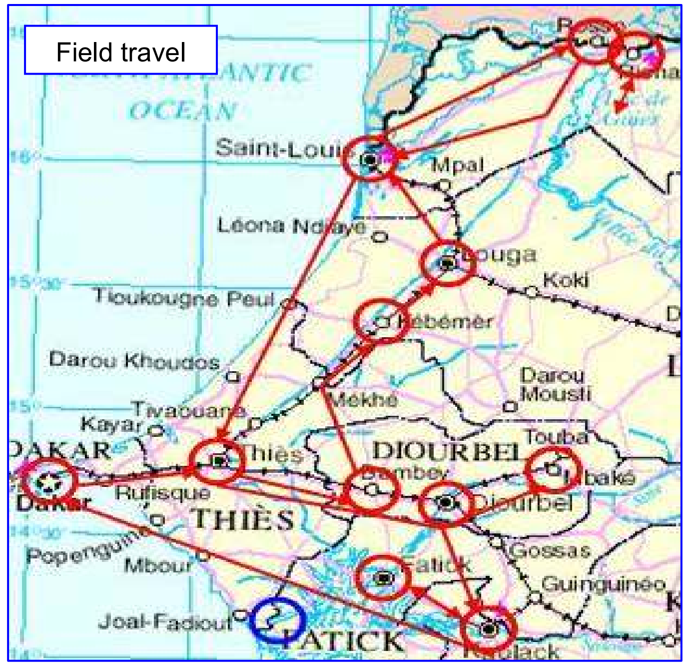
The study team had to be selective in its destinations; north-eastern and eastern parts of the country, with large migratory cattle herds, were not visited. The southern regions, with its large forest reserves were omitted too as they can be expected to have a low(er) biogas potential. The study team was advised not to visit the Casamance, south-west Senegal, because of the security situation. Hence, the report cannot claim to provide an overall in-depth picture on the domestic energy situation.

[20] The ToR for the feasibility study is provided as annex 4 to the report

The socio-economic status of interviewed families is skewed towards more well-to-do farming families in peri-urban areas. The situation in really rural / remote areas has not been assessed.

1.5 Collection of additional information.

In view of the study limitations, in particular regarding the rural situation of cattle holding practices and, to a lesser extend, domestic energy use, SNV requested Mr. Raoul Snelder to conduct a mission to collect additional information, particularly in rural areas of the regions Fatick and Kaolack. The mission was conducted between July the 25th and August the 3rd 2007. The report on this mission is attached as annex 14 and relevant observations have been included in sections of this report.



2 Study findings.

The team started its field operations in Senegal on Tuesday the 17th of October 2006. The field study was concluded with debriefing meetings at ASER and RNE offices on Thursday the 2nd of November 2006. During this period, the team travelled in 14 days (4 days national holiday -21 to 24 October- on the occasion of the end of Ramadan) a considerable part of north-west, central and south-central Senegal. Due to time constraints, eastern Senegal and the Cassamance in the south were not visited[21].

2.1 Main characteristics of the visited farming households.

The team conducted interviews at 25 farms (mainly urban and peri-urban). The households were selected on the advice of the regional / local officers of the departments of livestock / PAPEL[22].

Economic status of the households: The team has the impression that the share of well-performing farming households is over-represented in the interviews. Admittedly subjective, the team assessed 68% of the visited farmers as “well-to-do and 14% even “very well-to-do”. Only 4 families appeared poor. This probably is partly the result of livestock officers being eager to show “success-cases” but should also be attributed to the fact that -in absence of domestic biogas in Senegal- it proved hard to clearly explain the “target group” the team had in mind for the interviews.

Livestock: Not surprising then, that all visited households had livestock in abundance; 92% of the farms had cattle, 58% had donkeys or horses, 55% sheep or goat, 8% pigs and 38% poultry.

Cattle holding: Cattle typically are grazing on range grounds during the day, and return to the stable for the evening and night. Further into the dry season, when range land gets exhausted, farmers may keep their cattle stabled permanently and feed with stored fodder crops and agricultural residue.

Stables: Stabling conditions, important when manure has to be fed daily to a biogas plant, in general left much to be desired. 17% of the cattle, particularly in the north- are penned outside the farm yard, sometimes quite a distance from the farm house. When cattle are kept on-farm, 33% stays on an open yard, 63% of the stables are roofed, 21% of the stables have a smooth, cemented floor and 63% of the cattle feed from proper troughs.

21 Please refer to Annex 5 for a detailed travel itinerary.

22 A detailed overview of the characteristics of the visited households is provided in Annex 6, table A and B.

Dairy: Cattle are kept for dairy (91%), fattening (83%) and breeding (59%). Dairy production, however, is modest; on average a lactating cow would produce 1.5 litres per day, and daily production of farms would vary between a few up to 15 litres per day. The milk price, at FCFA 500 per litre, however is high. As milk storage, transportation and processing infrastructure is hardly available in Senegal, most dairy produce was sold as fresh milk, either on-site or in shops in towns close by.

Availability of dung: As livestock herd sizes typically are substantial, the amount of available dung proved not to be a limiting factor for biogas operation. 92% of the households had more then sufficient dung available to properly feed a domestic biogas installation; the remaining 8% still had enough for a smaller sized plant.

Use of manure: The application of dung varied. Where farmers had fields (67% of the visited farms) in the vicinity of the stables dung from the stables was often applied as fertilizer (57%). However, manure was also often offered for free collection (42%) or sold (19%). 39% - a large share considering that we visited relatively well-to-do farmers- of the households used part of their dung to make dung cakes for cooking.

Water availability: Senegal has a history of reducing rainfall and water shortage. However, all visited farms had sufficient water available for their cattle, and additional water for the operation of a biogas installation would not appear an insurmountable problem. This is not to say that water is not scarce; where water was supplied by grids it typically comes at a high price (FCFA 1 to 2 per litre), where is comes from wells or rivers transport (larger quantities by donkey cart) is hard work and / or expensive (wind / engine pumps). Of the visited households, 17% received piped water from a communal tap, 67% had a water tap on-yard, 25% of the farmers had their own well and 8% pumped water from an adjacent river.

Farm ownership: On 68% of the visited farms the owner with family lived on the farm. The other farms were operated by employed farm managers and their families, the owner living in the adjacent town. In three cases the farm was not inhabited by a family (owner or manager) with a (significant) domestic fuel need. The household size on Senegalese farms is large; also on our visited farms families[23] counted on average 15 persons.

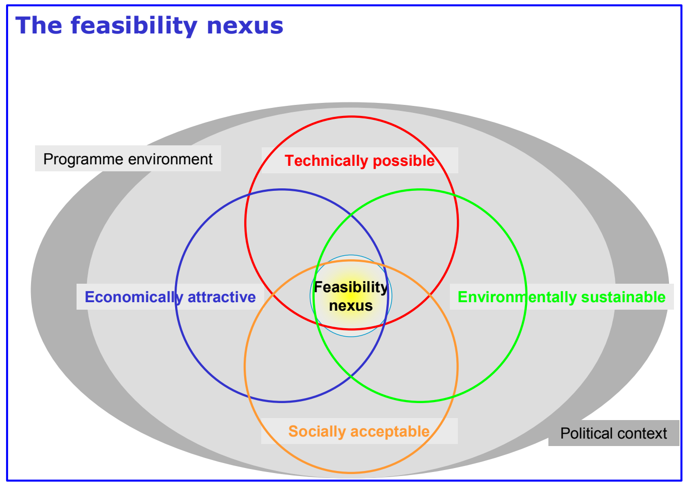
Domestic energy need: The cooking energy need of Senegalese families is substantial; families are large and many of the main dishes require long preparation (couscous). It is not uncommon for the women (no men reported to cook) to be involved in cooking for over 6 hours per day. A range of cooking fuels is used simultaneously. Fuelwood was used by 63% of the households, 53% used charcoal, 68% used butane gas and 39% of the households used dung-cake. Fuelwood and charcoal consumption proved hard to estimate for households, but for butane gas this posed less of a problem. Typically, a family would use between 20 and 30 kg of butane gas (nearly always in addition to the other fuel sources) per month.

Potential for domestic biogas: To assess the current potential of the visited households for domestic biogas, the following "hard" criteria are applied: "Sufficient manure available"; "Dung applied at own fields"; "On yard stabling"; "Water available < 20 minutes", and "Farmer-owner at farm". Out of the 25 visited households, 6 (25%) scored positive on all these criteria[24].

[23] "Families" is used here in the wide sense of the word: how many people are eating together.
[24] Refer to Annex 6 table C for details.

3 The feasibility nexus.

For a national domestic biogas programme, the notion "feasibility" is multi-facetted. The study applied a framework incorporating technical, economic, social and environmental elements within a programmatic environment and political context[25]. The nexus of these factors indicates the feasibility of a large-scale biogas programme.



In this chapter the factors will be discussed individually. For a proper assessment of some of the aspects of these feasibility factors additional study will be necessary.

3.1 Technical factors.

Technical factors include not only the primary conditions for a biogas installation to function properly at family level but also view at programmatic conditions for sustainable large scale dissemination.

Integrated farming: True integrated farming, in the sense of mutual dependence of livestock keeping and agriculture is not (yet) the most common practice in Senegal in general. In northern and north eastern areas (extensive) pastoral livestock and dedicated crop farmers can be found. In the Bassin Arachidier, however, most farmers combine livestock keeping with cropping. Cattle farmers have little use for animal dung; often the manure is collected free of costs -or against a nominal compensation- by cropping farmers.

Also Mr. Raoul Snelder reports: "The dung is collected and carted out to the fields but it is not commercialized nor used for other purposes such as fuel for cooking."

This situation is markedly different around urban areas and in the Bassin Arachidier. Agricultural extension services (PAPEL) stimulate farmers to adopt a more intensive ways of agriculture (dairy, cropping, fodder crops), including increasing awareness and the advantages of integrating livestock keeping and farming.

Raoul Snelder observes: "There is a clear tendency towards zero-grazing for at least part of the livestock. This tendency is the logical corollary of another trend: improving the livestock through breeding using artificial insemination techniques and imported genetic material. On the one hand local stock is improved seeking increased productivity and inversely imported stock is improved to adapt to local conditions and hardships. The dairy sector is developing rapidly and non-traditional operators are joining those who come from a long cattle farming tradition".

Dung availability: Most of the visited households have (more than) sufficient dung available. Although cattle are pre-dominantly free-ranging during the day, the animals are normally –possibly with the exception of the pastoral herds in the north-western part of the country- brought back to stables or open pens for the evening and the night. Often farming households keep (the dairy part of) their cattle on the farm yard during the evening and night. As cattle herds are typically quite large, these households will have sufficient dung available to feed a biogas installation and dung collection will not take unreasonable efforts. However, some (rural) households practice night-penning of cattle outside the village. Because of the distance of these pens to the households, up to 5 km was reported, here dung will be available in excess, but the necessary collection and transport efforts may limit the appropriateness of biogas.

[25] A description of the feasibility factors is provided in Annex 7

Also Raoul Snelder reported:" Again cattle seemed very much part of the daily life and even though considerable numbers may be involved in transhumance (leaving in July an coming back in December, I learned) the impression was formed that there is a strong tendency to maintain a sizable number of cattle near the homestead on a year-round basis and that the transhumance is not so much a 'positive' tradition but rather a necessary defence mechanism used as the need arises."

It should be noted that, in general, stabling conditions are poor. Roofed stables with fodder troughs, smooth, concrete flooring and dung or urine collection facilities are an exception. Typically, cattle are stabled on sandy farmyards. This reduces the amount of available dung, increases the effort for collection and negates the possibility to use cattle urine for plant feeding / process water substitution.

Raoul Snelder too observes: "Obviously the traditional transhumance is no longer a realistic or even a necessary option and the number and dynamism of 'modern' operators that we visited made the development of this activity very impressive. However there is some cause for concern in my view where the quality of the accommodation and spatial organization is concerned. While some improvement and rationalization in terms of lay-out and quality of building was observed most premises were lacking on both counts."

Water: Despite the scarcity of water nation-wide, most farmers have sufficient water available to properly operate a biogas installation. As substantial amounts of water would be required for their livestock anyway, farmers carry water from adjacent waterways or have a well within reasonable distance. In peri-urban areas and many villages, piped water is available. Water comes at significant costs though; piped water is paid for at rates in the range of FCFA 20 per 20 litre can, surface and well water is often hauled from larger distances by hand or donkey cart or supplied by diesel-pumps.

As the requirement for process water for the installation can partially be met by "grey water" of the household and, in view of the effort households anyway face to meet daily water requirement, for most of the visited households the availability of water would not be a limiting factor for biogas.

Also Raoul Snelder reports: "Water is far less of a problem than it used to be (in the area the water table can be very low and boreholes have to go down to considerable depth) as many villages are now equipped with wells, water towers (cf. photo sheets) and a basic distribution system using standpipes.

Technical potential: The paper "Le Biogaz au Senegal; situation et perspectives"[26], bases Senegal's biogas generation potential on animal manure on the country's livestock of 1998. The paper concludes that the highest cattle population is in the regions Tamba, Kolda, St Louis, Louga, Kaolack and Fatick. Piggery is well developed in the Kolda, Ziguinchor and Fatick regions. Furthermore the paper argues that use of dung cake for domestic energy is rare and only during periods of severe scarcity of fuelwood. Competing use of fuelwood (house construction) is negligible. Taking only the paper's totals for cattle and pig manure, the total amount of dung produced arrives at over 21 thousand tonnes (dry material) per year. This amount could potentially generate over 3.6 million m^3 biogas per day, out of which nearly 1.5 million m^3 biogas / day is estimated as "accessible". Assuming an average family would require 2 m^3 biogas per day to satisfy its cooking needs, potentially nearly **750,000 families** could be served with biogas.

The paper "Domestic biogas in Africa: a first assessment of the potential and need"[27], takes a more conservative approach based on regional (African) data on agricultural households keeping cattle and having access to water. For Senegal, this assessment suggests a technical potential for domestic biogas in Senegal of **439,000 installations**.

Both results seem too high in view of the number of agricultural holdings in Senegal; the agricultural census of 1998-99 counted just over 437,000 agricultural holdings (see also section 1 chapter 2.3).

[26] Lamine Diop, CERER, Le Biogaz au Senegal, situation et perspectives
[27] Felix ter Heegde, 2006, Domestic biogas in Africa: a first assessment of the potential and need, unpublished

In absence of more precise information, combining (incomplete) data sets for population, urbanization and cattle holding would show that some 433,000 agricultural holdings share over 2.9 million cattle. A cattle holding then ranges from 1.1 heads/holding in the Dakar region to 14.3 heads/holding in the Louga region. To operate a biogas installation a minimum of 20 kg of dung should be available; with cattle in Senegal predominantly only night-stabled, a minimum of some 6 heads of cattle would be necessary. Therefore, regions are divided in three categories as follows:

- avg of >3 to 6 heads/holding: 50% of the holdings;
- avg of >6 – 12 heads/holding: 75% of the holdings, and;
- avg >12 heads/holding: 50% of the holdings will qualify[28] for domestic biogas.
- Regions with an average less than 3 heads/holding are excluded.

Region	Agricultural holdings	Cattle	Cattle per holding	Cattle holding category >3-6 0.50	>6 -12 0.75	>12 0.50	Total biogas household
Dakar	2723	2904	1.1				
Diourbel	42977	102917	2.4				
Fatick	48714	222302	4.6	24357			**24357**
Kaolack	64530	306567	4.8	32265			**32265**
Kolda	56133	568808	10.1		42100		**42100**
Louga	43241	617168	14.3			28067	**28067**
Matam	29528	no data					
Saint-Louis	41095	386629	9.4		30821		**30821**
Tambacounda	44774	614074	13.7			20548	**20548**
Thiès	32600	82965	2.5				
Ziguinchor	26928	72378	2.7				
Total biogas hh	**433243**	**2976712**	**6.80**	**56622**	**72921**	**48614**	**178158**

This (very) conservative approach would still indicate a technical potential of over **178,000 biogas plants**.

The latter approach supports the findings of the paper "Le biogaz au Senegal" and the observations of the field study; the largest potential for domestic biogas seems in the Bassin Arachidier (Fatick, Kaolack), Kolda, Louga, Saint Louis and Tambacounda.

For the regions Kaolack and Fatick, Mr. Raoul Snelder arrives at the following approximation:

- Kaolack: the updated number of rural households (1997 figures, 2.6% annual growth rate) amounts to just over 45,000. Estimating that between 1/4th and 1/3rd of these households would technically qualify for a domestic biogas plant; the potential in Kaolack would be between 11.000 and 15,000 installations.
- Fatick: the updated number of rural households (2004 figures, 2.6% annual growth rate) amounts to over 60.000. Estimating that between 1/3rd and half of the population would technically qualify for a domestic biogas plant; the potential in Natick would arrive at 20.000 to 30.000 installations.

Two notes are due regarding this assessment:

- Although the technical potential in the Kolda and Tambacounda regions is significant, active demand may prove smaller as these regions have ample access to fuelwood.
- No consistent data on cattle population for the Matam region could be found. However, as population density in this region is very low and a large part of cattle holding is pastoral, the potential for biogas in this region can be expected to be limited

Taking the above estimations in consideration, the longer-term technical potential for domestic biogas is would be between **175,000 and 400,000 installations**.

Tested and robust biogas design: Senegal has virtually no experience with domestic biogas. The installations constructed have a strong demonstration / experimental character (Sassal, CERER), or are geared towards industrial applications (Transpaille). Hence, Senegal does not have a tested, robust biogas design at its disposal.

Biogas construction material and appliances locally available: Typical tested and robust domestic biogas plants are of the "fixed dome" design. Construction materials for this type of installations would include bricks, cement blocks, stabilized clay blocks or stone with cement. Good quality burned bricks are available in the Dakar area, but costs, certainly in more rural areas, would be prohibitive. Cement blocks are widely available at reasonable prices, although often the observed quality leaves lots to be desired.

[28] Regions with a high average cattle holding can be expected to have a higher share of pastoral livestock keeping

On stabilized clay blocks:
The quality of stabilized clay blocks, produced and applied properly, can compete with cement blocks. However:
- So far, stabilized clay block have not been used in large scale domestic biogas programmes; some research and testing will prove necessary prior to introduction.
- As these blocks have to be protected well against water / moisture, plant design / construction may have to be adjusted
- Production of stabilized clay blocks of homogenous quality, particularly the proper mixing, is hard, unattractive work. Maintaining the correct quality standards in a larger programme may prove cumbersome.

Good quality stabilized clay blocks were found in the Bassin Arachidier and would, both quality- as well as price-wise, be more competitive than cement blocks. Cement and sand is widely available in all larger villages and towns.

Fitting material for a biogas installation (galvanized pipe and small parts, ball valves, flexible gas hose) differs little from such material for ordinary civil construction. In larger villages and towns hardware shops have the necessary fitting material on stock.

In absence of a biogas market, specific biogas appliances -like stove, stove tap and lamp- are not obtainable. Workshops sufficiently equipped to manufacture such items, however, can be found in all towns. As households use butane gas and kerosene pressure lamps, gas lamp mantles are widely available.

Local construction and after sales facility: Domestic biogas is a new technology in Senegal; very few, if any local private enterprises can readily provide construction and after sales services. Civil construction and mechanical engineering companies were found in the larger villages and towns throughout the visited area. Experienced masons are probably available in most villages.

Quality awareness: The impression on quality awareness is mixed. Judging from some rural (civil) construction there would be ample room for improvement, but at the other side quality management in ASER's solar pV programme seemed well organized and thought-through.

Mr. Raoul Snelder adds to this: "Given the fairly low level of masonry skills in the country the risk of problems with the technical aspects is a concern. Frequent failure of the digesters in terms of leaking and loss of pressure could negatively impact on the credibility.

3.2 Economic factors.

For a domestic biogas programme to be commercially interesting, the services provided by the installation should be economically attractive, most importantly from the end-users' point of view.

Response of the market?

"Reactions to the information about the potential of biogas were very positive and the problems of procuring wood, charcoal, butane gas and other fuel (agricultural residue) were eagerly exposed. One lady showed us the various materials and techniques she used: five bottles of butane gas monthly at about 3000 francs each, charcoal, firewood and one particular stove using densely packed agricultural residue - cotton waste in this case - that had to be burned using a fairly complicated procedure to keep it slowly smouldering. While she knew about the use of cow dung as fuel she refrained from using that alternative because of eye problems that would be aggravated by the smoke."

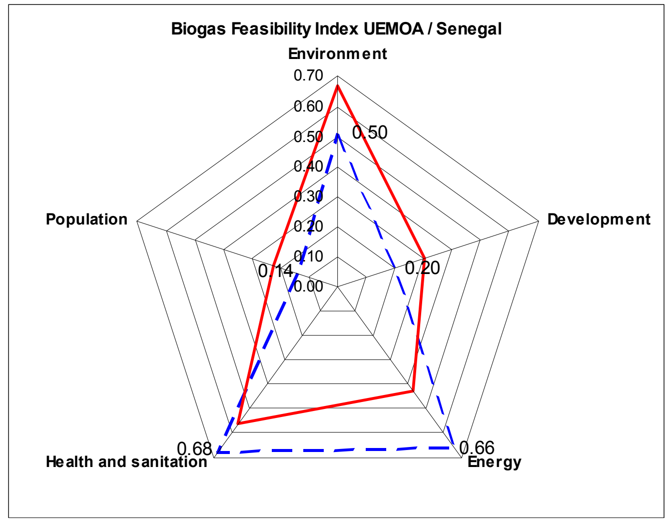
From Raoul Snelder (annex 14)

Sufficient active demand: There is no "active demand" for domestic biogas technology in the strict sense of the meaning, simply because the technology is virtually unknown with farming households. There is, however, a strong need among farming households for the services biogas technology could render.

Expressed needs include improving the cooking condition (lengthy, cumbersome, smoke invested kitchen) and alternatives for traditional cooking energy (expensive, supply unreliable / difficult –particularly during the wet season). Increasingly, noticeable among more advanced farmers, the importance of the availability of fertilizer is recognized. From the high incidence of toilets, also in more rural areas, a need for improved sanitary conditions can be implied.

As households have no point of reference regarding domestic biogas, it proved hard to establish to which extent this strong need can be translated in active demand, and surely awareness and extension efforts of a programme shall be significant. Another consideration of importance is that farmers appear to expect rather high subsidy contributions for innovations (like biogas).

The actual demand for domestic biogas does not only depend on the availability of sufficient manure and process water, but is also subject to environmental, developmental, energy, health & sanitation and population factors. The paper "Domestic biogas in Africa, a first assessment of the potential and need" assessed these factors, based on regional data, by calculation a multi-dimensional "biogas feasibility indices (BFI)" for each factor. Rather then "potential", these indices would indicate "need" for the services of a biogas plant.



The "BFI-score" for Senegal (red line in the spider graph) shows the high value of biogas services for "Environment", "Health and Sanitation" and- to a lesser extent- "Energy". The average BFI value for Senegal (0.43) is only marginally higher then the average value for the UEMOA countries (blue dotted line in the spider graph). Notably Energy and Health & sanitation conditions are worse in the neighbouring countries, whereas the Environmental situation in Senegal is more worrying.

Households can make a 10% down payment:
Investment costs for domestic biogas installation in Senegal will be substantial. Although substituting burned bricks with clay-stabilized bricks or concrete blocks may offer price reduction opportunities, the price tag to a plant is likely to exceed € 800.

Most of the visited households hardly classified as "poor farmers" and many showed recent significant investment in housing, water, stables, latrines, cattle stock etc. Many of the visited households reported to have non-farming sources of income (small shops, government employment, remittances). It seems fair to conclude that for the visited "well to do" smaller farming households, an initial down payment of 10% of the total investment will not provide an insurmountable obstacle. Poor farmers relying entirely on the revenue of their farm, however, may experience the high initial investment for the biogas installation as a significant barrier. In addition, for most of the farms the investment for the biogas installation will not come alone; often significant investments in improving kitchen and cattle stables would be desirable.

Scarcity and/or high prices of traditional domestic cooking fuel: The presently available main cooking fuels -fuelwood, charcoal and butane gas- are expensive[29], to the extent that domestic biogas can definitely offer an economic alternative, and scarce to the extent that even our relatively well-to-do farmers reported (seasonal) problems in their domestic energy provision. Government interventions in the fuelwood / charcoal trade rule-out free collection in most of the peri-urban areas, leaving households with dung cake as the only alternative non-commercial source for cooking energy.

More rural, large parts of the country are savannah with little standing wood; here "free" cooking energy only comes at a significant collection effort while butane gas is often not reliably available and up to 20% more expensive than in urbanized areas. As a result for urban and peri-rural areas –and to a lesser extent for rural areas- domestic energy supply is almost entirely commercial. In view of global energy market developments, national population growth and deforestation rates and Senegal's limited scope for alternatives for traditional cooking energy, it is likely that this commercialization trend will continue and domestic energy costs will increase.

Appropriate, affordable and accessible credit facilities: Although time did not permit visiting any credit and saving institutes, the (semi) rural credit infrastructure appears to be reasonably well developed. All major villages are reported to have at least one –but often more- micro saving & credit facility. Interest rates -between 12 and 17% p.a.- and repayment schedules –up to 3 years- would seem reasonable and

[29] See annex for domestic fuel prices and the resulting biogas substitution value.

an appropriate. A biogas loan would match to the (higher side) of what is locally on offer. Collateral-free loans or loans under “group collateral” are practiced. In Diourbel the Livestock Extension Office (PAPEL) assists farmers with the loan application. At the same time, our interviews indicate that farmers perceive the interest rate as high and show some reluctance on taking a loan.

From his debriefing meeting, Mr. Raoul Snelder reports: “Upon hearing the estimated unit cost for the 4 m^3 unit Mr. Niang (Director ASER) suggested that for the pilot phase ASER may succeed in mobilizing funds from the government and extend credit to the selected farmers against monthly reimbursements of a sum just under the amount of the monthly expenditure for butane gas.

Potential for productive use: In general, the potential for productive use –other than domestic cooking and lighting- of biogas generated in domestic installations is limited.

In Senegal a trend towards intensification and commercialization of farms can be observed; stimulated by government extension work, many farms show signs of increasing investment in livestock improvement, better veterinary services, improved stables, dairy farming. In this setting domestic biogas could contribute to this development, strengthening the economy of improved agricultural practices. In particular the market for dairy products is real and biogas could well play a role in small scale processing (and refrigeration perhaps) of dairy products.

In the northern areas along the river the Senegal large irrigation schemes are under development and much of the developed area will be leased-out to smaller farmers. There is a growing awareness in this area that in order to maintain soil-fertility, the agricultural practice shall balance cropping with livestock keeping. Here bio-slurry, possibly applied through the irrigation water, can contribute to the productivity of soils.

As far as small scale integrated farming is practiced (Bassin Arachidier) bio-slurry can contribute to maintaining soil productivity. Direct economic gains could result from substitution of chemical fertilizer, although much of the current land is actually under-fertilized. At the same time many farmers do not appreciate (organic) fertilizer. Particularly livestock farmers make little use of their manure, and cattle dung is often collected at little costs by (neighbouring) cropping farmers.

Potential to monetize non-energy benefits of biogas: The potential to monetize non-energy benefits of biogas seem, at least initially, modest for Senegal. Revenue from the Clean Development Mechanism is an opportunity but, due to the substantial transaction costs, at the moment -at best- only feasible for larger programmes.

3.3 Social and cultural factors.

Operation of a biogas plant should fit in the social and cultural setting of the family environment.

Land and livestock ownership: Although legal land ownership is still somehow disputed, in general farmers have security of land tenure. Most farmers own their livestock; modern exceptions are farms where ownership is with an “investor” (e.g. “eleveurs de dimanche”) while the farm operation is done by an employed manager and his family.

Potential to improve health and sanitary conditions: Health issues pertaining to cooking – workload and time consumption- are perceived as real problems. In particular indoor air pollution and the resulting respiratory diseases caused by preparing food on biomass fuelled open fires was frequently brought forward during the interviews.

Health issues pertaining to sanitation rank high as well, many households can be seen to construct / have constructed toilets on their yards. The connection of a latrine with the biogas plant would have health / sanitary as well as economic benefits. Without any reference, however, it is difficult to assess to which extent families would accept connecting a latrine to their biogas installation. Initial enthusiasm was not overwhelming, indicating that acceptance would require time and a considerable extension effort. The general sanitary condition of farm yards appears to get proper attention. However, some of the visited stables had substantial amounts of manure piled-up. Here too, biogas installations would be able to improve the sanitary condition.

Mr. Aliou Niang (ASER) insisted that the option of including human waste as part of the inputs to the digesters should be promoted as much as possible. He pointed out that the "*peril fécal*" (threat of faecal contamination) is causing increasing concern as a health hazard, especially for children and this opportunity to improve the situation should not be lost.

Manure handling: Farmers are used to handling manure, be it for application as fertilizer, preparation of dung cakes or just collection for removal. However, as argued earlier, not all farmers are conversant with using manure as fertilizer. At the same time, in the Bassin Arachidier dung is valued well (composting practice) or –in absence of own fields, is sold to cropping farmers (FCFA 450-600 per donkey cart).

Cooking practices: Food preparation, three times a day, takes a considerable amount of effort. For larger families women reported to be occupied with food preparation up to 7 hours per day. Switching to biogas –as far as households are not using butane gas- will certainly reduce cooking time for these women.

Whereas breakfast is -in cooking terms- largely limited to tea, lunch and dinner consume considerable amounts of energy. It would need a larger biogas installation (8 or 10 m^3) and large stoves to fully substitute the traditional fuel sources. Households currently use fuelwood, charcoal, butane gas and dung cake simultaneously. As most visited households already are used to butane gas, cooking on biogas would be familiar. Noteworthy is the success of introducing butane gas for domestic energy in urban areas on the one hand and –particularly in view of the scarcity of fuelwood and charcoal- the (very) limited acceptance of improved cooking stoves (ICS) on the other. Despite a long history of research and dissemination projects, only a few of the visited households showed (very simple examples of) improved cook stoves. ENDA blames the incompatibility of the promoted designs for this failure and will embark on further research.

Gender balance in household expenditure decisions: In general, the formal decision for larger household expenditures is taken by the male head of the households. As many of the benefits of biogas are most prominent for the female members of the households, this may result in a "cost-benefit mismatch"; an issue to be taken due note-off during promotion of biogas technology.

On this issue, Mr. Niang (ASER) stressed the importance of associating the women as they were to benefit most directly from the programme and should therefore be the most interested stakeholders.

3.4 Environmental factors

Domestic biogas installation can potentially contribute to the improvement of the environment at both micro and meso level. Important in this context is to assess to which extent environmental problems are present and pose a direct threat to the prospective end-user.

Environmental issues in Senegal: Deforestation, desertification, soil erosion / degradation and overgrazing are serious environmental issues in Senegal. Partly, these environmental problems are related with domestic energy use and agriculture.

- The high demand for (domestic) energy drives deforestation. The released grounds are vulnerable to water and wind erosion.
- The substantial livestock of Senegal exhausts savannah areas. Overgrazed savannah is more sensitive to turn into waste land or desert.
- Extensive cropping practices with low levels of nutrient input contribute to soil degradation and, subsequently, erosion.
- All the above reduces the water-holding capacity of soils, aggravating water shortage.

Potential contributions of a biogas programme: A domestic biogas programme in Senegal can (initially modestly) contribute to mitigating environmental problems.

- By substituting wood fuels, the pressure on the forests will reduce.
- Indirectly, domestic biogas will stimulate zero-grazing practice, reducing the risk of exhausting savannah land.
- Bio-slurry, an excellent organic fertilizer when properly applied, will close the nutrient loop to the fields, improving soil structure and fertility.
- As a significant share of the fuelwood production appears to be unsustainable and butane gas is a well accepted source of domestic fuel, biogas will reduce greenhouse gas emissions.

In more densely populated (peri-) urban areas, however, bio-slurry may increase water pollution. Whereas very little –if any- of the livestock manure currently is discharged on surface water, farmers without direct use for fertilizer may chose to dispose their slurry in the sewage system. Also, for some areas, the limited year-round fodder availability may be insufficient for full-time zero grazing / stable feeding of larger herds.

On the issue of cattle fodder, Mr. Raoul Snelder reports: “A powerful inducement is the fact that local industry produces by-products that can be used as fodder (peanut cake, melasse) and other sources of similar products are at reasonable distance (cotton mills).” His observation was shared by this mission for the Louga and Bassin Arachidier areas.

3.5 Programme factors

The vision of a programme is a commercially viable, multi-stakeholder approach. Programme factors highlight the most important aspects for this approach to be successful.

The rural private sector: Not surprisingly, there are very few –if any- local entrepreneurs that can readily provide domestic biogas construction and maintenance services. However, in most of the visited places, private sector activities in related fields (construction, metal work and plumbing) can be observed. Experienced masons will also be available in the more remote villages.

Raoul Snelder writes: “Given the fairly low level of masonry skills in the country the risk of problems with the technical aspects is a concern. Frequent failure of the digesters in terms of leaking and loss of pressure could negatively impact on the credibility. This concern turned out to be shared by ASER.”

A programme introducing domestic biogas at a larger scale, hence, will have to anticipate on a considerable vocational training and quality management effort.

Rural extension infrastructure: Both the Department of Livestock as well as PAPEL have a strong, dedicated and dense extension network. Their influence and impact on rural farmers appears to be substantial.

Rural credit infrastructure: Local micro saving and credit organizations are common in even the smaller villages in Senegal. They primarily play a role in agricultural –shorter term- credit, but their conditions appear applicable for biogas with little modification. It should be noted that the mission did not interview officials of (local) saving and credit organizations; factual appropriateness of the credit infrastructure for domestic biogas would need confirmation.

Independent organizational entity:

The VEV wind-pumping project or the numerous solar pV initiatives under ASER’s coordination are exemplarily for national or regional programmes that are implemented with an independent entity providing technical assistance.

For the implementation, VEV and its “parent NGO” LVIA, although not in the Bassin Arachidier proper, would be a promising partner at the start of a biogas programme, but also other organizations showed interest to participate.

Women groups: Except for the Women Dairy Agence in Diourbel, the mission did not meet with women groups.

3.6 Political factors

Crucial for the success of a programme is the extent to which the main national actors are committed and involved in its preparation and implementation, and the extent to which biogas fits in the relevant national policy framework.

Significant but limited role of government: Given the importance of establishing and maintaining very credible and effective quality and safety controls, the government can not be too far removed: the sector needs a strong regulatory and norm-imposing agency to accomplish these tasks. ASER predominantly plays a facilitating and coordinating role in the dissemination of rural energy (SHS and Community pV). In view of ASER’s track record in pV dissemination and considering the initiative for domestic biogas has been entirely theirs, ASER should be considered “with an open mind” as the lead partner for a larger scale programme.

In the Solar pV programme ASER focuses on policy development, programme facilitation and market regulation. ASER is an outspoken promoter of public – private partnerships in rural development.

Stable and secure area: Senegal has a long history of political stability and non-violence. To the north of the Gambia the country is absolutely safe and harbours no threats for programme implementation. In the south, however, the long living conflict with the inhabitants of the Casamance occasionally flares up (the mission was advised not to visit this area). As long as the conflict continues a biogas programme would be difficult to implement here.

Initial request for assistance from a national actor: ASER requested SNV for a feasibility study and participated in bearing the study expenses.

Favourable policy environment: Energy for development is imbedded in Senegal’s Poverty Reduction Strategy Paper. ASER is responsible for rural energy supply in particular.

4 Costs and benefits

4.1 Costs

Proposed design: For the calculation of the investment costs, as point of departure a fixed dome biogas digester of the model “GGC 2047” is used. Main reasons for –at least initially- proposing this model include:

- Robust and tested design; over 150,000 of this type of installations have successfully been disseminated in Nepal.
- Compared with other fixed dome models, this design requires relatively low levels of specialized skills and is less sensitive to smaller construction mistakes.
- This installation can be constructed with bricks, stone, cement blocks and stabilized clay blocks. In view of the high price of burned bricks in Senegal, construction in blocks will likely make this the design with the lowest initial investment costs.

Material prices: Prices for construction material have been collected from various block manufacturers hardware stores and construction companies in various regions[30]. All required construction

[30] A detailed price-list for the required materials is provided as annex 8.

and fitting material –except the HDPE 200 mm inlet pipe- were found widely available in the visited areas. Appliances like gas stoves and lamps, however, are not available; these would have to be manufactured locally and the prices used for this cost calculation are estimates.

Investment cost GGC 2047 fixed dome digester in Senegal: Investment costs for a fixed dome biogas installation in Senegal range from FCFA 612,000 for a 4 m^3 installation to FCFA 892,000 for a 10m^3 installation built in brick. Construction in stabilized clay blocks would reduce the investment costs to FCFA 406,000 for the smallest and FCFA 591,000 for the largest size[31].

Investment costs fixed dome digester GGC 2047

	4 m^3			6 m^3			8 m^3			10 m^3		
	burned brick	cement block	stabilized clay block	burned brick	cement block	stabilized clay block	burned brick	cement block	stabilized clay block	burned brick	cement block	stabilized clay block
Contribution farmer in kind	64,033	64,033	64,033	78,039	78,039	78,039	92,045	92,045	92,045	108,651	108,651	108,651
Supplied materials	379,838	234,838	214,838	426,438	256,438	233,938	514,018	319,018	289,018	558,918	348,918	318,918
Technical services	48,000	48,000	48,000	48,000	48,000	48,000	57,000	57,000	57,000	57,000	57,000	57,000
Company fee	108,559	72,309	67,309	120,209	77,709	72,084	143,904	95,154	87,654	155,129	102,629	95,129
Programme fee	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Total investment (CFA)	**612,431**	**431,181**	**406,181**	**684,686**	**472,186**	**444,061**	**818,967**	**575,217**	**537,717**	**891,698**	**629,198**	**591,698**
Total (Euro)	*935*	*658*	*620*	*1,045*	*721*	*678*	*1,250*	*878*	*821*	*1,361*	*961*	*903*

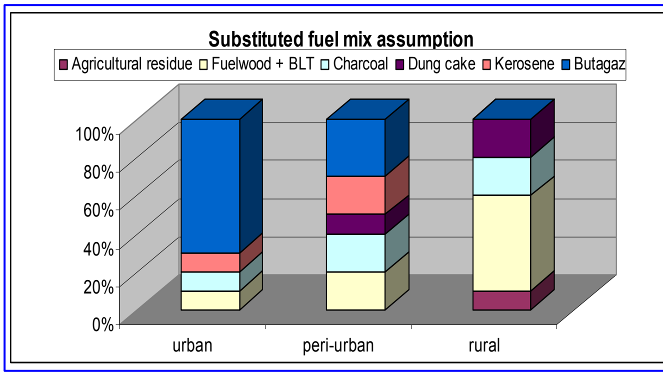
The cost reduction of stabilized clay brick construction of just over 30% –related to construction in burned bricks- is significant. The investment difference between stabilized clay brick and cement blocks is small but the observed quality of cement blocks appears insufficient for digester construction; production of a better quality cement blocks will likely increase the construction price.

4.2 Benefits.

Although benefits of biogas installations stretch considerably beyond traditional fuel substitution, for the benefit calculation only these values are included as they present the most tangible and direct benefits to the investor[32].

Fuel prices	Unit	urban	peri-urban	rural
Agricultural residue	[CFA/kg]	-	*30*	*13*
Fuelwood	[CFA/kg]	75	60	25
Charcoal	[CFA/kg]	250	200	150
Dung cake	[CFA/kg]	-	*30*	*13*
Kerosene	[CFA/kg]	400	425	450
Butagaz	[CFA/kg]	480	520	550

Biogas substitution value: Fuel prices are used as recorded during the study trip. As agricultural residue and dung cake are not commercially traded, a shadow value based on the replacement value of fuelwood is assumed (values in italics in the table). Fuel availability and price depend on the location. The value of the fuels substituted by the generated biogas can serve as a value for the gas itself. As fuel mixes, prices and level of commercialization differ greatly from urban to peri-urban to rural, for each area a tentative biogas substitution value can be derived, presenting three different scenarios.

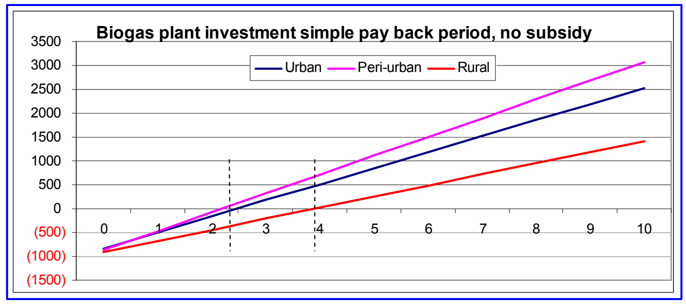


The biogas substitution value ranges from € 0.55 in peri-urban areas to € 0.33 in rural areas[33]. For comparison, the similarly calculated biogas substitution value in Vietnam amounts to € 0.16 and € 0.35 for Ethiopia.

		financial value		
Biogas substitution value	Unit	urban	peri-urban	rural
Agricultural residue	[Euro/m^3 gas]	*0.00*	*0.00*	*0.02*
Fuelwood	[Euro/m^3 gas]	0.08	0.13	0.13
Charcoal	[Euro/m^3 gas]	0.11	0.18	0.13
Dung cake	[Euro/m^3 gas]	*0.00*	*0.05*	*0.04*
Kerosene	[Euro/m^3 gas]	0.04	0.08	0.00
Butagaz	[Euro/m^3 gas]	0.24	0.11	0.00
Biogas substitution value	[Euro/m^3 biogas]	**0.47**	**0.55**	**0.33**

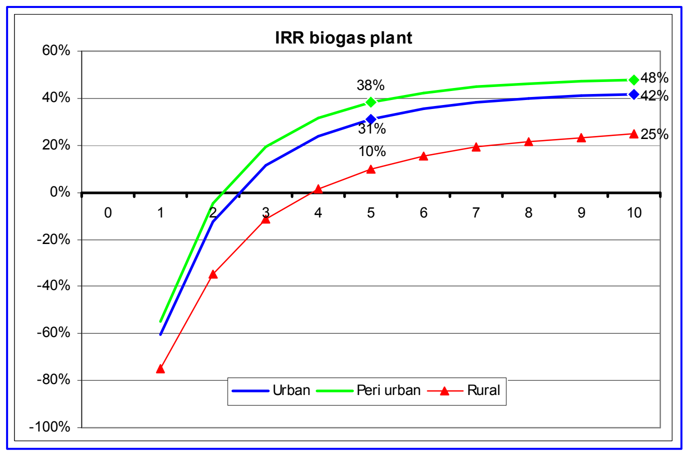
31 See detailed bill of quantities with costing in annex 9.
32 See also annex 3 for the biogas tangibility matrix
33 A detailed calculation of the biogas substitution value is provided in annex 10.

Simple pay back period: The period over which the investment will be repaid by the cost savings depends for domestic biogas on the amount, type and value of the fuel traditionally used on the one hand and the amount of biogas produced by the installation. Assuming an 8m^3 installation is fed with 55 kg substrate daily, a biogas installation would generate nearly 2 m^3 biogas per day, some 714 m^3 per year. It is further assumed that investment costs for such plant range from € 835 in urban areas, € 860 in peri-urban areas and € 910 in rural areas.



According to the simple pay back period method then, installations in urban and peri-urban areas would have repaid themselves around the end of the second year of operation. Rural installations, however, due to the higher investment costs and lower biogas substitution value, would repay themselves only after nearly 4 years.

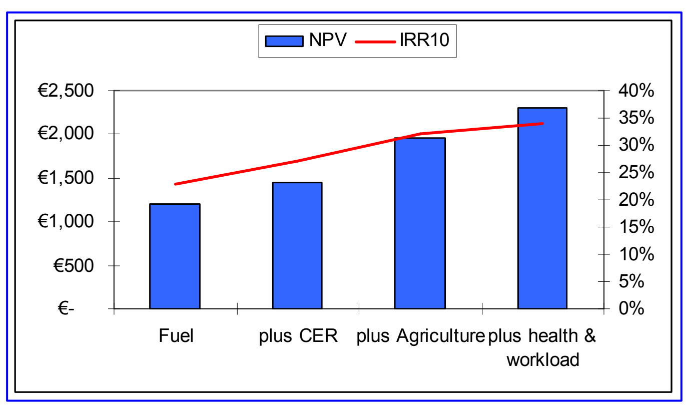
The internal rate of return (IRR): The IRR is the return rate that can be earned on the invested capital. Although widely accepted as a tool to assist decisions on long term investments, farmers should compare the IRR of a biogas installation with alternative investments (agricultural input, refrigeration of dairy produce, means of transport to reach better markets for produce etc). Such a precise economic analysis falls beyond the scope of this study. Obviously, the IRR of an investment should at least be higher then the interest rate on savings.



The IRR for individual biogas installations in Senegal has been calculated with the same plant parameters as used for the simple pay back method. In addition, inflation, maintenance and repair have been included[34]. The calculation, using strictly monetary costs and benefits for the farmer, represents the Financial Internal Rate of Return (FIRR). For similar reasons, the IRR too shows marked differences between the peri-urban and the rural situation. With a ten-year horizon, the peri-urban rate of return, IRR_{10}, results to over 50% whereas the IRR_{10} for rural installations is only 29%.

The IRR for the programme as a whole, representing more the Economic Internal Rate of Return (EIRR), additionally would include at the cost side depreciation and opportunity costs as well as programme support costs for a large scale programme. At the benefit side potential revenue from greenhouse gas emission reduction, improved agriculture revenue and reduced expenditures on sanitation and health.

For a 5 year programme -including a one year pilot phase- support costs (including a suggested subsidy component of, on average, € 230 per installation) have been estimated at approximately € 100 per year for the project period.



Despite the high initial programme support costs, the EIRR still ranges from 23% when fuel savings alone are included, to 34% when the full scope of benefits is added to the calculation.

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34 Details on the IRR calculation are provided in the cost / benefit analysis in annex 10.

4.3 Potential revenue from greenhouse gas emission reduction.

Energy generation by a biogas digester is carbon-neutral. Replacing fuels that do emit greenhouse gasses (non-renewable fuelwood, petrol products) a biogas digester is reducing the emission of greenhouse gasses. Increasingly, mechanisms are getting operational to generate revenue from this reduction (CDM, Gold Standard and various smaller initiatives). Without going into detail and without claiming precision in the calculations, in view of the financing of a future biogas dissemination programme, this chapter aims provides a first estimate on the potential GHG emission reduction of a biogas installation.

For the calculations the IPCC guidelines have been used. These calculations prove sensitive for, in particular, the substituted fuel mix, the share of non-renewable fuelwood here in, and the actual manure management modality. As these parameters can differ significantly from area to area, and from farming system to farming system, an accurate assessment requires dedicated research and monitoring.

With these reservations, calculations show that a typical domestic biogas installation in Senegal would potentially reduce greenhouse gas emissions with some 4.7 tons CO_2 equivalent per installation per year. Over a 10 year period, the value of the emission reduction could amount to € 250 or more.

Summary greenhous gas reduction by programme:

	Component	**baseline** [$kgCO_2$/pl/yr]	[%]	**biogas** [$kgCO_2$/pl/yr]	[%]
1	Manure management	4461	*45%*	5013	*97%*
2	Chemical fertilizer	0	*0%*	0	*0%*
3	Fuel	5455	*55%*	67	*1%*
4	GHG construction plant @ 2%		*0%*	76	*1%*
		9916		**5156**	
	Reduction:			**4760**	

Section 3
Conclusions and recommendations


Pic 10


Pic 11


Pic 13


Pic 12

1 Conditions for large-scale dissemination of domestic biogas in Senegal.

	Condition	Score	***Conditions for large-scale dissemination of domestic biogas in Senegal*** Remark
Technical	Even daily temperatures over 20^{o}C throughout the year	++	Average maximum temperatures range in the 20s throughout the year.
	At least 20kg of fresh animal dung available per plant per day	++	The current holding regime sedentary farmers would need at least 4 cattle. Most of the visited households had significantly larger cattle herds
	Availability of water required to mix with fresh dung in a 1:1 ratio	+	Water comes at considerable costs, financial or otherwise. Nevertheless, all visited households had sufficient water in the vicinity. In more remote areas, however, water availability should be duly assessed.
	Sufficient space for biogas plant in the compound of potential users	++	Compound space is not an issue in peri-urban and rural areas; farmers have yards of reasonable size. In urban areas, however, this may not always be the case
	History of proper performing biogas installations	- -	Senegal has (virtually) no track record on domestic biogas; Hence tested robust designs or biogas service providers are not readily available.
Financial	Traditional practice of using of organic fertilizer	+/-	Dung is used as fertilizer but cropping and livestock keeping are often separated activities. Integrated farming is most common in the Bassin Arachidier.
	Scarcity of traditional cooking fuels like firewood	++	Possibly with exception Kolda and Tambacounda, fuelwood is scarce and the trade to a large extent commercialized.
	Potential users have access to credit	+	Good micro credit facilities were reported, but not tested. Obviously, there is no experience with biogas credit.
	Livestock farming is the main source of income for potential households	++	Livestock farming is common in Senegal. Modalities, however, are often extensive and not always ideal for biogas.
Social	Role of women in domestic decision-making process and life	–	Traditionally, domestic decision making is male-skewed. The decision for an investment in a biogas installation would definitely be within the male domain.
	Biogas plant can be integrated into normal working routine at the farm	+	Households practicing integrated farming will be able to fit in biogas seamlessly. For some proper livestock farmers the penning area will be too far from the kitchen, and bio-slurry may not always be an asset.
	Awareness of effects of biogas technology among potential users	- -	In absence of a track record on domestic biogas, households are totally unaware of the potential benefits of biogas
	Willingness among potential users to attach a toilet to the plant	+/-	Handling (products of) night soil definitely seems sensitive issue.
Institutional	Political will of the Government to support a national biogas programme	+	ASER and the Ministry of Energy and Mines showed keen interest, the feasibility was initiated and (financially) supported by ASER.
	Willingness of (potential) stakeholders to get engaged in biogas programme	+	The regional PAPEL / Dep of Livestock officers are interested as did LVAI/VEV and an NGO in Diourbel. The unfamiliarity with the technology should however be taken into account.
	Availability of organizations having access to potential users	+	The government's agricultural extension network reaches down to village level.

Score	*Condition*
++	*Fully met*
+	*Met*
+/-	*Doubtful*
-	*Not yet met*
- -	*Falls short*

2 Conclusions.

The prevalence of small-scale livestock holding is such that the market potential for domestic biogas digesters is sufficient to justify a pilot operation with a view to start dissemination of the use of domestic biogas on a larger-scale

Domestic biogas is largely unknown in Senegal. Only one (of the very few) installations visited can be considered a truly family sized biogas installation. All other installations are either more "industrial" installations or installations that were constructed with an R&D / demonstration purpose.

None of the biogas installations was in operation at the time of visiting and all except one would need a considerable effort to bring them into operation. The installations visited were of the "Transpaille"[35], fixed dome or floating drum design and all but one had a demonstration / research purpose.

[35] Information on the "transpaille" biogas digiester at http://www.cirad.fr/fr/prest_produit/materiel/page.php?id=61.

There is, however, a substantial need for the services of a domestic biogas installation. The currently used domestic fuels are scarce, expensive and to a large extent commercialized. Increasingly farmers are aware of the importance to maintain soil fertility and structure. Indoor air pollution and its health consequences, resulting from cooking with biomass on simple stoves, is for many women a serious problem. The observed farm yard hygiene, especially due to animal manure, is not optimal and the situation must be worse in the rainy season. At country-level, deforestation and desertification are grave environmental issues.

The technical conditions for operating a biogas installation are met in many households. Most of the visited households have (more than) sufficient dung available on a daily basis. Although water comes at a high price, farming households typically have access to either piped water (individually, at the yard or shared in the ward), a well or pumped water from the river / irrigation channel.

Yet, the visited households that qualify for biogas cannot be considered poor. The high share of “well to do”, innovative farmers in the household interviews obscure a balanced, representative view on the real situation. Interviews also concentrated in peri-urban and “rural-but-not-so-remote” areas. Although these areas harbour a substantial potential, the situation in proper rural areas is likely significantly different.

The initial socio-economic and technical potential for domestic biogas appears most promising in the Bassin Arachidier (Fatick, Kaolack), mainly due to the relative dens agricultural population and high incidence of integrated farming in this area.

Some communities in northern Senegal (Louga, St. Louis), certainly qualify for biogas as well, but active demand may be insufficient and too dispersed to justify a programme start. Similarly, South Senegal (the Casamance) shows promise but here competition with easily available charcoal and fuelwood may stand in the way of quick adoption of biogas technology.

There are a good number of local / national organizations with whom a large-scale biogas programme could link. The Ministry of Livestock, PAPEL, LVIA/VEV and a variety of GIEs and NGOs are involved in rural development in general and improving farming practices in particular. Also ASER’s rural electrification network will prove fruitful points of entry and cooperation. Biogas promotion could be integrated in the activities of these organizations.

There are no private enterprises that can readily provide biogas marketing, construction and after sales services. Although general civil construction and metal manufacturing enterprises are widely available, the programme will have to prepare for a considerable capacity building / training effort.

Investment costs for a domestic biogas installation are high. At a price of fFCFA 450,000 to 650,000, the up-front investment will be a substantial barrier for most households. In order to reach a substantial share of the potential market, financial support (subsidy, credit) will prove necessary.

3 Recommendations.

3.1 Recommendations, general

3.1.1 *Use a separate pilot-phase to fill in the experience and knowledge gaps:* Senegal’s technical potential for domestic biogas is substantial and likely to grow over the coming decade. The need for the services of the technology, both at household as well as national level seems beyond doubt.

However,
- As the country has no track record on domestic biogas dissemination, predictions regarding the extent to which technical potential and expressed need will translate into an active, commercial market for the

technology will remain inprecise. In absence of such reference, the actual response of households on the technology will have to be tested;
- Senegal does not have an example of a “robust, tested plant design”; construction of the proposed GGC 2047 model in stabilized clay bricks or concrete blocks will have to be piloted, not only in view of the technical asects and the capacity building requirements of the involved parties (masons, technicians) but also regarding the actual (local) construction costs and time. Appliances will neither be readily available;
- Following a commercial approach, local private biogas construction companies and manufacturers are required. Prior to the capacity building aspects of establishing and supporting these enterprises, there actual interest has to be gauged;
- Insight of the mission in issues regarding (rural) domestic energy needs, consumption and expenditure, household spending capacity, credit facilities and fertilizing practices seems incomplete. Similarly, the mission may not have a comprehensive view of the (rural) institutional infrastructure.

In view of the above, a pilot phase with a reasonable scope seems well-advised. Both a separate pilot, in which scope and content will only be considered after the end-report of the pilot is available, and an integrated pilot, directed towards envisioned programme goals, seem viable options.

The mission proposes a separate pilot, to be clearly demarcated from the dissemination programme proper to avoid the pilot raising “programme expectations” that are not yet warranted by the pilot results and to avoid that the pilot will phase-over into the programme-proper without the potential being properly confirmed. The costs of a pilot, however, are considerable to the extent that justification will be based on the intention to scale-up activities significantly

Objectives, success criteria and activities for the pilot phase are formulated more in detail in section 4, chapter 1.1 of this document.

3.1.2 *Start a domestic biogas programme in the Bassin Arachidier:* Although more regions qualify for domestic biogas, the regions Kaolack and Fatick seem to be best-placed for starting up a nation wide programme.
- The technical potential in these two regions only is estimated to be well over 50,000 installations[36].
- Domestic fuel is scarce, relatively expensive and largely commercial to the extent that domestic biogas will prove an economically attractive investment.
- Many households have sufficient and regular input material (manure and process water) available.
- Integrated farming is more common then elsewhere in Senegal. Many farmers will have good use for bio-slurry and where this would not be the case it is likely that interested crop farmers are to be found in the vicinity.
- The area is reasonably densely populated, enabling effective promotion and construction in clusters (particularly in the peri-urban areas).
- Biogas-specific facilities -necessary construction- and fitting materials, (semi) skilled labour, experience in construction in stabilized clay blocks, and mechanical workshops (for manufacturing stoves and gas lamps)- are widely available.

3.1.3 *Link the biogas programme with rural development programmes:* Rather then building-up a new promotion infrastructure, it will prove (mutually) beneficial to link a domestic biogas programme with existing rural development programmes.
- The regional departments of Livestock and PAPEL, particularly in the Bassin Arachidier but also in other regions, are making a significant effort to improve cattle breed, stabling conditions and dairy production. Integration of domestic biogas in stable improvement and dairy development will prove cost effective. The supported “model farmers” are innovative and their role-model function will support the introduction and acceptance of domestic biogas. The PAPEL programme assists farmers with loan applications.

[36] See section 2 chapter 3.

- L'Associazione Voluntari Internationale Laici (LVIA), an Italian NGO, has been active (amongst other activities) in dissemination of wind pump - water schemes in Senegal from 1972 onwards. In the late 1980s the NGO established private company, VEV (Vent et Eau pour la Vie), for commercial wind pump construction, marketing, maintenance and repair. More recently, VEV also embarked upon overhaul and relocation of wind pumping installations. They have knowledge and experience in rural extension and marketing and cooperate with PAMECAS (savings and credit bank) to finance new construction, maintenance schemes and overhauls of wind mills. VEV has the disposal of a well equipped workshop in which they manufacture all wind mill parts. LVIA would positively consider hosting an initial start-up of the programme in the Thies area, just outside the Bassin Arachidier proper, and VEV would be interested in diversification, adding domestic biogas to their product line.
- In the Diourbel area, also on the fringe of the Bassin Arachidier, the Christian Children Fund indicated to see significant potential in promotion of domestic biogas in their working area.
- At local level, there are many farmer Agences (GIEs) cooperating in the field of agricultural input, cropping, cattle breeding and diary. These GIEs would be good points of entrance for local biogas awareness and promotion campaigns.

3.1.4 *Offer domestic biogas with a "financial package":* Economically, biogas seems competitive in comparison with most existing domestic fuel mixes. However, the up-front investment will prove to be a significant barrier for many households –also in view of the unfamiliarity of the technology.

- A reasonable subsidy component (25-35% of the investment) will position the Internal Rate of Return of a biogas installation within the scope of a medium sized farming household.
- An appropriate loan arrangement –say at an interest rate of 12% with a maturity of at least 3 years- for the remaining investment, preferably also covering necessary investments for improvement of stables and kitchen) would return a monthly repayment schedule that is likely lower than the actual domestic fuel expenses of the family.
- To ensure that mal functioning or operation does not lead to disappointment with the technology, subsequently resulting in failing to repay the loan, a guarantee period equal to the loan repayment period should be considered.
- In an early stage of the programme, close cooperation with financial institutions / saving and credit organizations will be necessary to develop a sustainable and mutually attractive financial arrangement for subsidy channelling and credit.

A set-up like this would –particularly with longer loan maturity- look quite like the "fee for service" arrangements used in Senegal for (wind pump-) water schemes and rural solar pV systems.

3.1.5 *Pay significant attention to health improvement, workload reduction and bio-slurry application in biogas promotion:* The workload associated with food preparation –collection of fuel wood, preparation of dung cake, cleaning pots, tending the fire etc) is substantive (over 8 person hours per day per family). With a proper lay-out of plant, kitchen and stables, biogas can significantly reduce this burden.

- Indoor smoke pollution, very often brought forward in the household interviews, is a serious issue in Senegal.
- The awareness on the importance of proper fertilizing practices is rising. Bio-slurry can play an important role in better closing the nutrient cycle for agricultural soils.
- Connection of the latrine to the biogas installation would even further improve the health and sanitary conditions of farming families. However, in view of the apparent general reluctance it would be ill-advised to make this compulsory; traditional taboos may lead to families avoiding the bio-slurry or abandoning the installation all together. Equipping of installations with a second inlet pipe to which at a later stage a latrine can be easily connected should be compulsory however.
- As a large share of the benefits, particularly regarding health and sanitation and workload reduction, accrues to the female part of the family, women shall be properly included in assessment, awareness, promotion and user training activities.
- Focus of promotion should be on farming families that live on small and medium sized farms; they are best placed to reap the full benefits of the investment. Larger farms and "managed farms" will often have expectations that cannot be fully met with a simple domestic biogas installation.

3.1.6 *Develop the programme, regarding quality assurance and monitoring arrangements, "CDM / VER-compliant" from the on-set:* Substituting fossil and, at least partially, non-renewable fuel, biogas reduces greenhouse gas emissions and will potentially qualify for CER or VER revenue.
Initially, due to limited implementation, the costs involved in becoming fully "CDM compliant" may be too large, but the revenue can contribute to the financing of the up-scaling of the biogas programme.

3.1.7 *Link with the Peri-Urban smallholder Improvement Project in the Gambia*. This project, not far from the proposed project area, reportedly obtained good results with a domestic biogas pilot.

3.2 Recommendations for SNV-West Africa:

3.2.1 *Start discussions regarding engagement of SNV in biogas activities in Senegal*. These activities could either be "stand-alone" or in the framework of regional biogas activities. A decision should be available by November 2007.

3.2.2 *Identify a partner organization for implementation of the pilot phase.* Although both missions indicate ASER as a potential partner organization, alternatives like PAPEL, PROGEDE, ENDA or LVIA (especially in view of local presence) should receive proper consideration. As the importance of selecting the correct partner organization can hardly be overestimated, a third, short mission to Senegal seems justified. This mission should preferable be fielded in the second half of November 2007 in order for SNV to decide before the end of this year.

3.3.3 *Start recruitment of a Senior Biogas Advisor.* Recruitment could start following the decision recommended in 3.2.1. To facilitate a swift recruitment procedure, a draft function-task description for the position is provided with this document as annex 15. Recruitment should aim at having the Senior Biogas Advisor operational before the end of the 1st quarter of 2008.

3.3.4 *Prepare the programme Implementation Document*. In close cooperation with the selected partner organization, a small team -including SNV's Senior Biogas Advisor- shall detail the implementation modalities of the programme.

3.3.5 *Submit the Feasibility Study Report, the Institutional Assessment Report and, later, the Programme Implementation Document to the "Biogas for a Better Live, an African Initiative".* This initiative supports larger scale domestic biogas initiatives in Africa and may play an important role in mobilization or facilitation of further technical and financial assistance.

4 Main opportunities and risks

Opportunities:

- The traditional domestic fuels are in short supply, expensive and to al large extent commercialized. Domestic biogas, from a social, economic and environmental point of view, appears to be able to provide valuable services.
- In large parts of the country the trend in agriculture seems to be towards integrated, intensive farming. With this trend continuing, biogas would increasingly fit into the farming practices.
- The "Biogas for a better live, an African initiative" could assist in facilitation of programme funding.

Risks:

- In absence of a reference only a proper pilot phase will offer clarity on actual, commercial market for domestic biogas. The substantial investment required for the pilot cannot be guaranteed to render a return.
- Although the Casamance appears to have a reasonable potential for domestic biogas, the safety situation in this area may prove prohibitive for a biogas programme.

5 SWOT analysis.

The conclusions and recommendations are based on the SWOT analysis of the mission findings. An overview of this analysis is provided hereunder.

Technical factors

Strong

•Most hh have sufficient **dung** available.
•Most hh have sufficient **water** available
•**Clusters** of qualifying hh in peri-urban / rural areas in the basin arachide
•Necessary **construction material** generally available in (larger) villages

Weak

•**Integrated farming** not common
•No example of domestic biogas, no **proven design**
•Very few, if any, **local micro business** that can readily provide biogas services
•**Cattle stabling conditions** mostly not perfect for biogas
•Sometimes **insufficient space** (peri-urban) for biogas plant on hh yard

Opportunity

•Real problem with availability **present domestic fuels** (wood/charcoal/gas)
•Livestock development programmes stimulate **semi-intensive and integrated farming**
•In some areas **manure has value** (basin arachide)

Threat

•**Dung** largely (still) has little or no value
•**Family size** sometimes very large (>20)
•**Water** is expensive
•More **remote villages** may not be attractive for private enterprise
•**Year-round water** availability in rural areas may be insufficient
•**Drought** may move cattle (and households)

Environmental factors

Strong

•**Effective use of dung** will reduce nutrient depletion of soils (fodder, crops)
•Improvement of **farmyard and kitchen environment**
•**Reduction of fuelwood / charcoal** use will preserve of forests
•**Stable feeding** reduces overgrazing

Weak

•Slurry handling may cause **pollution in peri-urban areas**

Opportunity

•Biogas substituting charcoal / butane gas will qualify for **CDM revenue**

Threat

•Year round **fodder availability** for increased stable feeding may be insufficient

Economic factors

Strong

•Present domestic fuels **expensive**
•Improving **cooking conditions** will be appreciated
•Households **invest** in housing, improved stables, latrines, solar pV
•Hh with **economic activities** (dairy, cattle fattening / breeding)
•Some hh have **other sources of income** (employment / remittances)

Weak

•Large investment for poor target group
•Often **additional investment** necessary beyond biogas plant
•Value of good **organic fertilizer** low,
•In rural areas domestic fuel is still "**for free**" (but only at great effort)
•**Latrine connection** savings unlikely
•In more remote areas dairy produce hardly marketable
•**Experience** with credit at farmer level limited

Opportunity

•**High prices + high demand** of present domestic fuels (likely to remain)
•Domestic fuel is **commercial** (peri-urban)
•**Market for dairy** is real; opportunity for processing
•Construction with **clay-stabilized bricks** to reduce costs
•Availability of **local credit** facilities?

Threat

•Water is **expensive**
•**Interest rates** perceived high
•Earlier projects support innovations with **high subsidies**
•Availability of **local credit** facilities?
•Visitited qualifying hh **not** poor

Programmatic factors

Strong

•Encouraging experience with **quality standards** in solar pV and wind pumps
•**Extension network** of Dep of Livestock / PAPEL programme
•Reaction of **local officials** encouraging
•Strong **local organization** for drinking water programmes
•In some villages **strong NGO involvement** geared towards general development / livelihood improvement
•Local **training facilities** available

Weak

•Hardly any **biogas awareness / examples**
•Rural **quality awareness** limited
•Very few, if any, **local micro business** that can readily provide biogas services
•Considerable **awareness / promotion / training efforts** necessary
•**Remote rural potential** not thoroughly assessed but likely limited

Opportunity

•**Integration** in livestock / agriculture / water / rural development initiatives
•**Rural credit facilities** seem promising for biogas programme
•Linking with **NGO-private enterprise** in related fields (LVIA – VEV in Thies)
•Linking with (female) **dairy production** cooperatives

Threat

•**Initial dissemination** pick-up likely to be slow

Social factors

Strong

•In general, livestock and land are **owned by the farmer**
•**Traditional use of dung** (fertilizer, fuel) does not hamper operation of biogas plant (perception changed over time)
•**Health issues** related to cooking perceived as real problem
•Cooking on **gas** already introduced (urban)
•**Innovative farmers** have a good relation with Dep of Livestock

Weak

•**Latrine connection** not easily accepted
•Owner **not always living on farm** (Eleveurs de dimanche)
•Large **cooking energy** requirements
•Poor track record with **improved cook stove** diffusion

Opportunity

•Biogas could free **female workforce** for more productive / care use
•Linkage with WB / RNE **sanitation programme**?

Threat

•**Male dominance** in hh expenditure decisions

Political context

Strong

•**Initiative of ASER** in initiating domestic biogas feasibility study
•Role of **ASER in rural electrification** (solar pV)
•Domestic biogas programme in tune with major **development and environment policies** of Senegal government

Weak

Opportunity

•Financial and technical support of the "**Biogas for a better live**" initiative
•Linkage with other **rural development initiatives** not thoroughly assessed, but seems promising

Threat

•Part of **Cassamance** not politically stable / secure


Pic 14


Pic 15


Pic 17


Pic 16

1 Main features.

The Senegal Biogas Programme as proposed hereunder intends to lay out a robust foundation for the establishment of a commercially viable domestic biogas sector. Salient features of the programme would include:

Separate pilot phase: To fill in experience and knowledge gaps on technical, capacity building, socio-economic and institutional aspects of a large-scale domestic biogas programme in Senegal, the proposed programme is developed with an in-built pilot phase during its fists year. At the end of this year, the programme will facilitate a proper go / no-go decision.

Study: The programme aims to study and document rural domestic energy practices in general and biogas user experiences in particular. The study results will be used to direct the programme and -on the medium term- to justify and direct continuation of a domestic biogas programme in Senegal.

Scope: The programme, including the pilot phase, will aim to support the dissemination of 8000 domestic biogas installations for farming households.

Standardization of domestic biogas design, construction and after sales service: The programme will produce concise manuals for appropriate installations and appliances, including manuals for construction, manufacturing and after sales service and the formulation of the related quality standards.

Introduction of a quality management system: Precise control of the quality of construction, after sales and extension services will not only safeguard the investment of the farmer and enable the farmer to maximize the benefits of the investment. I will also level the playing field for aspiring biogas companies to operate on the emerging market. The quality management system will be compatible with quality assurance certification and CDM registration in a later stage.

Financing: The programme proposes a flat rate subsidy scheme for participating farmers, reducing the initial investment with ~ 25%. In addition, and key to the long term success, the programme will support an investment credit facility in cooperation with existing micro-finance institutions.

Training: The programme will invest significantly in training. On the supply side of the market -to ensure that necessary dissemination skills are as much as possible available locally- and on the demand side -to make sure households understand the operation and maintenance of their plants sufficiently and families apply biogas and bio-slurry to their maximum advantage.

Sectoral approach: The programme will strongly promote an approach in which Government, non-government and private sector organizations, in a complementary fashion assume those programme functions that intrinsically fit to the character of their organization.

Capacity building: The programme intends to invest heavily on developing the necessary indigenous organizational and institutional capacity within the biogas (sub) sector.

1.1 Pilot objective, scope and success indicators.

Objective: The objective of the pilot will be to confirm active demand for domestic biogas in Senegal and to fill in crucial knowledge gaps regarding its large scale dissemination.

Scope: The pilot is proposed in two Regions, Fatick and Kaolack, in the heart of the Bassin Arachidier. This area is expected to have the highest opportunity for domestic biogas. To create initial demand, the pilot will launch promotion / awareness campaigns for the technology in one Department of each Region. For this activity the pilot will cooperate closely with existing rural development organizations (NGOs, PAPEL, Dep of Livestock, VEV etc). The intention of the promotion is to identify 4 clusters (2 in each Region, 2 rural areas and 2 peri urban areas) of ~ 25 households that are willing to invest, under the pilot's conditions, in a domestic biogas plant. In total, the pilot will support the construction of 100 installations.

Parallel to the promotion activities, the pilot will train two (proto) Biogas Construction Companies (BCC) in each Region in the construction and after-sales service of domestic biogas plants (4 BCCs in total, some 6 to 12 persons). Initially, these BCCs would be either selected local masons (or staff) of small local enterprises active in a related field (construction, water, fitting etc); proper establishment as companies will follow later. At least one steel manufacturing workshop will be identified to start production of a small batch of biogas stoves. Possibly, this workshop could embark on the production of a first batch of biogas lamps as well, alternatively these could be initially imported (Ethiopia, Nepal).

The pilot will commission / implement the studies on:
- Plant design development and testing;
- Prospective household assessments for 100 households;
- Rural credit institutions and facilities;
- Rural stakeholder mapping;
- Domestic energy baseline study for two Regions;
- Bio-slurry applications, and;
- A first (small) biogas user survey

In addition, deliverables will include:
- the first set of biogas promotion material;
- the lay-out of the quality assurance system, including procedures, forms and database;
- Initial training of Biogas Users, Extension Workers, Masons and Technicians;
- a small number of slurry demonstration plots;
- the final report on the pilot, and –in case the results are positive;
- a draft Programme Implementation Document.

Success indicators: The go / no go decision for the programme-proper could be based indicators including:
- The number of households that registered their interest in domestic biogas as a result of the promotion / awareness campaigns (>100);
- The number of households that actually invested in a biogas installation (>50);
- The actual price of an installation (< € 1000);
- The operation performance of the constructed installations (>80%);

1.2 Programme goal and purpose.

The proposed goal of the programme is **to improve the livelihoods and quality of life of rural farmers in Senegal through exploiting the market and non-market benefits of domestic biogas**. By the end of the project:
- 8,000 new biogas plants will be built nationwide;
- 95% of all new biogas plants will be connected to indoor cooking facilities;
- 80% of all new biogas plants have a double slurry pit[37] and;
- 50% of all new biogas plants will have toilets attached[38];

The purpose of the programme is **to develop a commercially viable domestic biogas sector**. Therefore:

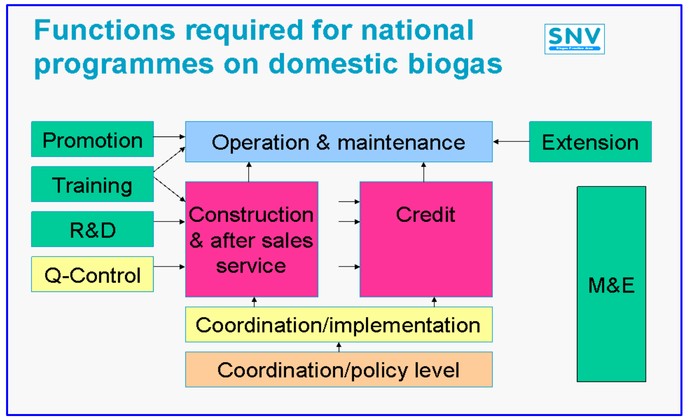
[37] For the proper application of bio-slurry as organic fertilizer, collection of the slurry would be a prime requirement. Double slurry pits enable to collect slurry, mix it with other organic material, and leave it for curing for a short period.

[38] It is acknowledged that 50% toilet connection in Senegal's context is a tall order. However, in view of the potential benefits for health and sanitation, the programme should be committed to invest significantly in proper promotion. Technically, the programme will assure that all installations are equipped with a second inlet pipe to ensure attachment of a toilet at a later stage.

- A pilot phase of one year to confirm the active demand for the technology and to fill in gaps of knowledge and experience pertaining to large-scale biogas dissemination of biogas.
- The programme will start operations in the regions with the highest potential for domestic biogas, Fatick and Kaolack, and subsequently gradually spread to all other potential regions.
- At least 3 Biogas Construction Companies (BCCs) are established in each Region in which the programme supports activities;
- New biogas plants are constructed in clusters of 25 to 50 installations per village in 3 Departements of 10 regions. As a result, communities in at least 150 villages have access to the services of Biogas Construction Company;
- All plant owners have access to credit for biogas construction and 60% of biogas owners utilise it by the end of the project[39];
- Regional vocational training institutes will be identified to provide biogas training and act as regional “reference institutes”.

1.3 Programme components.

The focus of the programme shall be the biogas sector as a whole. Sector development implies the close cooperation of all relevant stakeholders (Government, Non-Government and private sector) in the sector at all levels (micro and macro). The chart indicates the main functions in a large-scale domestic biogas programme and its relations.



To support the programme’s purpose, objectives for each of the programme components are proposed in the table below.

CN	Component	Objective
1	Promotion & marketing	To stimulate demand, informing beneficiaries and stakeholders on the benefits and costs of domestic biogas.
2	Financing	To lower the financial threshold and improve access to credit and repayment assistance, to facilitate easier access to domestic biogas for all potential clients, with particular emphasis on the poor, women and other disadvantaged groups.
3	Construction and After Sales Service	To facilitate the construction of 8000 domestic biogas-plants and ensure their continued operation.
4	Quality Management	To maximise the effectiveness of the investment made by the biogas owners and to maintain consumer confidence in domestic biogas technology.
5	Training	To provide the skills for business people to run biogas SMEs and for biogas users to be able to operate their plants effectively
6	Extension	To provide the information to allow biogas users to effectively exploit all the benefits of biogas
7	Institutional Support	To maximise the ability of key biogas related institutions to provide the services and support required by the biogas sector to facilitate access to domestic biogas and the development of quality biogas products.
8	Monitoring and Evaluation	To identify project progress and impact on stakeholders/other aspects in order to facilitate knowledge transfer.
9	Research and Development	To increase knowledge about domestic biogas issues to maximise effectiveness, quality and service delivery of the biogas programme.
10	Programme management (National / Regional)	To support, coordinate and supervise the activities driving the development of a commercially viable biogas sector.

1.4 Expected results.

[39] The assumption is that at the end of the programme 60% of the installations (5980 plants) are constructed with credit assistance. This credit share will increase from 30% during the first year to 70% in the last programme year.

The table shows a summary of the programme's main expected results[40]. Besides the environmental and energy aspects of domestic biogas, significant results can be expected in the socio-economic field and capacity building

Senegal Biogas Programme	expected results	
Biogas plant construction	**8,000**	[plants]
Energy		
Energy production	**232,659**	[GJ]
Power installed	**24,346**	[kW]
Environment		
GHG emission reduction	**66,728**	[t CO_2eq]
Deforestation reduction	**4,094**	[ha of forest]
Soil nutrificaton	**21,150**	[t(DM) bio-slurry]
Fuel substitution		
Biomass	**60,385**	[t biomass]
Fossil fuel	**1,820**	[t]
Socio-economic		
Persons reached	**64,000**	[persons]
Workload reduction (women & children)	**1,410**	[pers years]
Exposure to indoor air pollution reduced	**32,000**	[women & children]
Toilets attached	**4,000**	[toilets]
Productive slurry use	**6,400**	[households]
Employment generation (direct)	**560**	[person years]
Training		
User training	**11,200**	[person days]
Professional training	**3,428**	[person days]

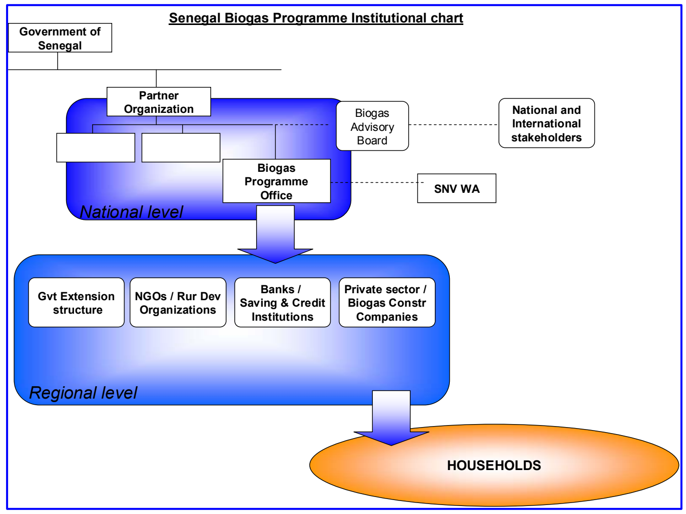
1.5 Actors & activities[41].

The mission proposes a multi stakeholder approach in which the key programme functions are attributed to actors best-placed to execute these. The matrix below provides an overview.

Actor - activity	Promotion & marketing	Investment financing	Construction and A.S.S	Quality Management	Training	Extension	Institutional Support	Monitoring & Evaluation	Research & Development	Programme Management
Biogas Advisory Board										green
National host organization				red		green	red	red		red
Senegal BPO	red	red	green	blue	red	red	blue	blue	red	blue
Saving & credit organizations	green	blue								
Extension entities	green	green		green	green	blue		green		
NGO / Rural Dev Organizations	green	green				blue				
BCCs	blue		blue	blue		green				
Regional training centres					blue					
Professional R&D / consult			red					blue	blue	

Initiating, primary responsible (red)
Executing (blue)
Assisting, supporting (green)

[40] A detailed overview of the expected results is provided in annex 12.
[41] The mission cannot claim to have an in-depth view on the institutional arena of Senegal's energy / rural development sector; the proposed actor - activity matrix should be regarded as a first approach and suggestions will be welcome.



The **Biogas Advisory Board** will accommodate representatives of all major programme stakeholders. The Board ensures the programme strategy matches relevant governmental policy (environment, rural development, energy) and facilitates a conducive and cooperative programme environment.

The BAB advises / comments on (draft) annual plans and reports, management responses to programme audits, and evaluation reports.

The Partner Organization will take overall coordination and supervision responsibility. The organization will ensure the programme is in tune with national energy / rural development policies. The Partner Organization facilitates cooperation with relevant national and regional programme partners in the fields of (rural) energy, environment, agriculture and general development.

The Biogas Programme Office will be the “operational entity” for the programme. Further discussions shall determine whether the BPO should be established as a “division” of the partner organization or as a more independent organization. The BPO will be responsible for the operational management of the biogas programme. To that extent, the BPO will develop technical and training manuals, corresponding quality assurance standards and procedures; develop and implement user and technical training, quality control and programme monitoring and commission R&D activities. The BPO will prepare the annual plans and reports for advice and approval by the BAB and the partner organization respectively.

Saving and Credit Institutions will support the programme by channelling subsidy funds to biogas households and offering appropriate biogas loans. The Institutions will play an important role in programme promotion as well.

Extension entities, in particular the regional Departments of Livestock, PAPEL but possibly other agricultural extension services, should play a main role in promotion of biogas and providing extension services regarding bio-slurry application.

Local NGOs, rural development organizations and farmer co-operations will, similar to the extension entities, support the programme with biogas promotion activities.

Biogas Construction Companies will be established and supported by the programme. These local BCCs, after proper training and certification, will be responsible for marketing, construction and after-sales service of domestic biogas installations. BCCs will be private enterprises that sell their product to farming households. Initially, BCCs probably will be small “proto-private” entities of trained masons but eventually they shall grow to proper rural commercial service providers.

Regional Training Institutes will, on behalf of the BPO, implement mason and technician training. To that extent, the BPO will support regional training centres with proper training curricula and ToT services. Especially during the start of the programme, involvement of the BPO in training will be significant. As the capacity of the regional training centres will gradually grow, they will increasingly act as resource centres for biogas technology in the region.

2 Activity schedule and budget outline.

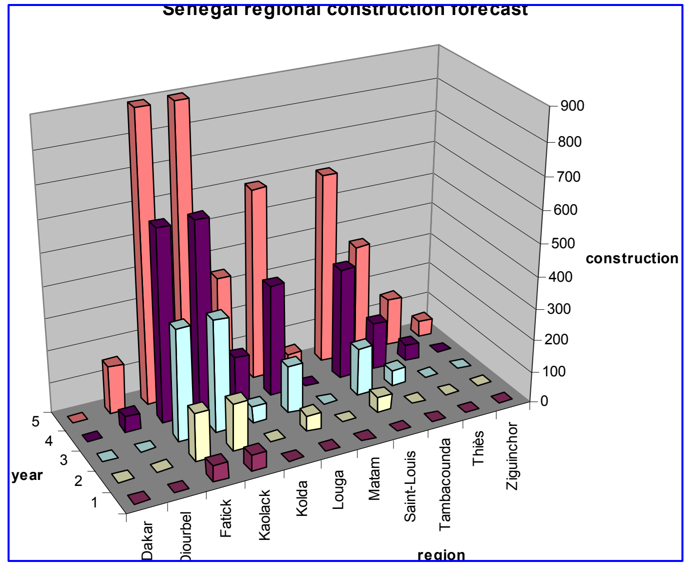
Detailed activity schedules and budgets will be prepared on an annual basis by the Biogas Programme Office. These annual plans will be proposed for advice to the Biogas Advisory Board. This outline suggests the boundaries of activities, scheduling and available budget[42].

General remarks to the activity schedule and budget:

- The investment (except subsidies) and support costs are corrected for inflation, assuming an inflation rate of 5% per annum.
- This schedule and budget merely serve to establish the "order of magnitude". Fine tuning should happen during the preparatory phase, together with the main implementing partner, in particularly while developing the Programme Implementation Document.

2.1 Production forecast.

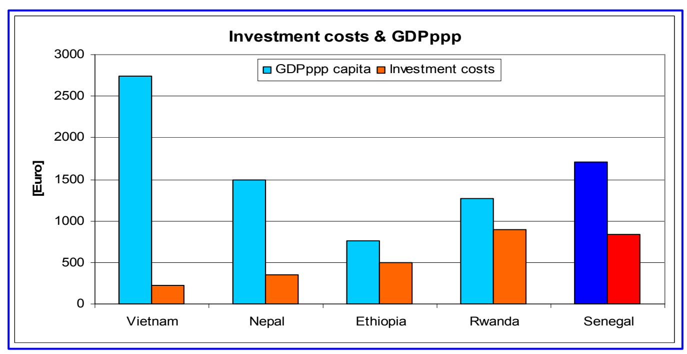
Foundation for this outline is the production forecast. The programme proposes to support the construction of 8,000 biogas plants, including 100 installations during the first-year pilot phase, over a period of 5 years. Production is forecast in 10 regions but will focus on high potential areas, in particular the Bassin Arachidier. The pilot phase may indicate a shift in this forecast, depending on actual demand and marketing opportunities. Initial production will be modest, but is expected to pick up as skills and awareness at demand and supply side increase. To facilitate effective supervision, it will be crucial to construct in batches.



For the pilot year the programme will stimulate to construct in one village of one Departement in Fatick and Kaolack. The programme will thereafter gradually develop activities in 10 Regions covering –tentatively- 1 to 3 Departements in each Region.

Investment costs	urban	peri urban	rural
construction share	10%	40%	50%
Investment costs	835	860	910
Avg investment costs	882		

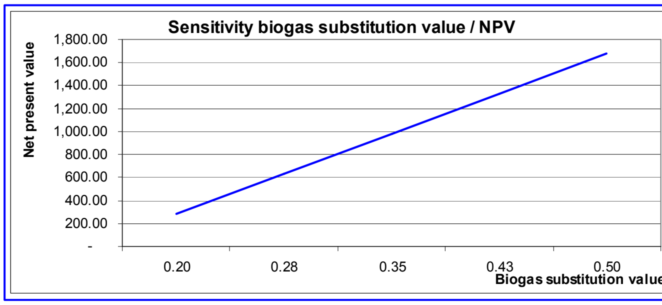
2.2 Subsidy.



The investment for the (modified) GGC 2047 fixed-dome biogas installation constructed in stabilized clay blocks will be in the range of € 629 to € 917 for plants with a digester volume of 4 to 10 m^3 respectively (price level end of 2006). In view of the large amount of dung available and the substantial domestic energy needs of most families, households would be best served with an 8 m^3 installation. The actual investment will depend on the location of the installation; the investment costs are estimated at € 835, € 860 and € 910 respectively for urban, peri-urban and rural areas. Assuming a construction share of respectively 10%, 40% and 50% for those areas, the average investment costs for budgeting purposes would arrive at **€ 882**. Typically, domestic biogas installations in Africa turn out more expensive than comparable installations constructed in Asia. Preliminary calculations indicate that the required investment for an installation in Senegal would equal 49% of the country's GDP_{ppp} per capita. In the African context, for as far as data is available (Rwanda 71%, Ethiopia 66%), this may not seem exorbitant, but there is a marked difference with relative investment costs in Asia (Vietnam 8%, Nepal 23%).

[42] The detailed activity schedule and budget outline is provided in Annex 13.

In addition, the financial performance of a biogas installation depends heavily on the biogas substitution value. With the significant difference of this value in different areas in Senegal (see Section 2 chapter 4.2.1) installations in rural areas are likely to be less financially attractive. Although the Net Present Value after 10 years is in all three scenarios positive after 10 years, each variation of € 0,10 in the biogas substitution value results in a variation of € 464 in the NPV[43].



Justification for a flat-rate subsidy.
The mission proposes a subsidy amount independent of the actual investment or plant size that will not be corrected for inflation.
- Larger plants are typically constructed for households with larger cattle herds. These households can be assumed to be richer and better able to contribute to the investment from their own means.
- The flat rate subsidy stimulates construction of installations that are better matched with the available amount of dung, stimulating a high feeding rate. Such installations perform better from both a technical as well as financial perspective.
- Refraining from inflation correction on the subsidy component results in gradual reduction of the effective share of the subsidy in the total investment (in this proposal from an average of 26% during the pilot to 21% in the 5th year.

The benefits of biogas are not all equally tangible and do not only profit the investor but have an impact on the community at meso and macro level as well. This, the substantial initial investment and the high sensitivity of the financial performance of the plant on the biogas substitution value would justify stimulating the dissemination of the technology with a two-tier flat-rate investment subsidy.

Subsidy levels can be justified by:
- The difference between Financial and Economic Internal Rate of Return, arguing that the investment benefits the community at large whereas the investment is made on an individual basis.
- The difference in investment costs between (peri-) urban and rural locations, arguing that the technology should be equally available to more remote areas.
- The difference in household income, arguing that poorer households should have an equal opportunity to reap the benefits of biogas.

However, these justifications hardly provide a hard, calculated subsidy level. To arrive at a more objective subsidy level, the potential CDM revenue of a biogas plant can be taken as a reference[44]. For Senegal, the CDM revenue of a domestic biogas installation would be in the order of €300 to €400.

Tentatively, a subsidy schedule of **fFCFA 100,000** (€ 153) for urban and peri-urban areas and **fFCFA 200,000** (€ 305) for rural areas is proposed[45]. Programmatically, for a two-tier subsidy scheme to work properly, a clear delineation for the different levels is crucial. Details on this shall be worked out during in the Programme Implementation Document.

Assuming that 50% of the installations will be constructed in rural areas, the average subsidy amount results in fFCFA 150,000 (€ 229) per installation. The subsidy fund requirement of the programme will thus amount into **€ 1.8 million**. During the pilot year, the programme will have a subsidy budget of € 22,901.

Annual subsidy requirement							[Euro]
	subsidy level	**1st year pilot**	**2**	**3**	**4**	**5**	**Total**
# of plants		100	400	1100	2300	4100	8000
Regular	152.67	7,634	30,534	83,969	175,573	312,977	610,687
High	305.34	15,267	61,069	167,939	351,145	625,954	1,221,374
Total subsidy requirement		**22,901**	**91,603**	**251,908**	**526,718**	**938,931**	**1,832,061**

43 A more detailed sensitivity analysis for biogas installations is provided in annex 11, Cost / benefit analysis.
44 The potential CDM revenue as a reference for subsidy levels for domestic biogas installations was first suggested by Mr. Bikash Pandey, Winrock International.
45 The higher subsidy, at this proposed level, will not entirely compensate the lower financial performance of rural installations

2.3 Direct investment.

For the assumed typical 8m3 installation the average price amount to € 882. Inflation will increase the investment to € 1073 in the 5th programme year. For the farmer, deducting the average subsidy of € 229, investment costs will range from € 653 to € 806 in the first and last year respectively.

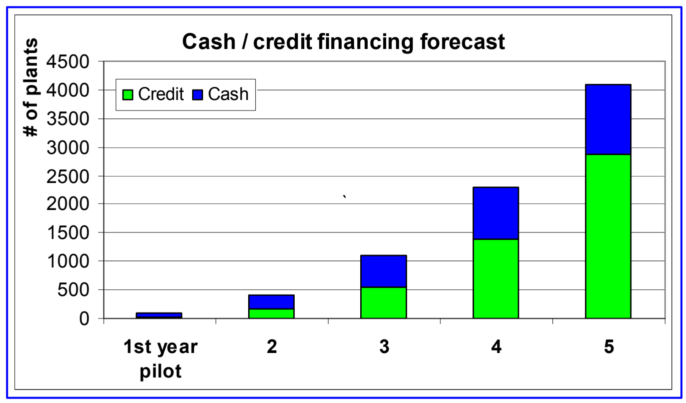
Investment costs / plant	1st year pilot	2	3	4	5	[Euro] AVG
Plant investment costs	882.49	926.61	972.94	1,021.59	1,072.67	1,034.59
Investment subsidy	229.01	229.01	229.01	229.01	229.01	229.01
Farmer investment	**653.48**	**697.60**	**743.93**	**792.58**	**843.66**	**805.58**
Subsidy share:	*26.0%*	*24.7%*	*23.5%*	*22.4%*	*21.3%*	*22.1%*

For the entire programme, the total direct investment (8,000 biogas installations) will amount to **€ 8.3 million**, out of which **€ 6. 5 million** is born by the farmer (directly or through a credit component). Similar amounts for the pilot year are € 88,249 and 65,348 respectively.

Direct investment SBP *(inflation correction in farmer investment)*	1st year pilot	2	3	4	5	[Euro] total
Annual production biogas plants	*100*	*400*	*1100*	*2300*	*4100*	*8000*
Farmer investment (avg)	65,348	279,042	818,328	1,822,938	3,459,011	**6,444,667**
Investment subsidy (avg)	22,901	91,603	251,908	526,718	938,931	**1,832,061**
Total direct investment	**88,249**	**370,645**	**1,070,237**	**2,349,656**	**4,397,943**	**8,276,728**

2.4 Credit.

The remaining investment will likely -despite the subsidy component- still be prohibitive for many farming households. Hence, a proper credit facility (assumed interest rate 12% pa, maturity 3 years) will prove crucial for the success of the programme.



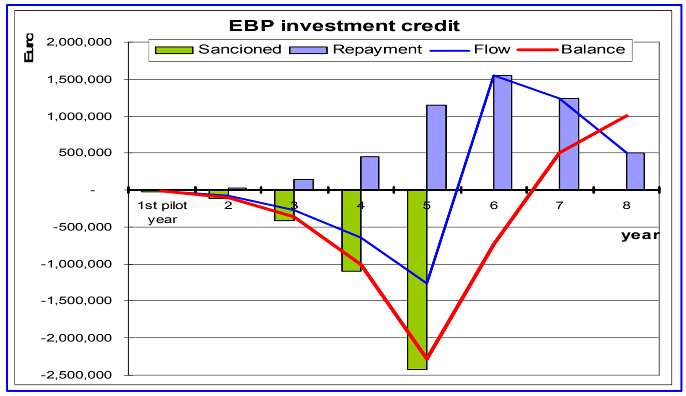
In these preliminary calculations it is assumed that in the first year 30% of the households get a loan for the biogas investment. Subsequently, the credit share shall increase to 70% in the 5th programme year. As a result, at the end of the programme 60% of the participating households will have constructed their plant with credit assistance.

Investment financing	1st year pilot	2	3	4	5	[Euro] Total
Total prinicpal	19,604	111,617	409,164	1,093,763	2,421,308	**4,055,456**
Financing costs	4,882	27,798	101,901	272,398	603,019	**1,009,999**
Total	**24,487**	**139,414**	**511,065**	**1,366,161**	**3,024,327**	**5,065,455**

On the total programme's principal loan amount of **€ 4.1 million**, the financing costs[46] will amount to just over**€ 1 million**. Similar amounts for the pilot year are € 19,604 and € 4,882 respectively. The necessary credit fund will be at its largest in the 5th year, at about € 2.3 million. Loan repayment loan will cover the sanctioned amount just after the 6th year.

[46] Financing costs: accumulated interest cost over the entire maturity period.

For the farmer the proposed financial package (subsidy and credit) would result in monthly loan repayment ranging from FCFA 5,700 to FCFA 10,200 per month for stabilized clay block plants of 4 and 10 m^3 respectively. The subsidy component reduces monthly repayment rates with 48% to 34% for the smallest and largest plant size respectively.



Financing costs fixed dome biogas digester GGC 2047 — *all amounts in CFA*

	4 m³			6 m³			8 m³			10 m³		
	burned brick	cement block	stabilized clay block	burned brick	cement block	stabilized clay block	burned brick	cement block	stabilized clay block	burned brick	cement block	stabilized clay block
Total investment	**618,031**	**436,781**	**411,781**	**690,286**	**477,786**	**449,661**	**828,167**	**584,417**	**546,917**	**900,898**	**638,398**	**600,898**
Contribution farmer in kind	64,033	64,033	64,033	78,039	78,039	78,039	92,045	92,045	92,045	108,651	108,651	108,651
Downpayment 10% remain	55,400	37,275	34,775	61,225	39,975	37,162	73,612	49,237	45,487	79,225	52,975	49,225
Investment subsidy	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
Fin cost without subsidy												
Remaining investment	**498,598**	**335,473**	**312,973**	**551,023**	**359,773**	**334,460**	**662,510**	**443,135**	**409,385**	**713,023**	**476,773**	**443,023**
Annual repayment	**(207,591)**	**(139,674)**	**(130,306)**	**(229,418)**	**(149,791)**	**(139,252)**	**(275,835)**	**(184,499)**	**(170,447)**	**(296,866)**	**(198,504)**	**(184,452)**
Monthly repayment	(17,299)	(11,639)	(10,859)	(19,118)	(12,483)	(11,604)	(22,986)	(15,375)	(14,204)	(24,739)	(16,542)	(15,371)
Total finiancing costs	*124,174*	*83,548*	*77,945*	*137,230*	*89,600*	*83,296*	*164,996*	*110,361*	*101,956*	*177,576*	*118,739*	*110,333*
Fin costs with subsidy												
Remaining investment	**348,598**	**185,473**	**162,973**	**401,023**	**209,773**	**184,460**	**512,510**	**293,135**	**259,385**	**563,023**	**326,773**	**293,023**
Annual repayment	**(145,138)**	**(77,221)**	**(67,853)**	**(166,965)**	**(87,339)**	**(76,800)**	**(213,383)**	**(122,046)**	**(107,995)**	**(234,414)**	**(136,051)**	**(122,000)**
Monthly repayment	(12,095)	(6,435)	(5,654)	(13,914)	(7,278)	(6,400)	(17,782)	(10,171)	(9,000)	(19,534)	(11,338)	(10,167)
Total finiancing costs	*86,817*	*46,191*	*40,588*	*99,873*	*52,243*	*45,939*	*127,639*	*73,004*	*64,599*	*140,219*	*81,382*	*72,976*

2.5 Programme support.

Programme support costs during the first year pilot amount to **€ 93,407**. The relatively high support costs, € 934 per installation, are a result of starting-up expenses any activity would face and the focus of the pilot on research and development. The total support programme budget **€ 1.6 million**.

Summary Programme Support Budget — *(corrected for inflation)* — *[Euro]*

			Budget					
			1st year pilot	2	3	4	5	total
1	Promotion & marketing		2,950	21,798	32,518	52,568	80,862	**190,696**
2	Finance		1,700	7,140	12,348	18,059	25,769	**65,016**
3	Construction & a.s.s		-	6,825	11,025	15,628	27,349	**60,827**
4	Quality assurance		22,529	21,550	25,857	60,601	77,942	**208,479**
5	Training		8,050	27,773	23,208	40,980	64,483	**164,493**
6	Extension		4,600	3,990	13,451	18,985	40,233	**81,259**
7	Institutional support		-	8,925	6,064	4,631	8,509	**28,128**
8	Monitoring & evaluation		5,000	44,100	27,563	41,675	36,465	**154,802**
9	Research & development		20,355	16,611	8,908	16,861	20,032	**82,767**
10	Project management		23,775	101,929	98,426	127,165	129,360	**480,655**
National Support Budget			**88,959**	**260,640**	**259,366**	**397,151**	**511,002**	**1,517,119**
Contingencies		**5%**	4,448	13,032	12,968	19,858	25,550	**75,856**
Total National Support Budget			**93,407**	**273,672**	**272,335**	**417,009**	**536,553**	**1,592,975**
Programme support / plant			*934.07*	*684.18*	*247.58*	*181.31*	*130.87*	*199.12*

2.6 Technical assistance.

The costs of Technical Assistance to the programme are based on SNV rates. The total TA budget amounts to **€ 997,900**, out of which € 138,800 is allocated to the pilot.

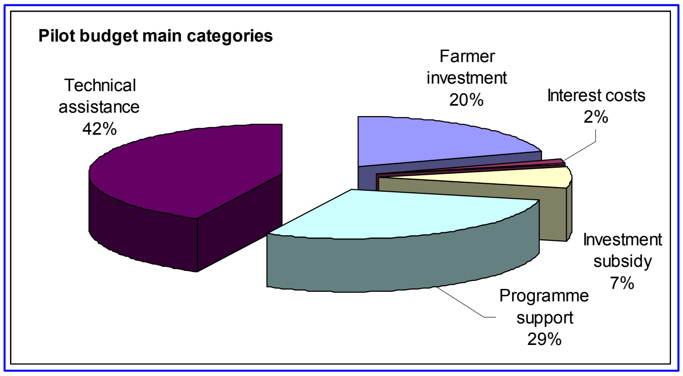
Summary Technical Assistance *(not corrected for inflation)* *[Euro]*

	Description	Budget					
		1st year pilot	2	3	4	5	total
1.01	Senior Technical Advisor (EUN)	115,200	100,800	84,672	66,679	46,675	**414,027**
1.02	Junior Technical Advisor (EUN)	-	88,200	92,610	97,241	102,103	**380,153**
1.11	Senior Technical Advisor (HCN)	12,600	17,640	18,522	19,448	20,421	**88,631**
1.12	Junior Technical Advisor (HCN)	-	12,600	13,230	13,892	14,586	**54,308**
1.21	Additional advisory services	6,000	6,300	6,615	6,946	7,293	**33,154**
1.22	Other support expenses	5,000	5,250	5,513	5,788	6,078	**27,628**
	Total Technical Assistance	**138,800**	**230,790**	**221,162**	**209,993**	**197,155**	**997,900**
					Technical assistance / plant		*124.74*

2.7 Budget summary.

The budget total for the pilot year amounts to **€ 325,338.** During this year, investment-related expenditure consumes only 29% of the budget, the remaining 71% will be used for programme support (in fact rather "programme development") and technical assistance.

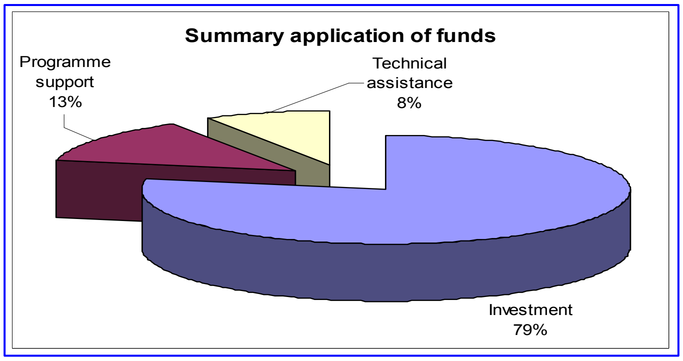
The total programme budget amounts to **€ 12.9 million**.



Senegal Biogas Programme *(corrected for inflation)* *[Euro]*

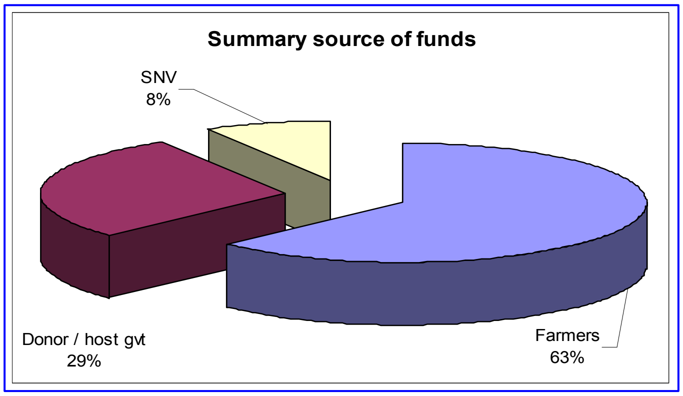
		SBP budget summary					
		1st year pilot	2	3	4	5	total
1a	Farmer investment	65,348	279,042	818,328	1,822,938	3,459,011	**6,444,667**
1b	Interest costs (credit component)	4,882	27,798	101,901	272,398	603,019	**1,009,999**
1c	Investment subsidy	22,901	91,603	251,908	526,718	938,931	**1,832,061**
2b	Programme support	93,407	273,672	272,335	417,009	536,553	**1,592,975**
2c	Technical assistance	138,800	230,790	221,162	209,993	197,155	**997,900**
	Total project	**325,338**	**902,905**	**1,665,634**	**3,249,056**	**5,734,670**	**11,877,602**
	fCFA	*213,096,457*	*591,402,751*	*1,090,990,203*	*2,128,131,574*	*3,756,208,640*	***7,779,829,625***

Application of funds: Investment, for the construction of 8000 installations, takes 79% (€ 9.3 million) of the total programme costs. The remaining 22% (€ 2.6 million) will be applied for programme support. Programme support includes a budget of nearly € 1 million for Technical Assistance.



Application of funds		[Euro]		[%]	per plant	[Euro]
1	**Investment**					
1a	Farmer investment	6,444,667	69%		805.58	
1b	Interest costs (credit component)	1,009,999	11%		126.25	
1c	Investment subsidy	1,832,061	20%		229.01	
	Total investment	**9,286,727**		78%		1,160.84
2	**Programme support**					
2a	Programme support	1,592,975	61%		199.12	
2b	Technical assistance	997,900	39%		124.74	
	Total project support	**2,590,875**		22%		323.86
	Total application	**11,877,602**				1,484.70

Source of funds: The lion share of the funds, 63% or € 7.5 million, is sourced by the participating farmers either directly or -more likely- indirectly through the repayment of biogas loans. The farmers' share covers investment and investment financing costs, minus the subsidy component. Donor(s) and the Senegalese Government are proposed to provide funds for the subsidy component (€ 1.4 million) and programme support costs (€ 3.5 million). A proposal for a division of the contributions by the partners will be subject to further negotiations during the development of the Programme Implementation Document. SNV might be approached to finance the Technical Assistance component.



Source of funds		[Euro]		[%]	per plant	[Euro]
a	**Farmers**					
a1	Farmer investment	6,444,667	86%		805.58	
a2	Interest costs (credit component)	1,009,999	14%		126.25	
	Total participating farmers	**7,454,666**		63%		931.83
b	**Donor / host government**					
b1	Investment subsidy	1,832,061	53%		229.01	
c1	National support	1,592,975	47%		199.12	
	Total donor / host gvt	**3,425,036**		29%		428.13
c	**SNV**					
d1	Technical assistance	997,900			124.74	
	Total SNV	**997,900**		8%		124.74
	Total source	**11,877,602**				1,484.70

Annexes to the report on the feasibility study on a national programme for domestic biogas in Senegal.

Pic 18

Pic 19

Pic 20

Pic 21

Pic 22

Pic 24

Biogas and Sustainable Development

Sustainable development covers three aspects of society - economic, social and environmental. Biogas contributes to these three aspects of sustainable development in the following ways:

Domestic biogas digesters contribute to economic development because:
– The expenses for domestic energy are significantly reduced.
– The labour required to maintain traditional energy systems (such as firewood collection) can be used in more directly economically productive ways.
– Substitution of petroleum products will reduce the countries foreign exchange demand.
– Application of bio-slurry increases the yield and reduces the need` -and expenses- for synthetic fertilizer.
– A vibrant biogas sector creates significant employment and related economic activities, particularly in rural areas.
– Reduced disease (human and animal) can improve productivity.

Bruntland & biogas

The generally accepted definition of Sustainable development, published in the Bruntland Report in 1987:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Domestic biogas is compatible with the Bruntland definition by:
– meeting household energy and income generation needs;
– reducing greenhouse gas emissions
– reduces reliance on fire wood therefore pressure on forest resources
– reduces ground and surface water pollution
– reduces reliance on non-renewable energy sources and raises the profile of renewable energy technology
– providing a long term solution to pollution and energy needs
– reducing reliance on chemical fertizer and improving soil condition and fertility through proper application of bio-slurry

Domestic biogas digesters contribute to social development because:
– The reduction in domestic workload, particularly for women and children, increases opportunities for education and other social activities.
– Respiratory illnesses resulting from indoor air pollution and gastro-enteric diseases as a result of poor sanitary conditions reduce significantly.
– In rural areas, biogas digesters often initiate innovation (education, sanitation, agriculture).
– Increase awareness of alternative farming and animal husbandry practices and environmental impacts of behaviour.

Domestic biogas digesters contribute to environmental development as follows:
– Substituting conventional fuels and synthetic fertilizer, and changing traditional manure management systems, biogas installations reduce the emission of greenhouse gasses significantly.
– Bio-slurry improves soil texture, thus reducing degradation, and reduces the need for further land encroachment.
– Reduction of firewood use contributes to checking deforestation and reduces forest encroachment.
– Improved manure management practices reduce ground and surface water pollution, odour and improve aesthetics.

Biogas & the United Nations Millennium Development Goals.
Domestic biogas programmes contribute to reaching the UN-MDGs in the following ways:

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 a household must have a minimum number of animals that is often more than a very poor family has. However, the biogas dissemination process and the resulting reduced claim on common ecosystem services do affect the livelihood conditions of (very) poor non-biogas households as well. For example:
- Construction and installation of biogas creates employment for landless rural people
- 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

> **Biogas and the World Summit on Sustainable Development**
>
> As a follow-up to the Rio Summit of 1992, the World Summit on Sustainable Development was held in Johannesburg in 2002. Energy was highlighted as a key topic for discussion as it was felt that there had not been enough focus on it at the previous summit. As with the previous Plan of Implementation, waste management, pollution control and social sustainability were highlighted.
>
> The Plan of Implementation states that about two billion people, or one third of the world's population, presently lack access to electricity or modern energy services and rely on burning firewood or biomass to meet their cooking and heating needs. Meeting the energy needs of these people with modern energy services was a major issue at the Summit, and governments committed themselves to "improving access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources."

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 a domestic energy supply. Biogas directly benefits this group in the following ways:
- Biogas can provide light that helps women and girls to extend the amount of time in the day that 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 on average 2-3 hours per household per day
- The reduced smoke from replacing traditional fire wood stoves with biogas can improve the health of women (and children) who are most exposed to the dangers of wood smoke.
- The provision of biogas can provide an additional or more cost effective home based energy source that can enable women to participate in home based enterprises 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 of 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 under small children (<5 mortality caused by diarrhoea is approximately 1.5 million persons per year).
- Biogas stoves substitute conventional cook stoves and energy sources, virtually eliminating indoor smoke pollution and, hence, 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 surrounding, lowering the exposure of household members to harmful infections especially children who spend extended periods in the farm yard.
- Proper application of bio-slurry will improve

> **Biogas and the Millennium Ecosystem Assessment**
>
> As part of the implementation of the MDGs, the Millennium Ecosystem Assessment was released in March 2005. This assessment examined the relationship between ecosystems and achieving the MDGs. It not only found that not sustainable ecosystem management and development are imperative for reaching the MDGs, but moreover that ecological limits to worldwide growth will affect both developed and developing countries.
>
> In addition to providing predictions and evidence the assessment provided a series of proposed responses and interventions. Biogas programmes have elements that are relevant to each of these responses and interventions.

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, which protects 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 influences national policies on sustainable development (e.g. agriculture, forestation, 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 forestation

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 farmyard therefore reducing the risk of water contamination.

	MICRO	**MESO**	**MACRO**
INFORMAL	• Reduced indoor smoke-induced illnesses. • Reduced poor-sanitation induced illnesses. • Reduced drudgery from fuelwood collection. • Reduced pressure for illegal forest encroachment. • Reduction drudgery from weeding fields. • Reduced workload for food-preparation. • Reduced soil degradation. • Improved opportunity for education.	• Reduced risk of erosion and landslides in mountainous areas. • Improved forest quality and quantity. • Reduced pollution of surface water. • Reduced pollution of the environment as a result of uncontrolled dumping of animal waste.	• Reduction of illness-induced production losses. • Improved biodiversity. • Increased non-marketable (NT)FP availability. • Increased efficient productivity. • Reduced mortality. • Improved human resource base. • Reduced risks as result of global warming.
FORMAL	• Increased efficient productivity. • Reduced direct medical costs. • Reduced expenses on conventional energy sources. • Reduced chemical fertilizer expenditures. • Increased opportunity for (small scale) animal husbandry. • Increased opportunity for (small-scale) organic agriculture. • Improved agricultural yields. • Increased family income.	• Increased employment and income generating opportunities. • Opportunity to develop markets for (organic) agricultural produce.	• Reduced (forex) cost on medication. • Reduced health system expenses. • Reduced (forex) costs on chemical fertilizer. • Reduced (forex) costs on fossil fuels. • Increased availability marketable (NT)FP. • Increased agricultural production. • Increased tax revenues. • Generating CDM revenues.

1. Introduction and background
The Director of SNV/Guinea Bissau, Mr. Marc Steen, requested the Biogas Practice Team (BPT) of SNV to conduct a brief desk study on the possible application of domestic biogas in Senegal. On behalf of this Team, Mr. Jan Lam conducted a pre-feasibility desk study and presented the draft report in September 2004. On 19 September 2005, the Regional Director of SNV West-Africa, Mr. Jan de Witte, together with Mr. Steen met with representatives of ASER, the Senegalese Agency for Rural Electrification, and of the Dakar University. The General Director of ASER, Mr. Aliou Niang, strongly requested SNV to assist ASER in conducting an in-depth feasibility study. This document presents the Terms of Reference (ToR) for such study.

2. Objective of the study
The objective of the study is to thoroughly assess the feasibility to set-up and implement a national biogas programme in the Republic of Senegal.
More specifically, the study will address the following areas; see Annex I for a tentative table of contents of the study report:
- Country background including agricultural & livestock sector, energy demand and supply, energy policy and plans, safety situation;
- History of domestic biogas;
- Potential demand for domestic biogas;
- Possible supply of services for domestic biogas; and
- Outline for a national programme on domestic biogas.

3. Activities and methodologies
The following activities and methodologies are proposed:

A. Preparation of a mission to Senegal by using the pre-feasibility desk study report, collecting secondary information, contacting key respondents and informants in Senegal and abroad, and drafting checklists for biogas plant visits and interviews;
B. Mission to Senegal to visit domestic biogas plants constructed in the past (if any), to meet with key respondents and informants for interview and discussion. The mission shall include a workshop to discuss with the main stakeholders the roles of the different actors in Senegal and the outline of a possible national biogas programme;
C. Formulation of the draft study report and submission for comment to SNV/Guinea Bissau, ASER and members of the Biogas Practice Team (BPT) of SNV;
D. Submission of the final study report by incorporating the comment from SNV/Guinea Bissau, ASER and members of the BPT.

4. Time schedule
The mission to Senegal shall be completed within a period of three weeks from 16 October to 3 November 2006. The draft report shall be submitted before the end of November 2006. SNV/Guinea, ASER and members of the BPT will provide within 10 working days comment on the draft report. After that, the final study report will be presented within five working days.

5. Required budget and proposed financing
The costs of this study will mainly consist of expenses for travelling and DSA of the team members. The personnel costs of the team members will be borne by SNV and ASER for their own staff. ASER will bear the costs of in-country travelling of the team, the costs of the international air tickets of the SNV appointed members and the accommodation and DSA of the ASER appointed team member. SNV will bear the costs of accommodation and DSA of the SNV appointed team members.

6. Expected output

The report on the feasibility study shall be well-structured and clearly written in English not exceeding 50 pages excluding annexes and provide informed recommendations on the possibilities for ASER to set-up a national biogas programme in Senegal. Annex I provides a tentative table of contents for the report.

7. Composition of the team

The mission team shall consist of three members. Two members including the team leader will be appointed by SNV (one of them will be a senior biogas advisor, the other an agronomist); out of which one masters the French language. The other member will be appointed by ASER.

8. Further arrangements

Prior to departure to Senegal, the team leader will come up with an itinerary for the mission. The mission team is free to discuss any matter concerning the assignment with any institution or individual, but is not authorised to make any official commitments on behalf of ASER or SNV.

9. References

Jan Lam, *Report (draft) on the Biogas Senegal Pre-Feasibility Desk Study.* SNV,
Biogas Practice Team, The Hague, September 2004.
Conditions for the large-scale dissemination of biogas plants. SNV, Biogas Practice Team.

Wim J. van Nes
The Netherlands, 22 August 2006

Tentative table of contents for the report on the feasibility study

Title page
Acknowledgement
Summary
Table of Contents
Abbreviations
1. Introduction and background
    - Country background
    - Agricultural & livestock sector
    - Energy demand and supply, policy and plans
    - Safety situation
2. Objective, methodology and limitations
3. History (previous projects) and analysis of domestic biogas
4. Potential demand for domestic biogas
    - Current consumption of energy in the rural areas
    - Current application of manure
    - Climatic conditions
    - Availability of water at livestock farms
    - Role of women in decision making and livestock keeping
    - Technical potential and benefits of domestic biogas
    - Financial and economic potential for domestic biogas
5. Possible supply of services for domestic biogas
    - Promotion and marketing
    - Construction, maintenance and after sales service
    - Subsidy and credit
    - Quality control and R&D
    - Training and extension
    - Monitoring and evaluation
    - Organisational strengthening and institutional development
6. Outline for a national programme on domestic biogas
    - Objectives, output targets and programme duration
    - Required tentative budget and financing
    - Proposed programme management structure
    - Required TA
    - Assumptions and risks
7. Conclusions and recommendations
8. References
Annexes:
- ToR
- Itinerary of the mission
- Contact details of visited organisations and individuals

Date	Location	Activity	Met with
20061016		Departure Amsterdam / the Netherlands Arrival Dakar / Senegal	
20061017	Dakar	Study logistics preparation, contacting ASER and Mr. Lamine Diop	
20061018		Meeting Royal Netherlands Embassy (RNE)	Mr. J. Hijkoop; Mr. A. Diallo
		Meeting with Agence Senegalais d' Electrification Rurale (ASER). Presentation "Setting the scope" and discussion	Mr. A. Niang, ASER Director General; Mr. C. Wade, ASER Conseilleur Technique; Mr. O. Sarr; ASER GIS, Mr. M. Sow, ASER; Mr. M. Kanoute, Min, de ''Energie et des Mines.
20061019		Meeting with ASER, GIS department	Mr. O. Sarr.
		Meeting with Ministry of Environment	Mme M. Sarr; Mme G. Diaw
		Meeting with Organization Mise en Valeur de Fleuve de Senegal	Mr. A. van Kooten
		Centre d"Etudes et de Recherches sur les Energies Renouvables (CERER). Guided tour.	Mr. L. Diop
		Environment et Development du Tiers Monde (ENDA-TM)	Mr. S. Sarr, Carge de Programme
20061020		Project d'Appui a l'Elevage (PAPEL) Departement of Livestock	Dr. M. Lo, Veterian Epidemologiste, Conseilleur Technique.
		GTZ/Programme pour la Promotion de l'Electrification Rurale et de l'Approvisionnement Durable on Combustible Domestique (PERACOD)	Mr. D. Mansour, Mr. A. Ndiaye, Mme. Mireille
20061021	Le Saloum	End of Ramadan holidays	
20061022			
20061023			
20061024			
20061025	Thies	LVIA	Mr. Giovanni
		VEV, workshop visit	
	Thies-village	Visit of wind pump and water reservoir	Mr. Cisse, extension worker LVAI; Mr. Diop, village chief
		Visit of farm compound	Mr. Diop, village chief
	Thies	Slaughterhouse, Transpaille biogas installation	Mr. A. Thioye, Directeur d'Abbatoir
	Sassal	Agricultural and Pastoral Training Centre	Mr. E. Gning
	Bambey	l'Institut Senegalais en Recherches Agricoles (ISRA), visit Transpaille biogas installation	Dr. O. Ndoye, Head of Research
		Visit biogas compound	Mr.? (Driver of Mme Bayane)
20061026	Louga	Maison d'Elevage	Dr. M. Sakho, Inspecteur Regional; Mme N. Fall, Adjointe Inspecteur Regional; Mr. M. Niang, Inspecteur Travaux
	Louga-town	Women dairy collective	Mme Falla, Presidente
	Louga-suburb	Dairy farm	Mr. M. Ndiaye
		Farm	Mme Sylla
	Kebemer	Dairy farm	Mr. Momer Kebe

		Dairy farm	Mr. Matham Kebe
	St.Louis	Dep of Livestock	Dr. P. Nime
	St.Louis outskirts	Eleveurs de dimanche, farms	Mr. C. Diop, farm owner Mr. M. Sarr, farm owner
20061027	St.Louis	Team meeting	
20061028	St. Louis region	Trip to Gilado village, Ross Bethio, Richard Toll, Lac Guyere	- Mr. Camara, manager farm of Mr. M.Lo
	St.Louis	Interview	Mr. M.Lo, farm owner Mr. A. Guhur, PERACOD intern
20061029	Thies	Meeting LVIA	Mr. A. Armando
20061030	Diourbel	Introduction at PAPEL office	Dr. Yade
	Diourbel-town	Interviews wood / charcoal vendors and buyers	
	Diourbel-outskirts	Visit cattle breeding / agriculture cooperative and 2 farms	Mr. M. Tian
	Mbake	Farm visit	Mr. S. Konte
		Farm visit	Mr M. Diaw
		Farm visit	Mr. M. Ka
		Farm visit	Mme B. Sow
	Diourbel	Debriefing meeting	
20061031	Kaolack	Introduction at PAPEL office	Dr. A. Thiam
		Farm visit	Mr. M. Sene
		Farm visit	Mr. G. Ndoye
		Farm visit	Mr. M. Diop
		Farm visit	Mr. A. Sow
		Farm visit	Mr. Kotal
	Fatick	PAPEL office	Mr. P. Cisse, Inspecteur Regional Mr. Fay, Chief of Dep of Livestock
	Village?	Farm visit	Mr. A. Ndior
	Patar	Farm visit	Mr. B. Fall
20061101	Kaolack	Team meeting, SWOT preparation	
		Preparation debriefing	
20061102	Dakar	Meeting	Mr. M. Steen, Dir. SNV Guinea Bissau
		Debriefing ASER	Mr. C. Wade
		Debriefing RNE	Mr. J. Hijkoop
		Departure Dakar / Senegal	
20061103	Amsterdam	Arrival Amsterdam / the Netherlands	
	Leiden	Debriefing BPT	Mr. W. van Nes

A Household situation, domestic fuel use, water availability, agriculture.

sn	Location	Name	Interview date	Water: Available	Water: Community tap	Water: Farm yard tap	Water: Well	Water: River	Household Situation: Farmer-owner at farm	Household Situation: Household size	Household Situation: Latrine / toilet on yard	Household Situation: Well-to-do?	Household Situation: remarks	Cooking fuel: Fuel wood	Cooking fuel: Charcoal	Cooking fuel: Butane gas	Cooking fuel: Dung cake	Cooking fuel: remarks	Fields: Own fields?	Fields: remarks
1	Thies	Mr. Diop	20061025	1	1	0	1	0	1	30	1	1	village chief	1	1	1	0	CFA 15000/month	1	Millet & sorghum
2	Sassal	Emanuel Gning	20061025	1	0	0	1	0	0	6	1	0	Compound care taker + family	1	1	0	0	Collecting @ 5 km	1	
3	Bambey	?	20061025	1	0	1	0	0	1		1	1	Driver of Mme Bayane	1	1	1	0	Latrine connected		
4	Louga	Mme Falla / GIE femmes de Ndime	20061026	1	0	1	0	0	1	25	1	1	30 hh around common caltte pen	0	1	1	0		0	
5	Louga	Mamadou Ndiaye	20061026	1	0	1	0	0	1		1	1							0	
6	Louga	Dielerbou Sylla	20061026	1	0	1	0	0	1	8	1	1	Husband working in Italy	0	0	1	0	20 kg gas / month	1	
7	Kebermer	Momer Kebe	20061026	1	0	1	0	0	0	3	0		Only herdsman, wife and 1 child	1	0	0			1	
8	Kebermer	Mathiam Kebe	20061026	1	0	1	0	0	1	16	1	1	Price winning farmer	0	0	1	1	25 kg gas / month	1	
9	St. Louis	Cheikh Diop	20061026	1	0	1	1	0	1	47	1	1		0	0	1	0	400 kg gas / month (fridge)	1	
10	St. Louis	Malick Sarr	20061026	1	0	1	1	0	0	6	0	0	Manager family on farm						0	
11	Gilado	Couli Sow	20061028	1	1	0	0	0	1		1	0	Peulh community	1	0	0	1	Collected from large distances	1	
12	Tiago	Moustapha & Lamine Camara	20061028	1	0	0	0	1	0	10	1		Farm manager, owner in town						1	Fruit trees
13	Diourbel	Cooperative of 40 hh	20061030	1	0	0	1	0	0			0	Manager family on farm						1	Horticulture
14	Diourbel	?	20061030	1	0	0	1	1	0				Manager family on farm						1	
15	Diourbel	Modi Tiame	20061030	1	0	1	0	0	1	13	1	1							0	
16	Mbacke	Marieme Diaw	20061030	1	0	1	0	0	1	15	1	2		0	1	1	0	20 kg gas / month	0	
17	Mbacke	Mbaye Ka	20061030	1	0	1	0	0	1	25	1	1	Peulh family	1	1	1	1	20 kg gas / month	0	
18	Mbacke	Bocar Sow	20061030	1	0	1	0	0	1	20	1	1	Chief of cattle breeding prog	1	1	1	1	Spends > CFA 300 / day energy	0	
19	Kaolack	Michel Doudou Sehe	20061031	1	0	1	0	0	1	14	1	2		0	1	1	0	20 kg gas + 60 kg charcoal / m	1	Rice & sorghum
20	Kaolack	Gora Ndoye	20061031	1	0	1	0	0	1	10	1	2	Husband works for forestry dep	0	1	1	0	30 kg gas / month	1	Sorghum, mais, soja, peanuts
21	Kaolack	Mamadou Niaye	20061031	1	0	1	0	0	0	8	1	1	Manager family on farm	1	0	1	0	30 kg gas / month	1	Fields far away
22	Kaolack	Darou Minane	20061031	1					0	6		1	Manager family on farm	1	0	0	0	Collecting one day / week	0	
23	Kotal	?	20061031	1	0	1	0	0	1	10	1	1	Peulh family	1	1	1	1		1	Millet, mais, peanuts
24	Fatick	Anabi Ndior	20061031	1	1	0	0	0	1	14	1	1	"model farmer"	1	0	0	1	Fuelwood hard to get	1	Millet, soy beans, peanuts
25	Patar	Bassirou Fall	20061031	1	1	0	0	0	1	15	1	1	Priced cattle breeder	1	0	0	1	Fuelwood hard to get	1	
		Total								301										
		Count		25	24	24	24	24	25	20	22	22		19	19	19	18		24	
		Count if 0										4								
		Count if 1		25	4	16	6	2	17	0	20	15		12	10	13	7		16	
		Count if 2										3								
		Average								15										

B Livestock holding (type, produce, manure application), stabling conditions.

sn	Location	Name	Interview date	Type: cattle	donkey/horse	sheep / goat	pig	poultry	Produce: Breeding	Fattening / meat	Dairy	remarks	Manure: Sufficient for biogas	Dung applied at own field	Dung disposed for free	Dung sold	Dung used for dung cake	remarks	Stabling condition: Outside farm yard	Open yard	Roofing	Cement floor	Troughs
1	Thies	Mr. Diop	20061025	1	1	0	0	1		1	1	Own consumption	2	1	0		0		0	1	0	0	0
2	Sassal	Emanuel Gning	20061025	0	1	1	1	1	1	1	0	Own consumption	1	1	0		0	Used to operate biogas plant	0	1	0	0	0
3	Bambey	?	20061025	0	0	0	1	0		1		Own consumption	1				0	Used to operate biogas plant	0	1	0	0	0
4	Louga	Mme Falla / GIE femmes de Ndime	20061026	1	0	0	0	0	0	0	1	Dairy cooperative	2	0	1	1	0	Large quantities are sold	0	1	0	0	0
5	Louga	Mamadou Ndiaye	20061026	1	0	0	0	0	0	0	1	Dairy sold directly	2	0	1				0	0	1	0	1
6	Louga	Dielerbou Sylla	20061026	1	1	1	0	1	1	1	1	Dairy sold directly	2	1	0		0	Dung daily to fields	0	0	1	0	1
7	Kebermer	Momer Kebe	20061026	1	0	0	0	0	1	1	1	Dairy sold in village	2	1	1			Some is used on fields	0	0	1	0	1
8	Kebermer	Mathiam Kebe	20061026	1	0	0	0	1	1	1	1	Dairy sold directly	2		1		1		0	1	1	0	1
9	St. Louis	Cheikh Diop	20061026	1	0	0	0	0	1	1	1	Dairy sold in town (also camel)	2	1	1		0		1	1	0	0	0
10	St. Louis	Malick Sarr	20061026	1	0	0	0	0	1	1	1	Dairy sold directly	2	0	1				1	0	1	0	1
11	Gilado	Couli Sow	20061028	1	1		0	0	1	1	1	Dairy for own consumption + sold di	2	0	0	0	1	Use chemical fertilizer	1	0	0	0	0
12	Tiago	Moustapha & Lamine Camara	20061028	1	0	1	0	1	1	1	1	Proper integrated farming	2	1	0	0		Used for typha / transpaille plant	0	0	1	0	1
13	Diourbel	Cooperative of 40 hh	20061030	1	0	0	0	0	0	1	0		2	1	0	0		Composted for horticulture	0	0	1	0	1
14	Diourbel	?	20061030	1									2	1	0	0			0	0	1	0	1
15	Diourbel	Modi Tiame	20061030	1	1	1	0	0	0	1	1	Dairy mainly for own consumption	2	0	1	0		Stable 400 m from house	0	0	1	0	1
16	Mbacke	Marieme Diaw	20061030	1	0	1	0	0	0	0	1	Dairy sold directly	2	0	1	0	0	Stored for collection	0	0	1	1	1
17	Mbacke	Mbaye Ka	20061030	1	1		0	1	0	1	1	Dairy sold directly	2	0	1	0	1	Stored for collection	0	1	0	0	0
18	Mbacke	Bocar Sow	20061030	1	1	1	0	0	1	1	1		2	0	1	0	1	Stored for collection					
19	Kaolack	Michel Doudou Sehe	20061031	1	1		0		0	0	1	Producing cheese	2	1	0	0	0		0	0	1	1	1
20	Kaolack	Gora Ndoye	20061031	1	1	1	0		0	1	1		2	1	0	0	0		0	0	1	1	1
21	Kaolack	Mamadou Niaye	20061031	1	1		0		1	1	1		2	0	0	1	0	Manure sold (CFA 450/chart)	0	0	1	1	1
22	Kaolack	Darou Minane	20061031	1	1	1	0	1	1	1	1	Dairy sold directly	2	0	0	1	0	Manure sold (CFA 250/chart)	0	0	1	1	1
23	Kotal	?	20061031	1	1	1	0	0	0	1	1	Dairy sold directly	2	1	0	0	1		1	0	0	0	0
24	Fatick	Anabi Ndior	20061031	1	1	1	0	1	1	1	1	Dairy for own consumption	2	1	0	0	1	Composted	0	0	1	0	1
25	Patar	Bassirou Fall	20061031	1	1	1	0	0	1	1	1	Dairy for own consumption	2	1	0	0	1	Composted, transport by donkey cart	0	1	0	0	0
		Count		25	24	20	24	21	22	24	23		25	23	24	16	18		24	24	24	24	24
		Count if 1		23	14	11	2	8	13	20	21		2	13	10	3	7		4	8	15	5	15
		Count if 2											23										

C Potential for domestic biogas.

sn	Location	Name	Biogas potential					
			Sufficient manure for biogas	Dung applied at own field	On yard stabling	Water available < 20 min	Farmer-owner at farm	Potential for domestic biogas
1	Thies	Mr. Diop	1	1	1	1	1	TRUE
2	Sassal	Emanuel Gning	1	1	1	1	0	FALSE
3	Bambey	?	1	0	1	1	1	FALSE
4	Louga	Mme Falla / GIE femmes de Ndime	1	0	1	1	1	FALSE
5	Louga	Mamadou Ndiaye	1	0	1	1	1	FALSE
6	Louga	Dielerbou Sylla	1	1	1	1	1	TRUE
7	Kebermer	Momer Kebe	1	1	1	1	0	FALSE
8	Kebermer	Mathiam Kebe	1	0	1	1	1	FALSE
9	St. Louis	Cheikh Diop	1	1	0	1	1	FALSE
10	St. Louis	Malick Sarr	1	0	0	1	0	FALSE
11	Gilado	Couli Sow	1	0	0	1	1	FALSE
12	Tiago	Moustapha & Lamine Camara	1	1	1	1	0	FALSE
13	Diourbel	Cooperative of 40 hh	1	1	1	1	0	FALSE
14	Diourbel	?	1	1	1	1	0	FALSE
15	Diourbel	Modi Tiame	1	0	1	1	1	FALSE
16	Mbacke	Marieme Diaw	1	0	1	1	1	FALSE
17	Mbacke	Mbaye Ka	1	0	1	1	1	FALSE
18	Mbacke	Bocar Sow	1	0	0	1	1	FALSE
19	Kaolack	Michel Doudou Sehe	1	1	1	1	1	TRUE
20	Kaolack	Gora Ndoye	1	1	1	1	1	TRUE
21	Kaolack	Mamadou Niaye	1	0	1	1	0	FALSE
22	Kaolack	Darou Minane	1	0	1	1	0	FALSE
23	Kotal	?	1	1	0	1	1	FALSE
24	Fatick	Anabi Ndior	1	1	1	1	1	TRUE
25	Patar	Bassirou Fall	1	1	1	1	1	TRUE
		Count if "TRUE"						6

Technical factors

- Households practice **integrated farming**.
- Households >**20 kg dung per day** available at site.
- Affordable (cash or time) access to (process) **water**.
- Technical potential > **10.000 plants** over 5 years.
- Programme start in "**high opportunity areas**".
- Reasonable density of rural population, opportunity to construct in **clusters ~ 25** installations.
- *Tested and **robust biogas design**(s) meeting local needs and conditions.*
- Biogas material and appliances **locally** available.
- *Established local **construction and after sales service** facility.*
- *Independent **quality control**, linked with subsidy component.*

Environmental factors

General **contribution to improvement** of the environment (micro & macro), with the potential to mitigate:

- Deforestation.
- Soil degradation / erosion.
- Overgrazing.
- Desertification.
- Water shortage.
- Water pollution.
- Global warming.

Economic factors

- Sufficient **active demand for services** that can be provided by the technology *and a marketing strategy that links up with this demand.*
- Households with cash-income or savings sufficient to make **down-payment** ~ 10% of investment.
- Scarcity and/or high prices of **traditional cooking fuels**.
- Appropriate, affordable, accessible **credit facilities**.
- Assets for collateral for biogas-credit / *potential for biogas micro credit with "social" collateral.*
- *Potential for **productive use** biogas service (lighting, bio-slurry fertilizing, organic agriculture, dairy, etc).*
- *Potential to **monetize "non-fuel substitution"** biogas services (CDM, health).*

Programme factors

- Rural **private sector** / *mason enterprises* as the **prime mover** for biogas marketing, plant construction and after sales service.
- Rural **extension** infrastructure.
- Rural **credit** infrastructure.
- Institutional set-up with fairly **independent operational entity** for programme coordination.
- Involvement of **women groups** during preparation and implementation.
- *Transparent, direct financial incentives to end-user.*
- *Monitoring and evaluation of national programme.*
- *Programme **integration** with related rural development initiatives (agriculture, dairy, water & sanitation, health etc).*
- *(Rural) vocational **training institutes** participating in training component of the programme.*
- *Support by traditional / local institutions.*
- *Active **participation** of stakeholders.*
- *Establishment of **BANG**.*

Social factors

- **Ownership** of livestock and **security** of land tenure.
- Potential to improve **health and sanitary** conditions.
- **Traditional use of manure** compatible with operation of the installation and treatment of slurry.
- **Cooking customs** compatible with use of biogas.
- ***Gender balance** in household expenditure decision.*
- *Acceptance of implications of **toilet connection**.*

Political context

- Government accepts **significant but limited role** (programme facilitation, policy development and market regulation).
- **Stable and secure** rural area.
- Initial request for assistance by **national actor**.
- Strong **commitment** of national Government.
- *Initial **financial assistance** (programme support / investment subsidy) by government and donors.*
- Favourable **policy environment** (rural development, agriculture, health, sustainable energy, global warming, etc) and opportunity for programme linkages.

Pricelist biogas material, appliances and labour				*fCFA*
Civil structure material	**unit**	min	max	used
Cement	[CFA/bag 50 kg]	3,150	3,400	3,300
Sand	[CFA/m3]	3,200	4,500	4,500
Sand	[CFA/bag 50 kg]			140
Gravel bulk	[CFA/m3]	13,000	18,000	17,500
Gravel	[CFA/bag 50 kg]			520
Bricks (incl transport)	[CFA/piece]	200		200
Cement blocks	[CFA/piece]	200		200
Stabilized clay blocks	[CFA/piece]	100		100
Reinforcement rod O8mm	[CFA/kg]	350	450	360
Fitting material	**unit**	min	max	used
Galvanized pipe 1/2" (15-21)	[CFA/length 6 mtr]	5,500	6,500	6,500
Galvanized pipe 1 1/2" (40-49)	[CFA/length 6 mtr]	17,000		17,000
Dome pipe 1 1/2" * 700 mm.	[CFA/piece]	mark up	200%	3,778
Elbow 1 1/2" - 1/2"	[CFA/piece]	800	1,500	1,500
Elbow 1/2"	[CFA/piece]	250		250
T 1/2"	[CFA/piece]	300	350	350
Main ball valve - connector 1/2"	[CFA/piece]	1,800	3,000	2,500
Gas tap (local ball valve)	[CFA/piece]	1,500		1,500
Nipple 1/2"	[CFA/piece]	1,000		1,000
Fitting tape	[CFA/piece]	250	500	500
PVC tube 200 mm	[CFA/length 6 mtr]	40,000	45,000	45,000
Inlet pipe PVC 200* 2mtr	[CFA/piece]			15,000
Rubber gas hose 2mtr	[CFA/mtr]	600	3,500	600
Acrylic emulsion paint	[CFA/ltr]	4,500		4,500
Appliances	**unit**	min	max	used
Stove, large	[CFA/piece]			*13,000*
Stove, small	[CFA/piece]			*8,000*
Lamp + valve	[CFA/piece]			*13,000*
Sparepart set	[CFA/set]			*4,000*
Mixer (?)	[CFA/piece]			*15,000*
Labour	**unit**	min	max	used
Unskilled labour	[CFA/person day]	2,000	2,500	2,000
Semi skilled labour	[CFA/person day]	2,500	4,000	3,000
Skilled labour	[CFA/person day]	3,000	6,000	4,000
Annual maintenance	[CFA/visit]	2,000	5,000	4,000
Programme fees	**unit**	min	max	used
QC contribution fee	[CFA/visit]	4,000		4,000
Programme participation fee	[lump sum 4 and 6 m^3 plants]	2,000		4,000

* Prices in italics are estimates.

Bill of quantities GGC 2047 biogas plant

Investment costs GGC 2047 biogas plant for Senegal *for construction in bricks*												
			4 m^3 digester			**6 m^3 digester**			**8 m^3 digester**			
		unit	qty	costs	total	qty	costs	total	qty	costs	total	qty
1	**Contribution farmer in kind**											
1.1	Unskilled labour	[person days]	20	40,000		25	50,000		30	60,000		35
1.2	Sand	[bags]	60	8,427		70	9,831		80	11,236		90
1.3	Gravel	[bags]	30	15,606		35	18,207		40	20,809		50
1	**Total farmer contribiution**				**64,033**			**78,039**			**92,045**	
2	**Supplied materials**											
2.1	Cement	[bags]	11	36,300		13	42,900		16	52,800		19
2.2	Bricks	[piece]	1200	240,000		1,400	280,000		1,650	330,000		1,750
2.3	Reinforcement rod	[kg]	11	3,960		11	3,960		14	5,040		14
2.4	Fitting material	[set price]		74,578			74,578			88,178		
2.5	Appliances	[set price]		25,000			25,000			38,000		
2	**Total materials**				**379,838**			**426,438**			**514,018**	
3	**Technical services**											
3.1	Skilled labour	[person days]	2	8,000		2	8,000		2	8,000		2
3.2	Semi skilled labour	[person days]	8	24,000		8	24,000		11	33,000		11
3.3	Annual maintenance fee	[fee per visit]	4	16,000		4	16,000		4	16,000		4
3	**Total services**				**48,000**			**48,000**			**57,000**	
4	**Company fee**											
4.1	Overhead	[person days]	1	4,000		1	4,000		1	4,000		1
4.2	Risk coverage	[share of 2]	5%	18,992		0	21,322		0	25,701		0
4.3	Company profit	[share of 2+3]	20%	85,568		0	94,888		0	114,204		0
4	**Total company fee**				**108,559**			**120,209**			**143,904**	
5	**Programme fee**											
5.1	QC contribution fee	[fee per visit]	2	8,000		2	8,000		2	8,000		2
5.2	Participation fee	[lump sum]		4,000			4,000			4,000		
5	Total programme fee				**12,000**			**12,000**			**12,000**	
	Total investment				**612,431**			**684,686**			**818,967**	
	Total investment [Euro]				*935*			*1,045*			*1,250*	

Investment costs GGC 2047 biogas plant for Senegal *for construction in cement blocks*												
			4 m^3 digester			**6 m^3 digester**			**8 m^3 digester**			
		unit	qty	costs	total	qty	costs	total	qty	costs	total	qty
1	**Contribution farmer in kind**											
1.1	Unskilled labour	[person days]	20	40,000		25	50,000		30	60,000		35
1.2	Sand	[bags]	60	8,427		70	9,831		80	11,236		90
1.3	Gravel	[bags]	30	15,606		35	18,207		40	20,809		50
1	Total farmer contribiution				**64,033**			**78,039**			**92,045**	
2	**Supplied materials**											
2.1	Cement	[bags]	11	36,300		13	42,900		16	52,800		19
2.2	Cement blocks	[piece]	475	95,000		550	110,000		675	135,000		700
2.3	Reinforcement rod	[kg]	11	3,960		11	3,960		14	5,040		14
2.4	Fitting material	[set price]		74,578			74,578			88,178		
2.5	Appliances	[set price]		25,000			25,000			38,000		
2	Total materials				**234,838**			**256,438**			**319,018**	
3	**Technical services**											
3.1	Skilled labour	[person days]	2	8,000		2	8,000		2	8,000		2
3.2	Semi skilled labour	[person days]	8	24,000		8	24,000		11	33,000		11
3.3	Annual maintenance fee	[fee per visit]	4	16,000		4	16,000		4	16,000		4
3	Total services				**48,000**			**48,000**			**57,000**	
4	**Company fee**											
4.1	Overhead	[person days]	1	4,000		1	4,000		1	4,000		1
4.2	Risk coverage	[share of 2]	5%	11,742		5%	12,822		5%	15,951		5%
4.3	Company profit	[share of 2+3]	20%	56,568		20%	60,888		20%	75,204		20%
4	Total company fee				**72,309**			**77,709**			**95,154**	
5	**Programme fee**											
5.1	QC contribution fee	[fee per visit]	2	8,000		2	8,000		2	8,000		2
5.2	Participation fee	[lump sum]		4,000			4,000			4,000		
5	Total programme fee				**12,000**			**12,000**			**12,000**	
	Total investment				**431,181**			**472,186**			**575,217**	
	Total investment [Euro]				*658*			*721*			*878*	

Investment costs GGC 2047 biogas plant for Senegal *for construction in stabilized clay blocks*

			4 m^3 digester			6 m^3 digester			8 m^3 digester			
		unit	qty	costs	total	qty	costs	total	qty	costs	total	qty
1	**Contribution farmer in kind**											
1.1	Unskilled labour	[person days]	20	40,000		25	50,000		30	60,000		35
1.2	Sand	[bags]	60	8,427		70	9,831		80	11,236		90
1.3	Gravel	[bags]	30	15,606		35	18,207		40	20,809		50
1	Total farmer contribiution				**64,033**			**78,039**			**92,045**	
2	**Supplied materials**											
2.1	Cement	[bags]	11	36,300		13	42,900		16	52,800		19
2.2	Stabilized clay blocks	[piece]	750	75,000		875	87,500		1050	105,000		1100
2.3	Reinforcement rod	[kg]	11	3,960		11	3,960		14	5,040		14
2.4	Fitting material	[set price]		74,578			74,578			88,178		
2.5	Appliances	[set price]		25,000			25,000			38,000		
2	Total materials				**214,838**			**233,938**			**289,018**	
3	**Technical services**											
3.1	Skilled labour	[person days]	2	8,000		2	8,000		2	8,000		2
3.2	Semi skilled labour	[person days]	8	24,000		8	24,000		11	33,000		11
3.3	Annual maintenance fee	[fee per visit]	4	16,000		4	16,000		4	16,000		4
3	Total services				**48,000**			**48,000**			**57,000**	
4	**Company fee**											
4.1	Overhead	[person days]	1	4,000		1	4,000		1	4,000		1
4.2	Risk coverage	[share of 2]	5%	10,742		5%	11,697		5%	14,451		5%
4.3	Company profit	[share of 2+3]	20%	52,568		20%	56,388		20%	69,204		20%
4	Total company fee				**67,309**			**72,084**			**87,654**	
5	**Programme fee**											
5.1	QC contribution fee	[fee per visit]	2	8,000		2	8,000		2	8,000		2
5.2	Participation fee	[lump sum]		4,000			4,000			4,000		
5	Total programme fee				**12,000**			**12,000**			**12,000**	
	Total investment				**406,181**			**444,061**			**537,717**	
	Total investment [Euro]				*620*			*678*			*821*	

		4 m³ digester		6 m³ digester		8 m³ digester		10 m³ digester	
		min	max	min	max	min	max	min	max
Feeding	[kg dung/day]	24	36	36	48	48	60	60	90
Water requirement	[ltr water/day]	24	36	36	48	48	60	60	90
Cattle (night stabling only)	[heads]	4	6	6	8	8	10	10	15
Gas production	[m³/day]	0.84	1.26	1.26	1.68	1.68	2.1	2.1	3.15

Investment costs GGC 2047 biogas plant for Senegal *for construction in stabilized clay blocks* *[CFA]*

			4 m³ digester			6 m³ digester			8 m³ digester			10 m³ digester		
		unit	qty	costs	total	qty	costs	total	qty	costs	total	qty	costs	total
1	**Contribution farmer in kind**													
1.1	Unskilled labour	[person days]	20	40,000		25	50,000		30	60,000		35	70,000	
1.2	Sand	[bags]	60	8,427		70	9,831		80	11,236		90	12,640	
1.3	Gravel	[bags]	30	15,606		35	18,207		40	20,809		50	26,011	
1	Total farmer contribiution				**64,033**			**78,039**			**92,045**			**108,651**
2	**Supplied materials**													
2.1	Cement	[bags]	11	36,300		13	42,900		16	52,800		19	62,700	
2.2	Stabilized clay blocks	[piece]	750	75,000		875	87,500		1050	105,000		1100	110,000	
2.3	Reinforcement rod	[kg]	11	3,960		11	3,960		14	5,040		14	5,040	
2.4	Fitting material	[set price]		74,578			74,578			88,178			88,178	
2.5	Appliances	[set price]		25,000			25,000			38,000			53,000	
2	Total materials				**214,838**			**233,938**			**289,018**			**318,918**
3	**Technical services**													
3.1	Skilled labour	[person days]	2	8,000		2	8,000		2	8,000		2	8,000	
3.2	Semi skilled labour	[person days]	8	32,000		8	32,000		11	44,000		11	44,000	
3.3	Annual maintenance fee	[fee per visit]	4	16,000		4	16,000		4	16,000		4	16,000	
3	Total services				**56,000**			**56,000**			**68,000**			**68,000**
4	**Company fee**													
4.1	Overhead	[person days]	1	4,000		1	4,000		1	4,000		1	4,000	
4.2	Risk coverage	[share of 2]	5%	10,742		5%	11,697		5%	14,451		5%	15,946	
4.3	Company profit	[share of 2+3]	20%	54,168		20%	57,988		20%	71,404		20%	77,384	
4	Total company fee				**68,909**			**73,684**			**89,854**			**97,329**
5	**Programme fee**													
5.1	QC contribution fee	[fee per visit]	2	4,000		2	4,000		2	4,000		2	4,000	
5.2	Participation fee	[lump sum]		4,000			4,000			4,000			4,000	
5	Total programme fee				**8,000**			**8,000**			**8,000**			**8,000**
	Total investment				**411,781**			**449,661**			**546,917**			**600,898**

1 Domestic fuel price.

Prices for domestic fuels arrive from interviews during the field visits of both the initial mission as well as the later mission to collect additional data.

For agricultural residue and dung cake, the interviews did not provide a costing, mainly because these fuels are only to limited extent traded commercially. Their values, in italics, have been taken at 50% of the fuelwood price.

Fuel prices show a considerable range from urban to rural areas, showing a trend whereby modern fuels get more expensive in more rural areas and traditional fuels get more expensive in urban areas.

Fuel prices	Unit	urban	peri-urban	rural
Agricultural residue	[CFA/kg]	-	*30*	*13*
Fuelwood	[CFA/kg]	75	60	25
Charcoal	[CFA/kg]	250	200	150
Dung cake	[CFA/kg]	-	*30*	*13*
Kerosene	[CFA/kg]	400	425	450
Butagaz	[CFA/kg]	480	520	550

Fuel prices	Unit	urban	peri-urban	rural
Agricultural residue	[Euro/kg]	-	*0.05*	*0.02*
Fuelwood	[Euro/kg]	*0.11*	*0.09*	*0.04*
Charcoal	[Euro/kg]	*0.38*	*0.30*	*0.23*
Dung cake	[Euro/kg]	-	*0.05*	*0.02*
Kerosene	[Euro/kg]	*0.61*	*0.65*	*0.69*
Butagaz	[Euro/kg]	*0.73*	*0.79*	*0.84*

2 Parameters for the biogas substitution value.

As domestically generated biogas is hardly a commercially tradable commodity, its value can only be inferred from the value of the traditionally used domestic fuels it replaces; the biogas substitution value.

The biogas substitution value thus depends on:

a. The calorific value of biogas (depending on its turn on the methane content of the gas)
b. The stove efficiency of biogas stoves
c. The financial value of the substituted fuels
d. The calorific value of the substituted fuels
e. The stove efficiencies of the traditional fuel stoves
f. The substituted fuel mix

The tables show the values of the variables as used in the calculations.

Calorific values	Unit	min	max	avg
Biogas	[MJ/kg]			20
Agricultural residue *(LHV on wet basis)*	[MJ/kg]	9.8	17.9	15
Fuelwood *(LHV on wet basis)*	[MJ/kg]	10.9	20	15
Charcoal	[MJ/kg]	20	36	29
Dung cake	[MJ/kg]		12	11.8
Kerosene	[MJ/kg]			43.75
Butane gas	[MJ/kg]			49.51

Stove effciencies (TEE)	Unit	min	max	avg
Biogas	[%]	40%	60%	**55%**
Agricultural residue	[%]	8%	12%	10%
Fuelwood	[%]	8%	14%	12%
Charcoal	[%]	10%	20%	15%
Dung cake	[%]	8%	12%	10%
Kerosene	[%]			45%
Butane gas	[%]			55%

3 The biogas substitution value.

The presented values will, particularly in rural areas, not represent the financial value of biogas, as part of the substituted fuels (agricultural residue, dung cake, and to a lesser extend firewood and charcoal) will be acquired without financial costs. The mission was not able to establish the degree of commercialization of the various types of domestic fuels. However, significant amounts of “free fuel” are rare, even in large parts of rural Senegal.

Substituted fuel mix assumption	Unit	urban	peri-urban	rural
Agricultural residue	[% of hh]	0%	0%	10%
Fuelwood + BLT	[% of hh]	10%	20%	50%
Charcoal	[% of hh]	10%	20%	20%
Dung cake	[% of hh]	0%	10%	20%
Kerosene	[% of hh]	10%	20%	0%
Butagaz	[% of hh]	70%	30%	0%
	total	**100%**	**100%**	**100%**

Based on the parameters listed above, the calculated biogas substitution value for Senegal arrives at € 0.47 per m^3 biogas in urban areas, € 0.55 in peri-urban areas and € 0.33 in rural areas.

A similar calculation made for rural and peri-urban Ethiopia[1] nearly a year earlier resulted in the economic biogas substitution value of € 0.56 per m^3 biogas, and a financial value of € 0.35 per m^3 biogas.

		financial value		
Biogas substitution value	Unit	urban	peri-urban	rural
Agricultural residue	[Euro/m^3 gas]	*0.00*	*0.00*	*0.02*
Fuelwood	[Euro/m^3 gas]	0.08	0.13	0.13
Charcoal	[Euro/m^3 gas]	0.11	0.18	0.13
Dung cake	[Euro/m^3 gas]	*0.00*	*0.05*	*0.04*
Kerosene	[Euro/m^3 gas]	0.04	0.08	0.00
Butagaz	[Euro/m^3 gas]	0.24	0.11	0.00
Biogas substitution value	[Euro/m^3 biogas]	**0.47**	**0.55**	**0.33**

[1] Gethachew Eshete, Kai Sonder, Felix ter Heegde: Report on the feasibility study of a national programme for domestic biogas in Ethiopia, May 2006

Cost / benefit analysis domestic biogas Senegal

1 Variables used in the calculations.

For the economic lifetime of a plant, the calculation uses 10 years. Although properly constructed and operated installations last considerably longer (plants of over 15 or 20 years are not exceptional), the economic lifetime is chosen shorter to better match the investment horizon of farming households.

The investment costs are as calculated in annex 9 for an 8m3 installation constructed in cement blocks. For peri urban and rural areas, a mark-up is used to compensate higher costs of materials and transport.

Maintenance costs are based on local prices of material and experience in countries with large scale biogas programmes.

The biogas substitution value is taken from the calculation as presented in annex 10

Financal parameters		
Exchange rate	[CFA/Euro]	656
Economic lifetime	[years]	10
Inflation		5%
Discount rate		11%
Finance rate		12%
Reinvestment rate		18%

Investment		urban	peri-urban	rural
Base investment costs 8m^3 plant	[Euro]	**835**	**835**	**835**
Area mark-up	[Euro]	0	25	75
Actual investment costs 8m^3 plant		**835**	**860**	**910**

Maintenance		urban	peri-urban	rural
Annual maintenance inspection	[Euro/year]	5.00	5.50	6.00
Stove replacement (every 5 years)	[Euro]	20.00	21.00	24.00
Pipes, valves and fittings (every 3 years)	[Euro]	10.00	11.00	12.00
Biogas lamp (every 4 years)	[Euro]	20.00	21.00	24.00

Fuel substitution value (see annex 10)		urban	peri-urban	rural
Biogas production	[m3/year]	**714**	**714**	**714**
Biogas substitution value	[Euro/m^3]	0.47	0.55	0.33

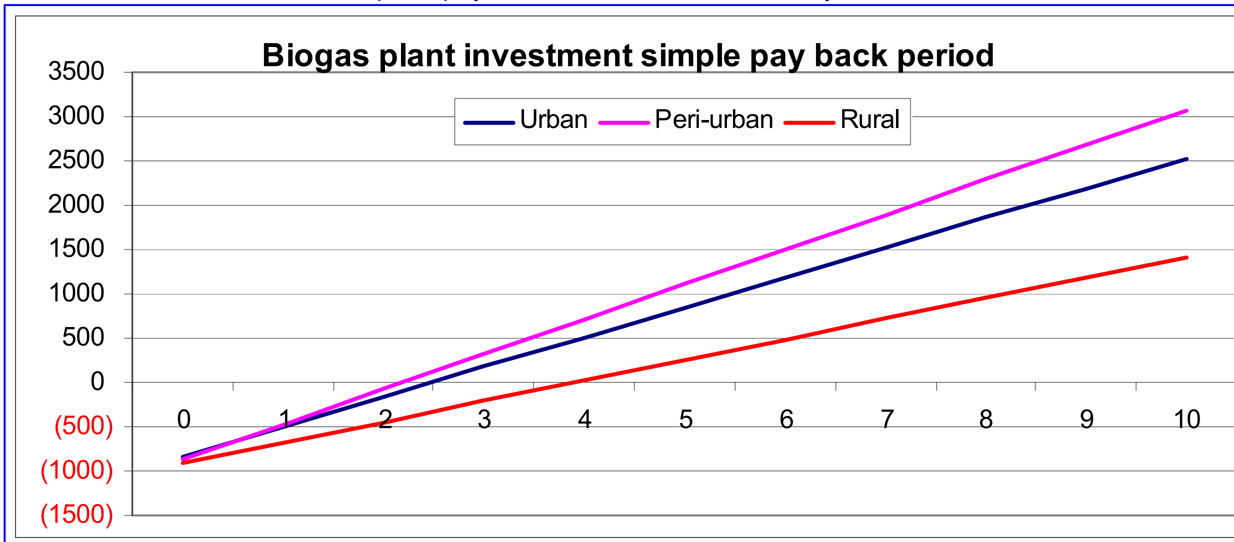
Greenhouse gas emission reduction		urban	peri-urban	rural
CO_2 reduction / plant / year	t CO_2	5	5	5
CER value	Euro/tCO_2	7	7	7

2 Simple payback period.

For the simple pay-back period, only investment costs and fuel savings have been included.

Simple payback period, without subsidy	0	1	2	3	4	5	6	7	8	9	*Euro* 10
Urban	(835)	(499)	(163)	173	509	845	1181	1517	1853	2189	2525
Peri-urban	(860)	(466)	(73)	321	714	1108	1502	1895	2289	2682	3076
Rural	(910)	(678)	(445)	(213)	19	252	484	716	949	1181	1413

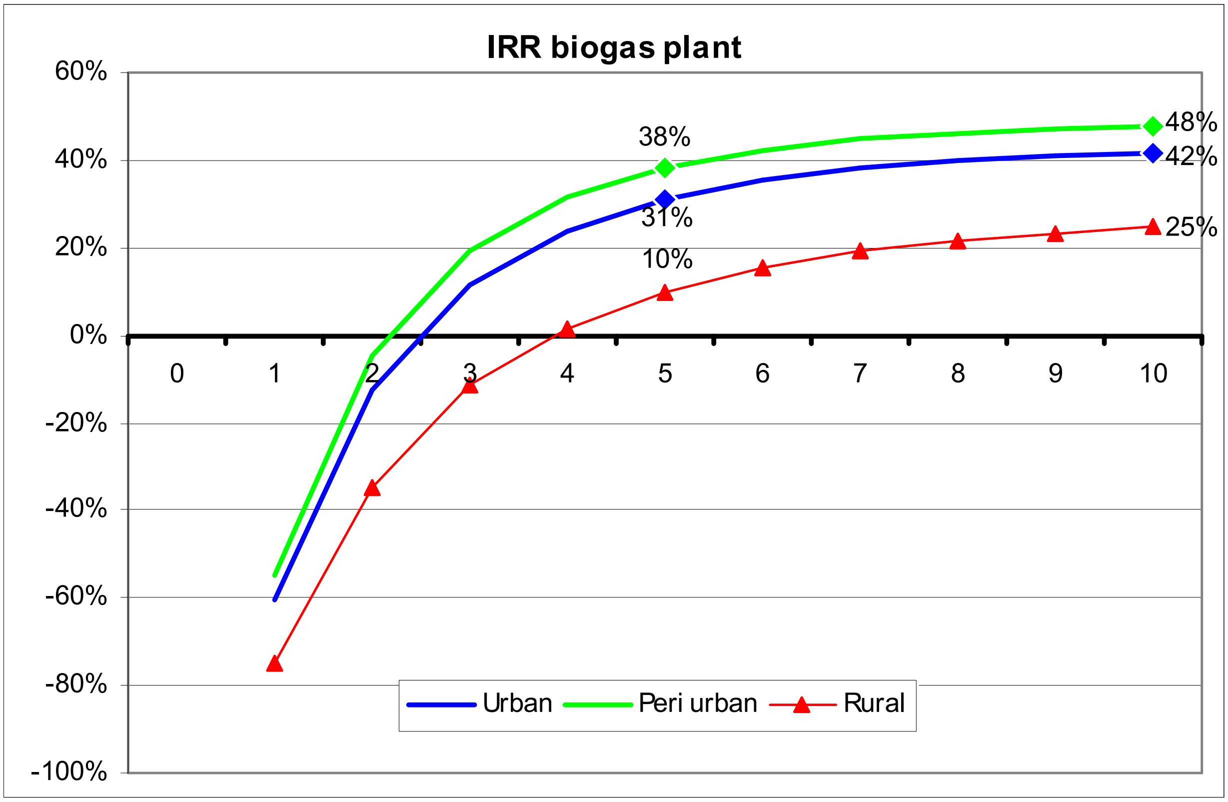
A typical domestic biogas plant in Senegal would repay itself after less than 2 years in urban and peri-urban areas. In rural areas, simple repayment would take less than 4 years.



3 Internal rate of return calculations at biogas plant level.

This internal rate of return (IRR) calculation for a biogas plant includes maintenance costs and inflation. For the inflow, only fuel savings are included.

Internal rate of return domestig biogas plant 8 m^3	0	1	2	3	4	5	6	7	8	9	10
Urban		-60%	-13%	11%	24%	31%	35%	38%	40%	41%	42%
Peri urban		-55%	-5%	19%	31%	38%	42%	45%	46%	47%	48%
Rural		-75%	-35%	-12%	2%	10%	15%	19%	22%	23%	25%



Biogas installations in urban and peri-urban areas have a comparable IRR. Rural areas however face higher investment costs against lower biogas substitution values, resulting in a considerably lower IRR.

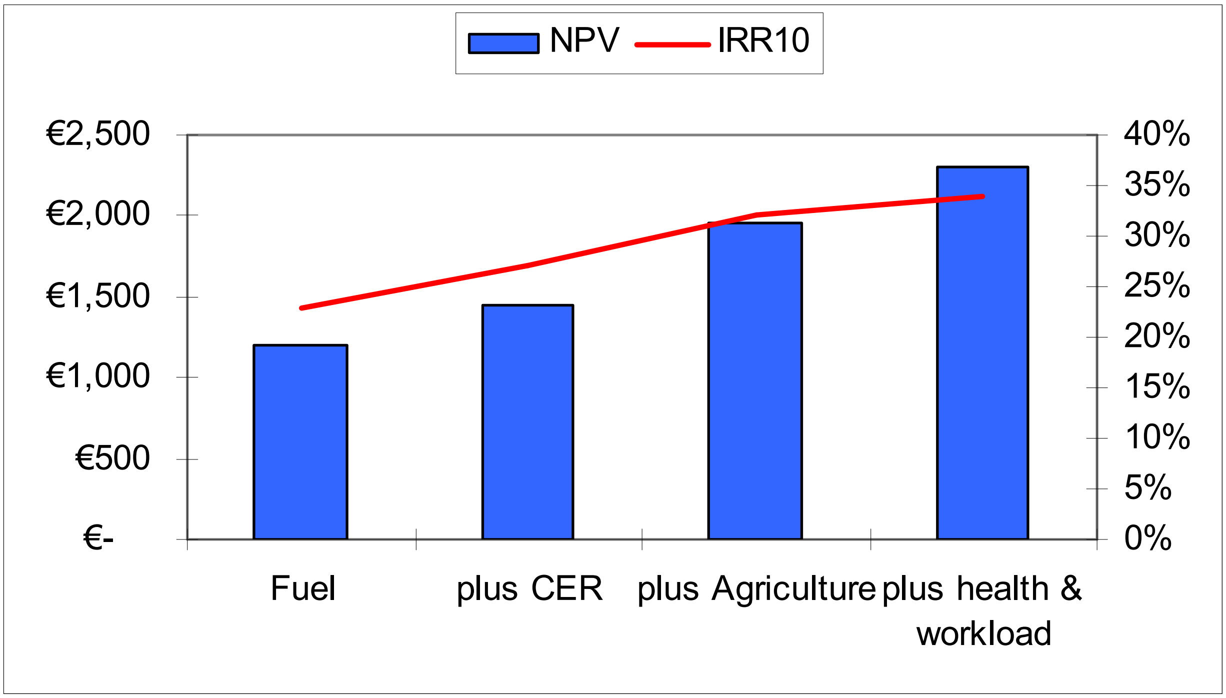
To properly appreciate the (high) results of the IRR calculation of domestic biogas plants the following should be noted:

- IRR values calculated for domestic biogas installations operated in other countries show similar high rates of return. However, it is very important to realize that the IRR is very sensitive to the biogas substitution value, that is, the financial value of the substituted “traditional” domestic fuels (see chapter 5 of this annex: Sensitivity analysis).
- IRR values on their own have only a limited value. To assess whether the return rate of a biogas installation is profitable for a farmer, the IRR of a biogas plant should be compared with other investment options the household has. In this light it is also important to realize that, in order to present an interesting investment option, IRRs for investments for poorer households tend to have to be higher.
- The IRR value “masks” the significant upfront investment needed for a biogas installations. This investment, despite a high return rate, will for many households be prohibitive, especially when proposed for a new technology. Also, intrinsically to the IRR method is the assumption that reinvestment of the return is possible at the IRR-rate; especially with high IRR rates, this often is not the case (see chapter 5 of this annex: Sensitivity analysis / Modified Internal Rate of return).

4 Internal Rate of Return at dissemination programme level.

Beyond the immediate environment of the biogas household, the installation provides benefits to the larger community (see annex 3). Of these benefits, those referring to the reduction of emissions of greenhouse gasses, increased agricultural production and reduced chemical fertilizer use, improved health and reduced workload have been included in the IRR calculation at programme level. At the costs-side of the calculation, full programme dissemination costs (promotion, training, quality control etc) excluding subsidy costs have been included.

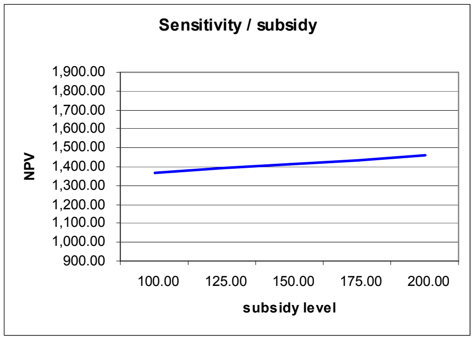
This calculation approaches a more economic assessment of the internal rate of return of a biogas dissemination programme, but does not include all aspects of and economic evaluation.

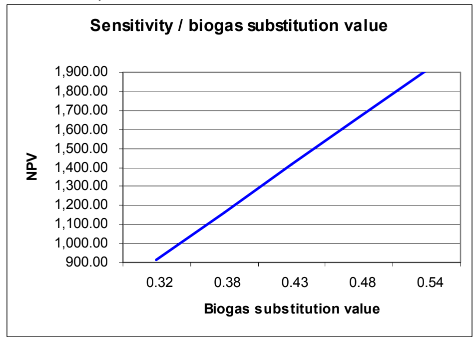


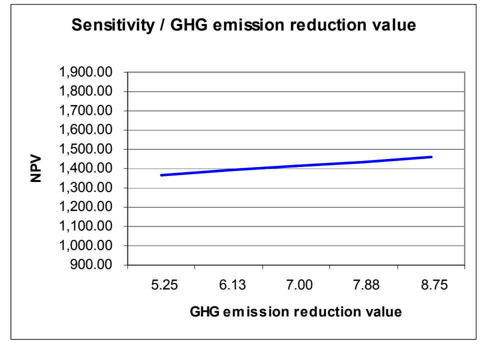
For Senegal, without biogas track-record, start-up costs of a larger dissemination programme are high (€ 100 per plant per year for a period of 5 years). Despite these high programme support costs, also at macro level a biogas dissemination programme shows favourable internal rates of return.

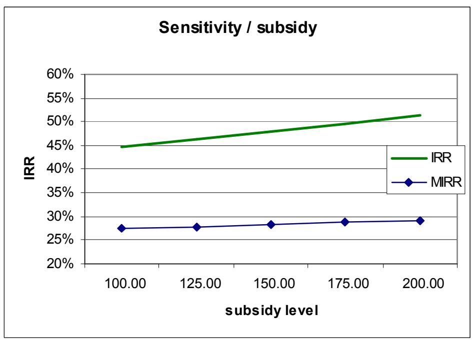
5 Sensitivity analysis.

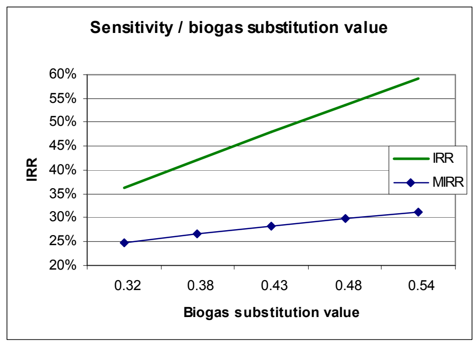
For the sensitivity analysis, the main variables for the cost benefit analysis -investment subsidy, biogas substitution value and GHG emission reduction value- have been calculated for similar relative variation (plus and minus 50% of the "nominal" value).

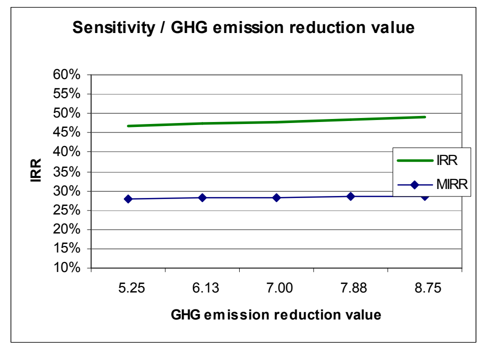












As clearly shown by the graphs, the cost benefit ratio depends heavily on the biogas substitution value: every € 0.10 change in the biogas substitution value affects the NPV with € 460 and the IRR with 10%. Similar variations in subsidy or GHG emission reduction values show far smaller variations in NPV and IRR.

The graphs also show the significant difference of the IRR and the Modified IRR calculation. As the MIRR uses a separate, more realistic rate for reinvestment of the return, MIRR rates are significantly lower.

Senegal Biogas Programme								Expected results	
Activity	**Rate**	**Unit**	**1**	**2**	**3**	**4**	**5**	**Total**	
Biogas plant construction	*annual*	[# of plants/yr]	100	400	1100	2300	4100	**8000**	[plants]
	cumulative	[# of plants]	100	500	1600	3900	8000		
Energy									
Energy production (gross)	17	[GJ/plant/yr]	1650	8250	26401	64352	132005	**232,659**	[GJ]
Power installed (nett)	1.73	[kW_{th}/plant]	173	863	2763	6734	13813	**24,346**	[kW]
Environment									
GHG emission mitigation	4.7	[tons CO_2 eq/plant/yr]	473	2366	7572	18457	37860	**66,728**	[t CO_2eq]
Deforestation reduction	0.3	[ha of forest/plant/yr]	29	145	465	1132	2323	**4,094**	[ha of forest]
Soil nutrificaton	3.0	[t (DM) bio-slurry/plant/yr]	150	750	2400	5850	12000	**21,150**	[t(DM) bio-slurry]
Fuel substitution									
Biomass									
Agricultural residue	0.30	[tons agric res/plant/yr]	30	151	484	1180	2420	**4,265**	[t agric residue]
Dung cake	1.08	[tons dungcake/plant/yr]	108	538	1723	4199	8614	**15,182**	[t dung cake]
Fuelwood	1.71	[tons fuelwood/plant/yr]	171	857	2743	6685	13714	**24,171**	[t fuelwood]
Charcoal	0.40	[tons charcoal/plant/yr]	40	198	634	1546	3171	**5,589**	[t charcoal]
Total biomass	4.28	[tons biomass/plant/yr]	**428**	**2141**	**6852**	**16702**	**34261**	**60,385**	[t biomass]
Fossil fuel									
Kerosene	0.04	[tons/plant/yr]	4	21	66	162	332	**585**	[t kerosene]
Butane gas	0.09	[tons/plant/yr]	9	44	140	342	701	**1,235**	[t butane gas]
Total fossil fuel			**13**	**65**	**207**	**503**	**1033**	**1820**	[t fossil fuel]
Socio-economic									
Persons reached (female)	4	[pers/biogas hh]	400	1600	4400	9200	16400	**32,000**	[women]
Persons reached (male)	4	[pers/biogas hh]	400	1600	4400	9200	16400	**32,000**	[men]
Workload reduction (women & children)	0.1	[pers-year/plant/yr]	10	50	160	390	800	**1,410**	[pers years]
Exposure to indoor air pollution reduced (\	4	[pers/biogas hh]	400	1600	4400	9200	16400	**32,000**	[women & children]
Toilets attached	50%	[connection rate]	50	200	550	1150	2050	**4,000**	[toilets]
Productive surry use	80%	[inclusion rate]	80	320	880	1840	3280	**6,400**	[households]
Employment generation (direct)	0.07	[pers-year/plant]	7	28	77	161	287	**560**	[person years]
Training									
User training									
Pre construction training (female)	0.2	[pers-day/plant]	20	80	220	460	820	**1,600**	[person days]
Pre construction training (male)	0.3	[pers-day/plant]	30	120	330	690	1230	**2,400**	[person days]
Post construction training (female)	0.4	[pers-day/plant]	40	160	440	920	1640	**3,200**	[person days]
Post construction training (male)	0.1	[pers-day/plant]	10	40	110	230	410	**800**	[person days]
Bio-slurry extension (female)	0.2	[pers-day/plant]	20	80	220	460	820	**1,600**	[person days]
Bio-slurry extension (male)	0.2	[pers-day/plant]	20	80	220	460	820	**1,600**	[person days]
Total User Training	1.4	[pers-day/plant]	**140**	**560**	**1540**	**3220**	**5740**	**11,200**	[person days]
Professional training									
Biogas Construction Company support	0.08	[pers-day/plant]	8	33	91	190	338	**660**	[person days]
Biogas technology	0.10	[pers-day/plant]	10	39	108	227	404	**788**	[person days]
Biogas construction	0.22	[pers-day/plant]	22	86	237	495	882	**1,720**	[person days]
Biogas extension	0.03	[pers-day/plant]	3	13	36	75	133	**260**	[person days]
Total professional training	0.43	[pers-day/plant]	**43**	**171**	**471**	**986**	**1757**	**3,428**	[person days]

Preliminary activity schedule and budget

1 Production forecast

Region	Total	Distribution by years 1st year pilot	2	3	4	5
Dakar	**0**	0	0	0	0	0
Diourbel	**200**	0	0	0	50	150
Fatick	**2050**	50	150	350	600	900
Kaolack	**2050**	50	150	350	600	900
Kolda	**550**	0	0	50	150	350
Louga	**1150**	0	50	150	350	600
Matam	**50**	0	0	0	0	50
Saint-Louis	**1150**	0	50	150	350	600
Tambacounda	**550**	0	0	50	150	350
Thiès	**200**	0	0	0	50	150
Ziguinchor	**50**	0	0	0	0	50
Total country	**8000**	**100**	**400**	**1100**	**2300**	**4100**
		1%	*5%*	*14%*	*29%*	*51%*

2 Subsidy

Subsidy levels SBP		rates			
	Subsidy level	fCFA	Euro	USD	**share**
1	Regular	100,000	152.67	202.43	50%
2	High	200,000	305.34	404.86	50%
	Avg subsidy	**150,000**	**229.01**	**303.64**	100%

Annual subsidy requirement	**subsidy level**	**1st year pilot**	**2**	**3**	**4**	**5**	*[Euro]* **Total**
# of plants		*100*	*400*	*1100*	*2300*	*4100*	*8000*
Regular	152.67	7,634	30,534	83,969	175,573	312,977	610,687
High	305.34	15,267	61,069	167,939	351,145	625,954	1,221,374
Total subsidy requirement		**22,901**	**91,603**	**251,908**	**526,718**	**938,931**	**1,832,061**

3 Direct investment.

Investment costs	urban	peri urban	rural
construction share	10%	40%	50%
Investment costs	835	860	910
Avg investment costs	882		

Investment costs / plant	1st year pilot	2	3	4	5	[Euro] AVG
Plant investment costs	882.49	926.61	972.94	1,021.59	1,072.67	1,034.59
Investment subsidy	229.01	229.01	229.01	229.01	229.01	229.01
Farmer investment	**653.48**	**697.60**	**743.93**	**792.58**	**843.66**	**805.58**
Subsidy share:	*26.0%*	*24.7%*	*23.5%*	*22.4%*	*21.3%*	*22.1%*

Direct investment SBP *(inflation correction in farmer investment)*	1st year pilot	2	3	4	5	*[Euro]* total
Annual production biogas plants	*100*	*400*	*1100*	*2300*	*4100*	*8000*
Farmer investment (avg)	65,348	279,042	818,328	1,822,938	3,459,011	**6,444,667**
Investment subsidy (avg)	22,901	91,603	251,908	526,718	938,931	**1,832,061**
Total direct investment	**88,249**	**370,645**	**1,070,237**	**2,349,656**	**4,397,943**	**8,276,728**
fCFA	*57,802,924*	*242,772,280*	*701,004,959*	*1,539,024,524*	*2,880,652,424*	*5,421,257,110*

4 Credit.

Estimated # of credit plants	1st year pilot	2	3	4	5	*[# of plants]* Total
Construction	*100*	*400*	*1100*	*2300*	*4100*	*8000*
Est investment share requested	30%	40%	50%	60%	70%	
# of credit plants	**30**	**160**	**550**	**1380**	**2870**	***4990***
Credit	30	160	550	1380	2870	***4990***
Cash	70	240	550	920	1230	***3010***
Total	100	400	1100	2300	4100	***8000***

Preliminary activity schedule and budget

Investment costs / plant	1st year pilot	2	3	4	5 [Euro]
Farmer investment (avg)	**653.48**	**697.60**	**743.93**	**792.58**	**843.66**

Estimated # of credit plants	1st year pilot	2	3	4	5	Total [# of plants]	
Construction	*100*	*400*	*1100*	*2300*	*4100*	*8000*	
Est investment share requested	30%	40%	50%	60%	70%		
# of credit plants	**30**	**160**	**550**	**1380**	**2870**	***4990***	*62%*
Credit	30	160	550	1380	2870	***4990***	
Cash	70	240	550	920	1230	***3010***	
Total	100	400	1100	2300	4100	***8000***	

Proposed credit conditions		
Interest rate	12%	[% per year]
Maturity	3	[year]

Credit costs per plant	1st year pilot	2	3	4	5	AVG [Euro]
Principal	- 653.48	- 697.60	- 743.93	- 792.58	- 843.66	- 805.58
PMT (annual)	272.08	290.45	309.74	329.99	351.26	335.40
Total repayment (end of year 5)	**816.23**	**871.34**	**929.21**	**989.97**	**1,053.77**	**1,006.21**
Financing costs	162.75	173.74	185.27	197.39	210.11	200.63

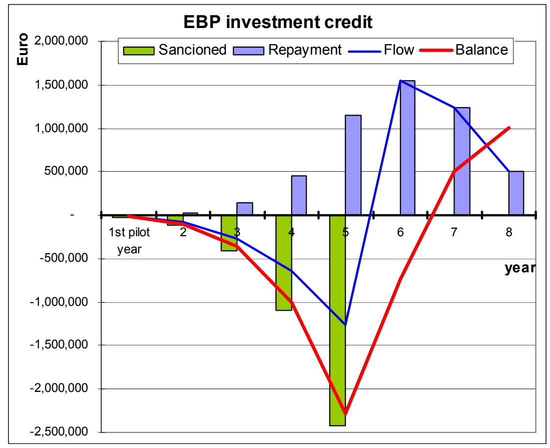
Investment financing	1st year pilot	2	3	4	5	Total [Euro]
Total prinicpal	19,604	111,617	409,164	1,093,763	2,421,308	**4,055,456**
Financing costs	4,882	27,798	101,901	272,398	603,019	**1,009,999**
Total	**24,487**	**139,414**	**511,065**	**1,366,161**	**3,024,327**	**5,065,455**

Project credit requirement	*Year of construction*	1st year pilot	2	3	4	5	Total [Euro]
Credit sanctioned end of:	**1st year pilot**	- 19,604					- **19,604**
	2		- 111,617				- **111,617**
	3			- 409,164			- **409,164**
	4				- 1,093,763		- **1,093,763**
	5					- 2,421,308	- **2,421,308**
		- **19,604**	- **111,617**	- **409,164**	- **1,093,763**	- **2,421,308**	- **4,055,456**

even distribution over the year: *50%*

		1st year pilot	2	3	4	5	Total
Credit repayment:	**1st year pilot**	4,081					**4,081**
	2	8,162	23,236				**31,398**
	3	8,162	46,471	85,178			**139,811**
	4	4,081	46,471	170,355	227,694		**448,601**
	5		23,236	170,355	455,387	504,055	**1,153,032**
	6			85,178	455,387	1,008,109	**1,548,674**
	7				227,694	1,008,109	**1,235,803**
	8					504,055	**504,055**
		24,487	**139,414**	**511,065**	**1,366,161**	**3,024,327**	**5,065,455**

Summary project credit requirement				*[Euro]*
Year	**Sanctioned**	**Repayment**	**Flow**	**Balance**
1st pilot year	- 19,604	4,081	- 15,523	- 15,523
2	- 111,617	31,398	- 80,219	- 95,742
3	- 409,164	139,811	- 269,353	- 365,095
4	- 1,093,763	448,601	- 645,162	- 1,010,256
5	- 2,421,308	1,153,032	- 1,268,276	- 2,278,532
6		1,548,674	1,548,674	- 729,858
7		1,235,803	1,235,803	505,944
8		504,055	504,055	1,009,999
Totals	**- 4,055,456**	**5,065,455**	**1,009,999**	



5 Programme support

5.1 Promotion

1	Promotion & marketing	unit	Planned activities: pilot	2	3	4	5	total	rate	Budget: 1st year pilot	2	3	4	5	total
1.01	Dev prom material	ls/year		1	1	0.5	0.5	**3**	1,500.00	-	1,500	1,500	750	750	**4,500**
1.02	SBP website & newsletter	ls/year		1	0.25	0.5	0.25	**2**	2,500.00	-	2,500	625	1,250	625	**5,000**
1.11	Project launch (regional level)	ls/year		4	2	2	2	**10**	1,500.00	-	6,000	3,000	3,000	3,000	**15,000**
1.12	Annual departemental prom cpgn	# of cpgn	2	6	12	16	20	**56**	1,000.00	2,000	6,000	12,000	16,000	20,000	**56,000**
1.13	Biogas awareness wsp (25 pers)	# of wsps	8	32	88	184	328	**640**	100.00	800	3,200	8,800	18,400	32,800	**64,000**
1.14	Hh assessment & registration	# of hh	100	400	1100	2300	4100	**8000**	1.00	100	400	1,100	2,300	4,100	**8,000**
1.21	Biogas flyer	pcs	200	800	2200	4600	8200	**16000**	0.25	50	200	550	1,150	2,050	**4,000**
1.22	Biogas benefits poster	pcs		60	120	160	200	**540**	4.00	-	240	480	640	800	**2,160**
1.23	Biogas slurry poster	pcs		60	120	160	200	**540**	4.00	-	240	480	640	800	**2,160**
1.24	Biogas calendar	pcs		60	120	160	200	**540**	8.00	-	480	960	1,280	1,600	**4,320**
	Total promotion									**2,950**	**20,760**	**29,495**	**45,410**	**66,525**	**165,140**

5.2 Finance

2	Finance	unit	Planned activities: pilot	2	3	4	5	total	rate	Budget: 1st year pilot	2	3	4	5	total
2.01	Subsidy transfer & administration	# of transfers	100	400	1100	2300	4100	**8000**	2.00	200	800	2,200	4,600	8,200	**16,000**
2.11	Auditing	# of audits	0.5	1	1	1	1	**4.5**	3,000.00	1,500	3,000	3,000	3,000	3,000	**13,500**
2.12	Departmental systems audit	# of deps		6	12	16	20	**54**	500.00	-	3,000	6,000	8,000	10,000	**27,000**
	Total finance									**1,700**	**6,800**	**11,200**	**15,600**	**21,200**	**56,500**

5.3 Construction & after-sales service

3	Construction & aftersales service	unit	Planned activities: pilot	2	3	4	5	total	rate	Budget: 1st year pilot	2	3	4	5	total
3.01	Biogas Construction Companies	# of BCC	**2**	**6**	**12**	**19**	**30**								
3.01	Biogas business development strategy	survey		1			1	**2**	2,000.00	-	2,000	-	-	2,000	**4,000**
3.02	Biogas business dev seminar (30pers)	# of seminars		1	2	2	3	**8**	1,500.00	-	1,500	3,000	3,000	4,500	**12,000**
3.03	BCC assessment & coaching	# of BCC		6	12	19	30	**67**	500.00	-	3,000	6,000	9,500	15,000	**33,500**
3.11	BCC Association support	# of assoc			4	4	4	**12**	250.00	-	-	1,000	1,000	1,000	**3,000**
	Total construction & a.s.s.									**-**	**6,500**	**10,000**	**13,500**	**22,500**	**52,500**

5.4 Quality assurance

4	Quality assurance	unit	Planned activities						rate	Budget					
			pilot	2	3	4	5	total		1st year pilot	2	3	4	5	total
		[control %]													
4.01	Plant control & acceptance	100%	100	400	1100	2300	4100	8000	4.00	400	1,600	4,400	9,200	16,400	32,000
4.02	Annual operation check	100%		100	500	1600	3900	6100	2.00	-	200	1,000	3,200	7,800	12,200
4.03	QC completed	10%	30	80	110	230	410	860	40.00	1,200	3,200	4,400	9,200	16,400	34,400
4.04	QC under construction	5%	15	40	55	115	205	430	60.00	900	2,400	3,300	6,900	12,300	25,800
4.05	Q administration	# of reports	145	620	1765	4245	8615	15390	0.20	29	124	353	849	1,723	3,078
4.11	QM IT-equipment	ls/year	1	2		1		4	1,500.00	1,500	3,000	-	1,500	-	6,000
4.12	QM database development	ls	1	1	1				2,000.00	2,000	2,000	2,000		-	6,000
4.13	QM IT-software & maint	ls/year	1	1	1	1	1	5	500.00	500	500	500	500	500	2,500
4.14	GPS equipment	sets/year	4	6	6	4	4	24	250.00	1,000	1,500	1,500	1,000	1,000	6,000
4.21	Motorcycle	# of m/cycles	3			4		7	3,000.00	9,000	-	-	12,000	-	21,000
4.22	Running costs	costs/km	30000	30000	30000	40000	40000	170000	0.20	6,000	6,000	6,000	8,000	8,000	34,000
	Total quality management									**22,529**	**20,524**	**23,453**	**52,349**	**64,123**	**182,978**

5.5 Training

5	Training	unit	Planned activities						rate	Budget					
			pilot	2	3	4	5	total		1st year pilot	2	3	4	5	total
5.00	Biogas Users	# of persons	100	400	1100	2300	4100	8000							
5.01	Pre-construction UT (25 pers)	# of wsp	4	16	44	92	164	320	100.00	400	1,600	4,400	9,200	16,400	32,000
5.02	FUT Operation & maintenance (25 pers)	# of wsp	4	16	44	92	164	320	100.00	400	1,600	4,400	9,200	16,400	32,000
5.10	Biogas Extension Workers	# of persons	2	8	22	46	82	160							
5.11	Biogas Extension Training (10 pers)	# of wsp		1	2	3	4	10	750.00	-	750	1,500	2,250	3,000	7,500
5.12	Biogas Ext Refresher Training (20 pers)	# of wsp			1		2	3	500.00	-	-	500	-	1,000	1,500
5.20	Biogas Masons	# of persons	4	12	32	60	104	212							
5.21	Biogas Mason Training (20 pers)	# of trg crs	1	1	1	2	3	8	3,000.00	3,000	3,000	3,000	6,000	9,000	24,000
5.22	Biogas Mason Refresher Training (30 pe	# of trg crs			1	1	2	4	750.00	-	-	750	750	1,500	3,000
5.30	Technicians	# of persons	2	4	6	4	4	20							
5.31	Biogas Technician trg (12 pers)	# of wsp	1	1	1	1	1	5	3,500.00	3,500	3,500	3,500	3,500	3,500	17,500
5.32	Biogas Technician refr trg (10 pers)	# of wsp		1	1	1	1	4	1,000.00	-	1,000	1,000	1,000	1,000	4,000
5.35	ToT supp Technician trg	# of trg		1	1	1	1	4	750.00	-	750	750	750	750	3,000
5.36	Technician exchange wsp	# of wsp			1	1	1	3	500.00	-	-	500	500	500	1,500
5.41	Consultancy trg development	# of adv days		40				40	300.00	-	12,000	-	-	-	12,000
5.42	Curricula dev / rev user trg	ls/curr	1		1			2	750.00	750	-	750	-	-	1,500
5.43	Curricula dev / rev biogas ext trg	ls/curr		1		1		2	750.00	-	750	-	750	-	1,500
5.44	Curricula dev / rev mason trg	ls/curr		1		1		2	750.00	-	750	-	750	-	1,500
5.45	Curricula dev / rev technical trg	ls/curr		1		1		2	750.00	-	750	-	750	-	1,500
	Total training									**8,050**	**26,450**	**21,050**	**35,400**	**53,050**	**144,000**

5.6 Extension

6	Extension	unit	Planned activities						rate	Budget					
			pilot	2	3	4	5	total		1st year pilot	2	3	4	5	total
6.01	Demo slurry plots	# of plots	4	8	12	8	8	40	150.00	600	1,200	1,800	1,200	1,200	6,000
6.02	Slurry applicaltion wsps (10 hh)	# of wsps		5	20	55	115	195	100.00	-	500	2,000	5,500	11,500	19,500
6.11	Bio-slurry application study	study	1		1		1	3	4,000.00	4,000	-	4,000	-	4,000	12,000
6.12	Dev bio-slurry manual	ls/year		1		1		2	500.00	-	500	-	500	-	1,000
6.21	Biogas Ext Worker fin support	ls/BEW		8	22	46	82	158	200.00	-	1,600	4,400	9,200	16,400	31,600
	Total extension									**4,600**	**3,800**	**12,200**	**16,400**	**33,100**	**70,100**

5.7 Institutional support

7	Institutional support	unit	Planned activities: pilot	2	3	4	5	total	rate	Budget: 1st year pilot	2	3	4	5	total
7.01	Biogas Advisory Board establishment	study		1			1	2	1,500.00	-	1,500	-	-	1,500	3,000
7.02	BAB support	ls/yr		1	1	1	1	4	1,000.00	-	1,000	1,000	1,000	1,000	4,000
7.03	Training & staff development facility	ls/region/yr		6	6	4	4	20	750.00	-	4,500	4,500	3,000	3,000	15,000
7.11	Biogas sector development	study		1			1	2	1,500.00	-	1,500	-	-	1,500	3,000
	Total research & development									-	**8,500**	**5,500**	**4,000**	**7,000**	**25,000**

5.8 Monitoring & evaluation

8	Monitoring & evaluation	unit	Planned activities: pilot	2	3	4	5	total	rate	Budget: 1st year pilot	2	3	4	5	total
8.01	Regional domestic energy baseline	survey/dep	1.2	4	6	4	4	19.2	2,500.00	3,000	10,000	15,000	10,000	10,000	48,000
8.02	Biogas user survey	survey	0.25	1	1	1	1	4.25	8,000.00	2,000	8,000	8,000	8,000	8,000	34,000
8.11	Biogas & environmental impact	study		1			1	2	8,000.00	-	8,000	-	-	8,000	16,000
8.12	Biogas & gender	study		1		1		2	6,000.00	-	6,000	-	6,000	-	12,000
8.21	External project progress evaluation	evaluation		1		1		2	8,000.00	-	8,000	-	8,000	-	16,000
8.22	External final project evaluation	evaluation					1	1	20,000.00						
8.21	MSc / BSc study support	ls/study		2	2	4	4	12	1,000.00	-	2,000	2,000	4,000	4,000	12,000
	Total extension									**5,000**	**42,000**	**25,000**	**36,000**	**30,000**	**138,000**

5.9 Research & development

9	R & D / Standardization	unit	Planned activities: pilot	2	3	4	5	total	rate	Budget: 1st year pilot	2	3	4	5	total
9.01	Progr Implentation Doc formulation	ls	1						2,000.00	2,000	-	-	-	-	2,000
9.02	Rural credit intitutions & facilities	ls	1						3,000.00	3,000	-	-	-	-	3,000
9.03	Rural stakeholder mapping	ls	1	1					2,000.00	2,000	2,000	-	-	-	4,000
9.11	Plant design	ls	1	1						3,000	6,000	-	-	-	9,000
9.12	Construction std development	ls	1					1	1,500.00	1,500	-	-	-	-	1,500
9.13	A.S.S std development & fomulation	ls	1					1	1,500.00	1,500	-	-	-	-	1,500
9.14	Appliances std dev & formulation	ls	1					1	1,500.00	1,500	-	-	-	-	1,500
9.15	Standards printing & distribution	booklet		100		100		200	10.00	-	1,000	-	1,000	-	2,000
9.16	R&D support	ls/study		1	1	1	1	4	1,000.00	-	1,000	1,000	1,000	1,000	4,000
9.17	Dev & distrib techn instruct. Updates	ls			1	1	1	3	1,000.00	-	-	1,000	1,000	1,000	3,000
9.21	User manual development	ls	1					1	1,500.00	1,500	-	-	-	-	1,500
9.22	User pre-construction flyer distribution	flyer	200	800	2200	4600	8200	16000	0.50	100	400	1,100	2,300	4,100	8,000
9.23	User pre-construction flyer distribution	booklet	120	480	1320	2760	4920	9600	1.50	180	720	1,980	4,140	7,380	14,400
9.31	Extension manual development	ls		1				1	1,500.00	-	1,500	-	-	-	1,500
9.32	Extension manual distribution	booklet		40		150		190	5.00	-	200	-	750	-	950
9.41	Mason manual development	ls	1					1	1,500.00	1,500	-	-	-	-	1,500
9.42	Mason manual distribution	booklet	70			100		170	10.00	700	-	-	1,000	-	1,700
9.51	Technician manual development	ls	1					1	1,500.00	1,500	-	-	-	-	1,500
9.52	Technician manual distribution	booklet	30			30		60	12.50	375	-	-	375	-	750
9.61	R&D appliances	ls		1	1	1	1	4	3,000.00	-	3,000	3,000	3,000	3,000	12,000
	Total research & development									**20,355**	**15,820**	**8,080**	**14,565**	**16,480**	**75,300**

5.10 Programme management

10	Programme management	unit	Planned activities						rate	Budget					
			pilot	2	3	4	5	total		1st year pilot	2	3	4	5	total
10.11	Coordinator	pers month	3	12	12	12	12	51	750.00	2,250	9,000	9,000	9,000	9,000	38,250
10.12	Administrator	pers month		12	12	12	12	48	600.00	-	7,200	7,200	7,200	7,200	28,800
10.13	IT / GIS systems officer	pers month		6	12	12	12	42	450.00	-	2,700	5,400	5,400	5,400	18,900
10.14	Promotion & marketing officer	pers month		6	12	12	12	42	300.00	-	1,800	3,600	3,600	3,600	12,600
10.15	Chief Biogas Engineer	pers month	3	12	12	12	12	51	600.00	1,800	7,200	7,200	7,200	7,200	30,600
10.16	Biogas Engineer	pers month	6	12	24	36	48	126	350.00	2,100	4,200	8,400	12,600	16,800	44,100
10.30	Avg # of programme staff	# of pers	1	5	7	8	9								
10.31	TA/DA SBP staff	days out	120	360	600	720	840	2640	10.00	1,200	3,600	6,000	7,200	8,400	26,400
10.32	Transportation	trip km	5000	7500	10000	12500	15000	50000	0.50	2,500	3,750	5,000	6,250	7,500	25,000
10.33	Additional programme staff costs	pers month	1	5	7	8	9	30	962.50	963	4,813	6,738	7,700	8,663	28,875
10.34	Indirect programme staff costs	ls/pers month	1	5	7	8	9	30	481.25	481	2,406	3,369	3,850	4,331	14,438
10.35	Staff development	ls/pers	1	5	7	8	9	30	481.25	481	2,406	3,369	3,850	4,331	14,438
10.41	Programme office rent & expenses	ls/month	3	12	12	12	12	51	1,000.00	3,000	12,000	12,000	12,000	12,000	51,000
10.42	Utilities	ls/month	3	12	12	12	12	51	500.00	1,500	6,000	6,000	6,000	6,000	25,500
10.43	Other office expenses	ls/month	3	12	12	12	12	51	500.00	1,500	6,000	6,000	6,000	6,000	25,500
10.44	Office furniture	ls						0		2,000	8,000		2,000		12,000
10.45	Office equipment	ls						0		4,000	16,000		10,000		30,000
	Total operational expenses									**23,775**	**97,075**	**89,275**	**109,850**	**106,425**	**426,400**

Programme support budget summary

Summary Programme Support Budget		*(corrected for inflation)*					*[Euro]*
		Budget					
		1st year pilot	2	3	4	5	total
1	Promotion & marketing	2,950	21,798	32,518	52,568	80,862	190,696
2	Finance	1,700	7,140	12,348	18,059	25,769	65,016
3	Construction & a.s.s	-	6,825	11,025	15,628	27,349	60,827
4	Quality assurance	22,529	21,550	25,857	60,601	77,942	208,479
5	Training	8,050	27,773	23,208	40,980	64,483	164,493
6	Extension	4,600	3,990	13,451	18,985	40,233	81,259
7	Institutional support	-	8,925	6,064	4,631	8,509	28,128
8	Monitoring & evaluation	5,000	44,100	27,563	41,675	36,465	154,802
9	Research & development	20,355	16,611	8,908	16,861	20,032	82,767
10	Project management	23,775	101,929	98,426	127,165	129,360	480,655
National Support Budget		**88,959**	**260,640**	**259,366**	**397,151**	**511,002**	**1,517,119**
Contingencies	5%	4,448	13,032	12,968	19,858	25,550	75,856
Total National Support Budget		**93,407**	**273,672**	**272,335**	**417,009**	**536,553**	**1,592,975**
Programme support / plant		*934.07*	*684.18*	*247.58*	*181.31*	*130.87*	*199.12*

6 Technical assistance

1	Technical assistance	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1st year pilot	2	3	4	5	total
1.01	Senior Technical Advisor (EUN)	pers month	12	10	8	6	4	40	9,600.00	115,200	96,000	76,800	57,600	38,400	384,000
1.02	Junior Technical Advisor (EUN)	pers month		12	12	12	12	48	7,000.00	-	84,000	84,000	84,000	84,000	336,000
1.11	Senior Technical Advisor (HCN)	pers month	9	12	12	12	12	57	1,400.00	12,600	16,800	16,800	16,800	16,800	79,800
1.12	Junior Technical Advisor (HCN)	pers month		12	12	12	12	48	1,000.00	-	12,000	12,000	12,000	12,000	48,000
1.21	Additonal advisory services	pers month	3	3	3	3	3	15	2,000.00	6,000	6,000	6,000	6,000	6,000	30,000
1.22	Other support expenses	ls/yr	1	1	1	1	1	5	5,000.00	5,000	5,000	5,000	5,000	5,000	25,000
	Total TA									**138,800**	**219,800**	**200,600**	**181,400**	**162,200**	**902,800**

Summary Technical Assistance		*(not corrected for inflation)*					*[Euro]*
		Budget					
	Description	1st year pilot	2	3	4	5	total
1.01	Senior Technical Advisor (EUN)	115,200	100,800	84,672	66,679	46,675	414,027
1.02	Junior Technical Advisor (EUN)	-	88,200	92,610	97,241	102,103	380,153
1.11	Senior Technical Advisor (HCN)	12,600	17,640	18,522	19,448	20,421	88,631
1.12	Junior Technical Advisor (HCN)	-	12,600	13,230	13,892	14,586	54,308
1.21	Additional advisory services	6,000	6,300	6,615	6,946	7,293	33,154
1.22	Other support expenses	5,000	5,250	5,513	5,788	6,078	27,628
	Total Technical Assistance	**138,800**	**230,790**	**221,162**	**209,993**	**197,155**	**997,900**

Technical assistance / plant 124.74

7 Budget summary

	Senegal Biogas Programme	(corrected for inflation)					[Euro]		[Euro]
		SBP budget summary							
		1st year pilot	2	3	4	5	total	/ plant	share
1a	Farmer investment	65,348	279,042	818,328	1,822,938	3,459,011	**6,444,667**	805.58	54%
1b	Interest costs	4,882	27,798	101,901	272,398	603,019	**1,009,999**	126.25	9%
1c	Investment subsidy	22,901	91,603	251,908	526,718	938,931	**1,832,061**	229.01	15%
2b	Programme support	93,407	273,672	272,335	417,009	536,553	**1,592,975**	199.12	13%
2c	Technical assistance	138,800	230,790	221,162	209,993	197,155	**997,900**	124.74	8%
	Total project	**325,338**	**902,905**	**1,665,634**	**3,249,056**	**5,734,670**	**11,877,602**	1,484.70	**100%**
	fCFA	213,096,457	591,402,751	1,090,990,203	2,128,131,574	3,756,208,640	**7,779,829,625**		

	Application of funds		[Euro]	[%]	per plant	[Euro]
1	**Investment**					
1a	Farmer investment	6,444,667		69%	805.58	
1b	Interest costs (credit component)	1,009,999		11%	126.25	
1c	Investment subsidy	1,832,061		20%	229.01	
	Total investment		**9,286,727**	78%		**1,160.84**
2	**Programme support**					
2a	Programme support	1,592,975		61%	199.12	
2b	Technical assistance	997,900		39%	124.74	
	Total project support		**2,590,875**	22%		**323.86**
	Total application		**11,877,602**			**1,484.70**

	Source of funds		[Euro]	[%]	per plant	[Euro]
a	**Farmers**					
a1	Farmer investment	6,444,667		86%	805.58	
a2	Interest costs (credit component)	1,009,999		14%	126.25	
	Total participating farmers		**7,454,666**	63%		**931.83**
b	**Donor / host government**					
b1	Investment subsidy	1,832,061		53%	229.01	
c1	National support	1,592,975		47%	199.12	
	Total donor / host gvt		**3,425,036**	29%		**428.13**
c	**SNV**					
d1	Technical assistance	997,900			124.74	
	Total SNV		**997,900**	8%		**124.74**
	Total source		**11,877,602**			**1,484.70**

Report
of a mission to collect additional information for the Feasibility study on a national programme for domestic biogas in Senegal

for ASER & SNV

Raoul Snelder

August 2007

Original content:

Mission Report	SEN Biogas Mission RS A Report.doc
Annex 1 Field trips	SEN Biogas Mission RS B Annex 1 Field Trips.doc
Annex 2 Mission Info & Daily Report	SEN Biogas Mission RS C Annex 2 Info Daily Report.doc
Annex 3 Approximate potential demand	SEN Biogas Mission RS D Annex 3 Appr Demand.doc
Annex 4 Foto sheets 1 – 5	SEN Biogas Mission RS E Annex 4 Foto Sheets.zip
Annex 5 Brochure Transtech	SEN Biogas Mission RS F Annex 5 Transtech.pdf

Only mission report and annex 3 included in this annex

Annex 14

Report of the mission to collect additional information for the Feasibility Study on a national programme for domestic biogas in Senegal

Object of the mission

The mission was to ascertain the market potential for domestic biogas in Senegal and in the regions selected for the pilot phase - *Région de Fatick* and *Région de Kaolack* - in particular. The suggestion to consider a shift to the east and south-east where market potential was better assured according to some informants was to be given some consideration.

For information about the author, the duration and the itinerary of the mission refer to annex 2.

Motivation

The findings of the feasibility study on market potential conducted in 2006 had raised some reservations about the real potential in terms of year-round availability of cow dung. The practice of transhumance in the region which is still characteristic for a large part of Senegal was seen as a possible threat to continuous functioning of domestic biogas digesters and thereby as a factor that could reduce its interest and significantly impact on numbers to be built.
The regions selected for the pilot phase both border on the 'sylvo-pastoral' zone which is a traditional pasture for periods when cattle cannot be kept near farms for lack of fodder and pasture.

Meetings in Dakar

In Dakar an introductory session was held with the ASER staff led by the study's initiator and General Director of the agency Mr. Aliou Niang and further meetings took place with a number of people who had been associated with and/or contributed to the earlier mission in order to explain the object of my mission and to exchange views on its main issue.
At the end of the mission a 'debriefing session' was held which was attended by most of the people I met earlier.
A list is given hereafter and a synopsis of the various discussions is given in annex 2.

Mr. Ablaye Ba, COSER
Mr. Jan Hijkoop, Embassy of the Kingdom of The Netherlands
Mrs. Touria Dafrallah, ENDA Energie
Mr. Oumar Wane, Global Environment Facility/Small Grants Programme
Lt. Col. Yossou Lo, M. Alassane Dème, PROGEDE
Messrs. Aliou Niang, Cheikh Wade, André Faye, Ousmane Fall Sarr, ASER
Mr. Shuva Sharma, Peri-urban Smallholder Project, Abuko, The Gambia
Mr. Ensa Colley, Peri-urban Smallholder Project, Abuko, The Gambia
Mr. Lamine Diop, CERER
Mr. Joep van Loon, Projet d'Amélioration et de Renforcement des Points d'Eau dans le Bassin Arachidier, Belgische Technische Cooperatie
Dr. Mamou Thiam, Inspection Régionale des Services Vétérinaires, Kaolack
Mr. Saneo Faye, Inspection Départementale des Services Vétérinaires, Fatick.
Mr. Eric Girardon, Transtech
Mr. Dioumaline Ba, cattle farmer at Ndialla Safokine
Various other cattle farmers of both genders.

Field visits

The ASER General Director, Mr. Niang, had kindly written letters of introduction to the *Préfets* of the regions I was to visit and these introductions proved very helpful; contact was established through these authorities with the *Inspection des Services Vétérinaires* as programmed upon arrival, first in Fatick then in Kaolack.
Unfortunately the inspectors could not immediately make time available for field visits and the accompanied or guided visits were scheduled for the next week. This left me on my own for the first field visits in the rural areas of both regions.
The dates and itineraries of the field trips are given in Annex 1 which also features maps of the areas.

Annex 14

Report of the mission to collect additional information for the Feasibility Study on a national programme for domestic biogas in Senegal

Fatick - *visit to rural area*

An extensive tour was made in the triangle Fatick – Diourbel – Sibassor with a number of stops and visits to speak to people[2] and to have a closer look at compounds and especially at the cattle pens.

To the north of the main road the first rains had fallen fairly recently and many fields were in various early stages of preparation. Even so, while driving through the countryside the number of cattle observed was quite considerable and traces of their passing were very much in evidence everywhere. From information gathered both during the trip and afterward it was found that though part of the cattle herds were engaged in transhumance (both in northerly and easterly directions) a sizable part of the cattle population was still around. This was further corroborated by the ongoing foraging of fodder including from the neem tree (please refer to photo sheets in Annex 4). In the compounds there were clear traces of small scale but still sizable daily occupancy and movement.

The pictures show various types of pens which are used in various periods of the year and which correspond to different numbers of cattle being catered to. The smallest pens are part of the households' courtyard and there were often signs of the presence of a number of cattle ranging from just a few to up to a dozen. The more affluent looking compounds seemed to have for the most part more than the minimum number of cattle required for our purposes.

The impression that was consistently formed was that there are a fair percentage of compounds where the minimum number of cattle is present and likely to be on a year round basis according to the answers to my questions. For a tentative approximation of the numbers refer to the field trip report in Annex 1 and to the rough estimate in Annex 3.

The dung is collected and carted out to the fields but it is not commercialized nor used for other purposes such as fuel for cooking. Some people have heard about this option but it is hardly practiced. One person mentioned the problem with smoke and the problems it had caused with her eyes which made her abandon such use.

Firewood is scarce but low quality (smaller branches and twigs, often cut from live trees) is still available free of cost. Quality firewood is coming from the east (Tambacounda) and is sold at 60 to 75 francs per kilogram. Obviously most households go to great lengths to avoid this expenditure and little firewood is bought in the rural areas. None was in evidence. Charcoal is used but it is almost prohibitively expensive - as everywhere else in Senegal - at prices that range from 150 to 250 francs per kg, the lower price being practiced when one gets closer to the sources in the east. It is mostly reserved for the ceremonial preparation of tea.

Water is far less of a problem than it used to be (in the area the water table can be very low and boreholes have to go down to considerable depth) as many villages are now equipped with wells, water towers (cf. photo sheets) and a basic distribution system using standpipes.

- *Tournée en zone péri-urbaine de Fatick*

Due to heavy rains during the night before and in the morning, no visit was possible. Mr. Faye however confirmed that the peri-urban livestock sector in Fatick was comparable to the one in Kaolack though on a somewhat smaller scale in keeping with the much smaller town size (Fatick is the smallest regional capital in Senegal with about 25.000 inhabitants). See infra.

Mr. Faye provided the very first draft of a list he had started to make with the names of all livestock farmers in the peri-urban area of the town of Fatick. There are 29 names on the list.

Kaolack - *visit of rural area of Kaolack*

The findings of this visit were very similar to those of the Fatick rural area. However, being further to the south and therefore benefiting from earlier as well as slightly more rainfall the cultural season was increasingly more advanced as I went south. The crops were well above ground and near Nioro du Rip almost two feet high (mil). Cattle were present in numbers but seemed much more closely herded and goats and sheep were attached in such a way that they could only feed on areas not under cultivation such as road banks and verges. Only calves were seen roaming free and this I was told was allowed because calves hardly damage the crops as long as they still get milk.

[2] I speak enough of the local 'lingua franca' to make contact and I can count in that language …

Again cattle seemed very much part of the daily life and even though considerable numbers may be involved in transhumance (leaving in July an coming back in December, I learned) the impression was formed that there is a strong tendency to maintain a sizable number of cattle near the homestead on a year-round basis and that the transhumance is not so much a 'positive' tradition but rather a necessary defence mechanism used as the need arises.

- *Visit of peri-urban area of Kaolack*

The visit to the peri-urban area of Kaolack showed a dynamic sector in the midst of a process of change. Obviously the market that the third largest city of Senegal at slightly less than 200.000 inhabitants represents is a driving force towards modernization and rationalization in the cattle raising sector. There is a clear tendency towards zero-grazing for at least part of the livestock. This tendency is the logical corollary of another trend: improving the livestock through breeding using artificial insemination techniques and imported genetic material. On the one hand local stock is improved seeking increased productivity and inversely imported stock is improved to adapt to local conditions and hardships. The dairy sector is developing rapidly and non-traditional operators are joining those who come from a long cattle farming tradition. Part of the development is the initiative of local investors who have other activities as their original professional occupation, including civil servants, employees of local businesses and industry, etcetera. A powerful inducement is the fact that local industry produces by-products that can be used as fodder (peanut cake, melasse) and other sources of similar products are at reasonable distance (cotton mills).

Obviously the traditional transhumance is no longer a realistic or even a necessary option and the number and dynamism of 'modern' operators that we visited made the development of this activity very impressive. However there is some cause for concern in my view where the quality of the accommodation and spatial organization is concerned. While some improvement and rationalization in terms of lay-out and quality of building was observed most premises were lacking on both counts. Given the fact that the building, maintenance and operation of biogas digesters require a fair level of workmanship and an understanding of the technical standards that must be applied – even by those who are only users - much attention must be given to these aspects and a great deal of training will be necessary.

In many cases what we observed is still a beginning cottage industry with a limited number of treasured animals in the household's courtyard but in other instances it has grown beyond that stage and compact farms are built on the outskirts of the town. Even if the owner's family is no longer living on such farms, in most cases there is a family or a group of people living on the premises making it a potential site for domestic biogas.

Reactions to the information about the potential of biogas were very positive and the problems of procuring wood, charcoal, butane gas and other fuel (agricultural residue) were eagerly exposed. One lady showed us the various materials and techniques she used: five bottles of butane gas monthly at about 3000 francs each, charcoal, firewood and one particular stove using densely packed agricultural residue - cotton waste in this case - that had to be burned using a fairly complicated procedure to keep it slowly smouldering. While she knew about the use of cow dung as fuel she refrained from using that alternative because of eye problems that would be aggravated by the smoke.

The number of farms was estimated to be well over 50 for the greater Kaolack area and probably quite a bit more but no listing was available.

Debriefing in Dakar, 2007-aug-01

After thanking the participants for their cooperation and apologizing for the short notice given for attending the debriefing, the object and the limitations of the mission were recalled and then the observations and impressions above were shared with the audience (cf. *Liste de presence* in Annex …) and the following tentative conclusions were presented:

- there are sufficiently favourable conditions for the launching of the proposed pilot phase (four clusters of 25 units, two in each of the proposed regions) to be considered;

- this does not mean that the large potential estimated earlier will then materialize in the short term but a successful pilot experience, followed by adequate dissemination efforts, may well lead to a growing market in accordance with the objectives through a combination of positive potential and negative constraints;
- the pilot phase could ideally include both cattle farmers of the peri-urban areas and from the rural areas, e.g. one cluster of each in Fatick and in Kaolack to fit the initial proposal;
- in the selection of candidates careful thought should be given to priorities of this particular stage and the credibility of the technology and the development of an adapted model must come first;
- as construction of the digesters requires high quality masonry the required skills may not be readily available and a considerable effort will have to be put in selecting and training the artisans – the programme is very much based on the creation of a market to be served by these artisans through small and medium enterprises;
- including, or even moving to, more easterly and southern locations are neither necessary nor desirable at this stage, i.e. the pilot phase. Given the distance, the very bad state of the road as well as the availability of alternative fuel (firewood) several important conditions are decidedly much less favourable for a pilot phase while nothing in particular stands to be gained.

Although some suggestions were made to consider other locations the conclusions were generally accepted and the following points were added:

Mr. Aliou Niang (ASER) insisted that the option of including human waste as part of the inputs to the digesters should be promoted as much as possible. He pointed out that the "*peril fécal*" (threat of faecal contamination) is causing increasing concern as a health hazard, especially for children and this opportunity to improve the situation should not be lost. The mission explained that the model to be propagated includes that option as a standard item so technically speaking the system is totally prepared. The socio-cultural aspects however had to be looked into as a matter of urgency if the suggestion was to be taken up during the pilot stage.
Mr. Niang also stressed the importance of associating the women as they were to benefit most directly from the programme and should therefore be the most interested stakeholders.
He finally expressed his satisfaction at the mission's findings and he thanked the participants for their contributions.
Mrs. Dafrallah informed the meeting that ENDA is in contact with ESAMI and preparing to play a major role in training for biogas in the francophone countries in West Africa. Several training modules are going to be proposed to the various actors and stakeholders, in cooperation with SNV, possibly DGIS and other donors.
M. Wade (ASER) informed us that possibly the greatest market potential was to be found in the region Kebemer-Louga but no actual change of location was proposed.
Mr. Wane – after reminding the audience that ENDA has been involved in biogas before, near Ziguinchor - explained his organization's involvement in the field of biogas at the village of Mbam and expressed his interest and willingness to collaborate in the microfinance and credit sphere. The possibility of providing seed capital for setting up a local revolving fund could be considered. He mentioned Micro-fem as an organization that would also be interested.
Mr. Dème (PROGEDE) pointed out that the success of the operation could be jeopardized if the availability of competing fuel - such as readily available firewood - was not carefully considered. While nobody disagreed it was generally felt and expressed that biogas would be welcomed as an alternative given the increasing shortage of traditional fuel. It also seems like an argument that actually weakens the case for extending the pilot action to the Tambacounda and Kolda regions as his organization would like to see.
Upon hearing the estimated unit cost for the 4 m3 unit Mr. Niang suggested that for the pilot phase ASER may succeed in mobilizing funds from the government and extend credit to the selected farmers against monthly reimbursements of a sum just under the amount of the monthly expenditure for butane gas.

The participants agreed to meet again on Thursday 9 August in order to exchange on the subject of the eventual institutional embedding of a pilot phase and the larger scale programme that may result.

Following the meeting Mr. Niang invited both Mr. Diop and myself to accompany him on a visit to a local manufacturer of plastic products. In informal talks some ideas had been exchanged on technical aspects including the matter of quality control with regard to the air tightness of the digesters. The possibility of using prefabricated parts to avoid this had been evoked and prompted this visit. An interesting meeting with the director took place during which confirmed that chances are that a prefabricated dome using recycled plastic waste may well be a feasible option.

Mission's findings and recommendations

On the basis of observations and information obtained from the meetings and interviews it is concluded that the prevalence of small-scale livestock raising is such that the market potential for domestic biogas digesters is sufficient to justify the pilot operation with a view to start dissemination of the use of domestic biogas on a wider scale. As shown in the very rough computation in Annex 4 a conservative estimate of the rural potential demand suggests a figure of between 30.000 and 45.000. Although the peri-urban zone has strong potential demand the number of digesters is of course limited and runs in the hundreds at most.

In order to create the necessary impact and position the technology as a credible option it is recommended to include both the rural and the peri-urban operators in the pilot phase. The initial proposal suggests the construction of digesters in four clusters of 25 each with 2 clusters in each of the 2 regions. The following distribution is given as a further suggestion: 25 in each of the rural areas and 25 in each of the peri-urban areas. For reasons of "geographical equity" some pressure may be exerted to start operations in every one of the 5 departments involved (3 in Fatick and 2 in Kaolack) and it would be fairly easy to accommodate.

It seems advisable to keep the pilot phase and the dissemination phase I separate but that does not mean that they can not overlap. As soon as (i) the technical adaptations are on track and (ii) the potential demand that has been tentatively indicated here is confirmed, the process of 'sensibilisation' in preparation of the dissemination phase can and should begin.

The model to be proposed includes the option to include human excreta in the digesters' inputs. ASER expressed a strong support for the early implementation and promotion of this option and we feel that there is good reason to bear this in mind. The case of the peri-urban installations offers a particularly interesting possibility in this respect as the problem of sanitary disposal is most urgently felt there.

Given the positive results that seem to be obtained by the Peri-Urban Smallholder Improvement Project on a small scale in The Gambia – which is not far from the pilot zone – it is recommended that early linkage is made with this project.

Given the fairly low level of masonry skills in the country the risk of problems with the technical aspects is a concern. Frequent failure of the digesters in terms of leaking and loss of pressure could negatively impact on the credibility. This concern turned out to be shared by ASER and resulted in a visit to a company that might produce a vital part. It is suggested that this approach be explored further as one of the options that could be developed.

For the institutional set up a national (lead-) partner must be found and some consideration must be given to ASER as the initiating agent. My short experience of working with them was entirely positive and the dynamism - with the *Directeur Général* as the driving force - was quite impressive. Since then the DG has been replaced and this change may or may not have further impact. However that may be, relations with ASER should be reconsidered with an open mind. The question remains whether a government agency is the best option for a lead-partner and, if so, whether that should be a temporary role to be transferred to a non- or para-government organization, etcetera. Given the importance of establishing and maintaining very credible and effective quality and safety controls it seems to me that the government can not be too far removed: the sector needs a strong regulatory and norm-imposing agency to accomplish these tasks.

The Netherlands Embassy representative expressed great interest and would appreciate to be informed on an ongoing basis – as biogas is a technology that positively impacts on development issues that are important to the Dutch development cooperation efforts. However, as Dutch development contribution is now channelled through the local government there is no direct involvement to be expected at this time or in the near future. However, it would seem that a request from the proper "aligned" sources is not necessarily without chances of success.

Annex 3, approximate potential demand.

Rough approximation of potential demand on the basis of discussions with villagers & Ministry of Finance statistics

Rural households in the *Region de Kaolack*: updated on the basis of 1997 figures											
Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Growth rate	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6
Multiplication		1,026	1,026	1,026	1,026	1,026	1,026	1,026	1,026	1,026	1,026
Households	**34 866**	**35 773**	**36 703**	**37 657**	**38 636**	**39 640**	**40 671**	**41 729**	**42 814**	**43 927**	**45 069**
Potentiel demand: proportion of households stabling 4 or more cattle over night on a year-round basis											
									Minimum 1/4		11267
									Maximum 1/3		15023

Population 1997: Source Min. de l'Economie et des Finances - Direction de la Prevision et de la Statistique - Service Regional de la Prevision et de la Statistique de Kaolack - SITUATION ECONOMIQUE ET SOCIALE DE LA REGION DE KAOLACK, Edition 2004, Décembre 2005.

Rural households in the *Region de Fatick*: updated on the basis of 2004 figures											
Annee	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Taux de croissance estime								2,6	2,6	2,6	2,6
Multiplication									1,026	1,026	1,026
Households								**55 818**	**57 269**	**58 758**	**60 286**
Potentiel demand: proportion of households stabling 4 or more cattle over night on a year-round basis											
									Minimum 1/3		20095
									Maximum 1/2		30143

Population 2004: Source Min. de l'Economie et des Finances - Direction de la Prevision et de la Statistique - Service Regional de Fatick - SITUATION ECONOMIQUE ET SOCIALE DE LA REGION DE FATICK, Edition 2004, Aout 2005.

Fatick + Kaolack minimum	**31363**
Fatick + Kaolack maximum	**45166**

Job Description: Senior Advisor

Salary scale: 11

Date of preparation: 29-06-2006

Theme: Context

- Organizational unit: SNV country level, country director
- Accountability: to Country director / portfolio coordinator on thematic positioning and management/development of knowledge
- Framework: Country Management Agreement, Operational Planning Portfolio, Programme Implementation Document and individual planning

Areas of results:

A. Effective advisory products and services conform agreements with the client, and quality standards and services of SNV.
B. Development of the advisory practice and learning organization
C. Positioning of SNV within thematic area.
D. Development and Management of knowledge

Responsibilities:

A. Advisory services

1 Participates in teams at specific moments of the different phases of the primary process (identification of product and/ or service to be provided; definition of quality under which service and/ or products will be delivered) and
2 Delivery of advisory services and identification of possible new clients.
3 Quality control on products and services

B. Learning & Teamwork

1. Coaching colleagues and provide feedback on performance
2. Facilitates / leads thematic group in the identification of best practices, shares and promotes learning of them; identifying the needs for training and/ or alliances; promoting the participation of SNV in thematic national and international networks, related to thematic expertise; in order to exchange experiences that might enrich internal knowledge

C. Positioning

1. Provide input for the decision-making with regard to the national- / regional positioning.

D. Knowledge management / development

1. Internal and external knowledge development: participates actively in knowledge development / thematic groups on cluster / corporate level and in external networks, in order to manage and publicize

Contacts:

- With Country Director, Portfolio Coordinator and team (s) for guidance related to expertise.
- Client/activity teams, to provide methodological guidance and feedback with regard to proposal of products and/ or services and quality standards.
- Thematic and knowledge groups, to share best practices and facilitate coaching processes.
- National Strategic MT to provide guidance with regard to possible opportunities/ treats in environment.
- Relationship with client (groups), when forming part of a client team, with advisory purposes.
- Local (international) knowledge providers, alliances etc. for networking
- Knowledge Management Unit HQ

Decisions:

- Established agreements with partners/clients
- Quality standards of products and/ or services
- Creation of learning environment
- Positioning and development of thematic area

Job requirements:

- Academic level of working and thinking with post-academic education in themes related to SNV
- Active knowledge of English and formal language of the country (verbally and written)
- Minimum of 7 – 8 years of relevant working experience (thematic area, advisory services and change management)

Knowledge and skills:

- Application of theory models related to development processes.
- (inter) organization and institutional development (IDOD)
- advocacy, networking / lobbying.
- strategic analysis of his/ her specialization both nationally as well as internationally
- coaching
- searching for knowledge (Internet, knowledge institutes)

Competencies profile: Senior Advisor

Core competencies (level 3):

Self-development (Motivation)	*Stimulates people in his/her immediate working environment to strengthen their knowledge, skills and behaviour, partly by setting an example to others*
Persuasiveness (Communication)	*Stimulates people within his/her immediate working environment to improve their reasoning. Sets an example to others by gaining an in-depth insight into other people in his/her immediate working environment and tuning his/her argumentation tot it*
Results orientation (Motivation)	*Stimulates people in his/her immediate working environment to set and realise ambitious goals, partly by setting an example to others*
Cross cultural awareness (SNV competency)	*Understands and appreciates issues from the perspective of other cultures and countries*
Gender awareness (SNV competency)	*Showing, by displaying vision, action, and sticking to policy, that the aim is to achieve equality between men and women in society, taking into account of the environment*

Job specific competencies (level 3):

Management & Leadership	Enterprise	Analysis & decision Making	Communication	Personality	Motivation
Coaching: Stimulates people in his/her immediate working environment to coach effectively, partly by setting an example **Group leadership:** Stimulates other people in his/her immediate working environment, to effectively direct and guide a team/group. Sets an example to others by creating a sense of "we" within the team/group and providing a safe environment for its members	**Market orientation (level 2):** Makes use of his/her knowledge of market and technological developments of his/her own accord and shares this knowledge with employees and colleagues **Customer orientation (level 2):** Actively thinks along with customers and comes up with suitable proposals of his/her own accord **Networking:** Stimulates people in his/her immediate working environment to build u p relations and networks independently. Sets an example to others by making use of his/her network in the interest of his/her division of the organisation		**Written communication (level 2):** Independently writes texts that are brief, to the point and tuned to his/her readers		**Quality orientation (level 2):** Makes proposals and takes actions to increase the quality of products and services of his/her own accord

Annex 15

FTD Senior Biogas Advisor, draft.

FTD Senior Biogas Advisor, additional part

The context of the Biogas / RE Practice Area:
Through its long-term involvement in domestic biogas programmes, SNV developed unique experience and expertise on all aspects of large scale dissemination of biogas in rural areas of Nepal and Vietnam. Over the coming years, SNV intends to profile itself further as an expert advisory organization on large scale dissemination programmes for biogas and renewable energy in Asia and Africa. Besides Nepal and Vietnam, where existing biogas programmes are consolidated and / or expanded, SNV started operations in Cambodia, Bangladesh, Laos PDR, Rwanda and Ethiopia. A team of internationally operating senior advisors, the SNV Biogas Practice Team, assist national entities in development and implementation of biogas and renewable energy programmes. For the intended domestic biogas programme in Ethiopia - SNV seeks to strengthen this team with a Senior Biogas Advisor.

Job Objective:
The objective of the job is to support clients in preparation, initiation and implementation of a successful domestic biogas programmes in Ethiopia, further strengthening SNV's position and reputation as an expert advisory organization in the biogas / RE sector in Africa.

The Senior Biogas Advisor will be posted in Dakar, Senegal (?). The Senior Advisor will play a central role in the preparation, contracting, initiation and establishment of a national domestic biogas programme. To that extent, the Senior Advisor will cooperate closely with the participating Ethiopian and international partners in the programme, SNV-Ethiopia and the Biogas Practice Team. Main activities include:

- sector-wide detailed stakeholder analysis, selection and contracting of main programme partners, identification of capacity strengthening requirements, liaising between implementing and financing parties;
- (joint) development of the Programme Implementation Document, including attribution of roles and responsibilities to the programme partners, detailed activity schedule and budget, financial channelling modalities, etc.
- Biogas market identification, assessment and development at regional and national level and, in a later stage, identification of new market / product combinations;
- advisory services on technical, managerial, economic and social aspects of dissemination programmes;
- developing a national knowledge network on biogas / RE, and;
- support and coaching of team members.

Responsibilities
A. Advisory services

1. Assures quality of services provided by SNV advisors within his/her field of expertise.
2. Initiates and contributes to regional activities within his/her field of expertise.
3. Stimulates market and product innovation by the team.
4. Monitors impact of services provided by the team.
5. Evaluates client satisfaction vis-a-vis the provided services.

B. Learning and Teamwork

1. Coordinates the activities of the biogas/RE team in the country.
2. Creates "continuous learning" conditions for clients and team members.

3. Coaching of clients and colleagues.
4. Promotes learning and sharing of best practices related to thematic expertise.

C. Positioning
1. Provides input for decision making in biogas / RE practice area development in the Asia region regarding positioning.
2. Actively explores new markets – product - client combinations
3. Acts as an expert in the biogas / RE practice area and exposes this to our clients and networks

D. Knowledge management / development
1. Ensures proper documentation of activities and achievements.
2. Ensures that best practices are published.
3. Creates knowledge networks / partnerships within his/her field of expertise.
4. Stimulates presentations on (inter-)national fora.

Areas of results:
A. Effective advisory services: clients are able to implement large domestic biogas programmes, maximizing economic, environmental and social benefits.

B. Learning and team work: a high motivated team, expressing a drive for continuous learning culture and a focus on results.

C. Positioning of SNV within thematic area: SNV's position and reputation as an expert advisory organization on domestic biogas in Africa is gaining strength.

D. Development and management of knowledge: Team members share knowledge and are regularly exposed to innovative ideas. The team plays an active role in knowledge networks / partnerships. Experiences are regularly published / presented to a wider audience.

Decisions:
Decision making powers will be based on a Management Agreement with the Portfolio Coordinator of the country of posting, with the Biogas Practice Team in an advisory role.

Job requirements:
- Academic level of working and thinking, preferably in the field of rural development / renewable energy.
- In-depth knowledge of and experience in:
  - Technical, economic and social aspects of domestic biogas;
  - Programme design, implementation and evaluation;
  - Institutional development / organizational strengthening activities;
  - Integrated (energy / environmental / social) impact studies;
  - Rural financing modalities;
- Relevant working experience 7-8 years in biogas / renewable energy