Enda-TM

“Renewable Energy Technology Working Group”

Global Network on Energy for Sustainable Development

The role of renewable energy in the development of productive activities in rural West Africa: the case of Senegal

Final Report

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TABLE OF CONTENTS

List of acronyms and abbreviations

AREED	**: African Rural Energy Enterprise Development**
ASER	**: Senegalese Rural Electrification Agency**
CNSOLER	**: Centre Régional d'Energie Solaire**
CNQP	**: Centre National de Qualification Professionnel**
CFPT	**: Centre de Formation Professionnel et Technique**
COSEC	**: Conseil Sénégalais des Chargeurs**
CWDI	**: Core Welfare Development Indicator**
DRSP	**: Document de la stratégie de réduction de la pauvreté**
EEC	**: European Economic Community**
ESAM	**: Enquête Sénégalaise auprès des Ménages**
ESP	**: Ecole Supérieure Polytechnique**
EER	**: Espace Eolien Régional**
IEPF	**: Institut de l'Energie et de l'Environnement de la Francophonie**
GNES	**: Global Network on Energy for Sustainable development**
GRET	**: Groupe de Recherche et d'Echanges Technologiques**
GWh	**: Giga watt per hour**
Km	**: Kilometres**
KWh	**: Kilo watt per hour**
LEA	**: Applied Energy Laboratory**
LSCER	**: Laboratoire de semi conducteurs et Energies renouvelables**
LVIA	**: Lay Volunteers International Association**
MWh	**: Mega watt per hour**
MDG	**: Millinium Developement Goal**
NTIC	**: New Technologies of Information and Communication**
PRS	**: Programme Régional Solaire**
PSAES	**: Projet sénégalo-Allemand d'Energie Solaire Photovoltaïque**
PREDAS	**Programme Régional de promotion des énergies domestiques et alternatives au Sahel**
RET;	**Renewable Energy Technology**
RPTES	**: Review of policies in the traditional Energy Sector**
SEMIS	**: Services de l'Energie en milieu Sahélien**
SHS	**: Système Solaire Photovoltaïque**
SDE	**: Société Des Eaux**
TER	**: Technologie d'Energie Renouvelable**
UCAD	**: Université Cheikh Anta DIOP**
UNDP :	**: United Nations Development Programme**
WAEMU	**: West African Economic and Monetary Union**
VEV	**: Vent Eau pour la Vie (wind for water and life)**

List of tables

List of figures

List of Boxes

Background

Western African Economic ad Monetary [2]Union (WAEMU)[1] countries, as with other developing nations, are marked by stark energy poverty despite possessing significant renewable energy potential. The region enjoys abundant sunshine (3000 hours per year) and average irradiation of 4.5 to 6 kWh/m²/day; hydro-electric potential to the tune of 4735 MW which is still very under-exploited; and, in some places, wind patterns that make it possible to harness wind for both pumping and electricity generation.

There is little access to modern energy in the region, hence households continue to use biomass for domestic fuel needs while human labour is still the main driver of productive activities. Average per capita energy consumption stood at 0.25 toe in 2001, of which just 0.07 toe went towards commercial energy. WAEMU countries have the lowest per capita rate of energy consumption (75 kWh) not just in Africa but in the whole world due largely to its low electrification rate (less than 20%).

This goes a long way towards explaining the low level of wealth creation and the lack of access to basic services – two facts that allow poverty to persist in the region. More than half of the population of this area survives on less than $1 per day. The poverty rate in Niger is 62.2%, in Mali it is 47.3%, in Guinea-Bissau it is 49.3% and in Benin it is 46.8%[2].

Poverty is most widespread in rural areas and tends to affect women more than men. This is because it is women who must fetch water, grind cereal and collect wood. In many cases they have only their own might to rely upon and some crude tools with which to carry out these tasks. In addition, these tasks are highly time-consuming and this, along with the huge physical effort deployed, help keep women trapped in absolute poverty.

A greater quantity and broader spectrum of energy services are required in order to meet the Millennium Development Goals for eradicating poverty. This entails harnessing new energy sources that can effectively be extended to the poor. The issue of widening access to renewable energy must, therefore, be seen as integral to overall local development.

Several national and regional projects have been launched in West Africa with the support of bi- and multi-lateral co-operation to foster the use of renewable energy technologies. Although these projects aimed to harness solar photovoltaic and thermal, biomass, wind or micro-hydro for applications such as lighting, pumping, heat production and the processing and conservation of agricultural and seafood produce, they have not significantly increased energy supply to those in need.

Nevertheless, the experiences to date have revealed both successes and dissemination-related difficulties in technical, economic and organisational terms. In turn, these lessons could guide the design of local development policies, especially at a time when these countries are following a pattern of institutional decentralization..

Because these projects are heavily donor-driven, very few field studies have been conducted to evaluate the effectiveness of the dissemination of renewable energy technologies (RETs) to tackle poverty.

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[1] WAEMU: Western African Economic ad Monetary Union, comprising Burkina Faso, Ivory Coast, Benin, Mali, Togo, Senegal, Niger.
[2] - UNDP, World human development report 2002.

Most West African countries have had similar experiences with RETs, at least in the kinds of technologies disseminated, so this study, which was launched as part of the GNESD, concentrated on Senegal, and examined the role of RETs in eliminating poverty. The analysis focused on the use of windmills and photovoltaic systems and their effect on income-generating activities and job creation at the household and community level.

1 – The energy context and the role of renewable energy

1.1-Situating the issue

The fact that energy is so important in so many different spheres means it is a crucial component of economic, social and environmental progress. More and more people are beginning to accept that it is a fundamental component of any poverty alleviation strategy . Access to energy services is also central to the satisfaction of priority human needs: food, drinking water, health, housing and wealth creation. Yet in West Africa, as in the rest of the continent, the supply of energy services is utterly inadequate in terms of achieving sustainable development objectives. Despite the fact that the region is relatively well endowed with natural resources and energy potential, very little has actually been harnessed. This is why energy policies have recognized renewable energy as a prime alternative for advancing **rural electrification** in areas where settlements are widely dispersed and there is very low load capacity. Secondly, they are seen as being useful for harnessing new ways of **processing and conserving agricultural products** (through drying and/or refrigeration) and the improvement of access to essential services (healthcare, education, water, etc.). Alas, these policy declarations have yet to be translated into tangible results on the ground. The use of renewable energy remains very marginal.

1.2 – Some energy characteristics of West Africa

Box 1: Energy resource data
- Oil: the Ivory Coast is the only country in the region to produce oil (5,457,225 barrels in 2002[3])
- Uranium reserves in Niger (269,000 T)
- Natural gas: reserves amounting to 327.4 billion m3 in 2003 are split between the Ivory Coast (297 billion m3) and Senegal (30.4 billionm3)[4].
- Mineral coal in Niger: reserves of more than 46 million tons.
- Solar: irradiation of between 4 and 6 KWh/m²/day in the West African Monetary and Economic Union
- Hydroelectricity: 4735 MW in the West African Monetary and Economic Union

The energy situation of countries in the region is distinguished by three features: i) biomass dominates the energy balance (ligneous fuels account for between 52% and 90% of consumption of final energy); ii) low consumption of modern energy due to the low electrification rate (between 5% and 45%).

[3] -Ivory Coast statistics; the energy board, 2003
[4] Energy Information Administration

and iii), the countries are net importers of oil products (see table 1)

Table 1: Data on the energy sector in 2001.

Country	Oil products import (millions of toe)	Total per capita energy consumption (toe)	Per capita commercial energy consumption (toe)	Per capita electricity consumption (Kwh/person) KWh and not Kwh
Benin	0.434	0.32	0.08	54
Burkina Faso	0.285	0.23	0.03	28
Ivory Coast	0.3	0.38	0.11	194
Guinea-Bissau	0.1	0.17	0.08	41
Mali	0.54	0.19	0.05	34
Niger	0.13	0.16	0.02	35
Senegal	0.57	0.32	0.14	114
Togo	0.313	0.3	0.08	106
Average		0.26	0.07	75.75

Sources: IEPF, profils énergétiques des pays ; www.iepf.org

i)- Dominant position of biomass in energy balances

Wood, charcoal and agricultural waste account for 52% to 90% of final energy consumption and between 90% and 98% of energy demand in the residential sector[5] in countries such as Mali, Niger and Burkina Faso. This is due in part to the low level of industrialisation, the low efficiency of production processes, end-use of ligneous fuels and the predominance of rural energy patterns in all of the countries' urban areas. Population in big urban areas (primarily the capitals) find themselves in the same energy predicament as rural-dwellers (in terms of their consumption wood and charcoal).

High demographic growth means this situation is likely to continue, as does the fact that the processes of transition to the use of alternative energy forms is advancing only tentatively in many countries for the reasons of high cost and the lack of adequate policies. There is no sign of this situation changing in any substantial way so long as Africa's energy sector has to cater to the needs of (1) a predominantly rural economy that uses relatively little machinery and has only small industry and (2) poor populations with few electrical appliances that generally use traditional forms of domestic fuel[6]. According to forecasts by the International Energy Agency in 2002, biomass energy will still account for 34% of total energy demand and 75% of energy demand from the residential sector in 2030[7].

ii) – Low level of electricity consumption.

The quantity of electricity generated in this zone was 7620 GWh in 2001, with more than 80% of that coming from thermal sources. Efforts have been made at regional level to further the cross-border exploitation of hydropower resources (e.g. the Manantali Dam - 200 MW – as part of the OMVS[8] and the WAPP[9] under the aegis of ECOWAS). The Ivory Coast is the only country in the region to exploit a significant amount of its hydro potential; in 2003, its installed capacity of 604 MW represented 50% of electricity generation capacity[10].

It is mainly because countries who import hydrocarbon products are so highly dependent on thermal power that their electrification rate and consumption of modern energy is so low. West Africa remains

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5 - Review of policies in the traditional Energy Sector, RPTES; Regional Report 1995.

6 - Energy issues for Africa and the NEPAD; workshop on modern energy and poverty reduction; Alioune Fall, Dakar - February 2003 .

7 - International Energy Agency- 2002

8 - As part of the Valorisation of the River Senegal (OMVS), 200 MW of capacity was installed in Manantaly (Mali) in 2002.

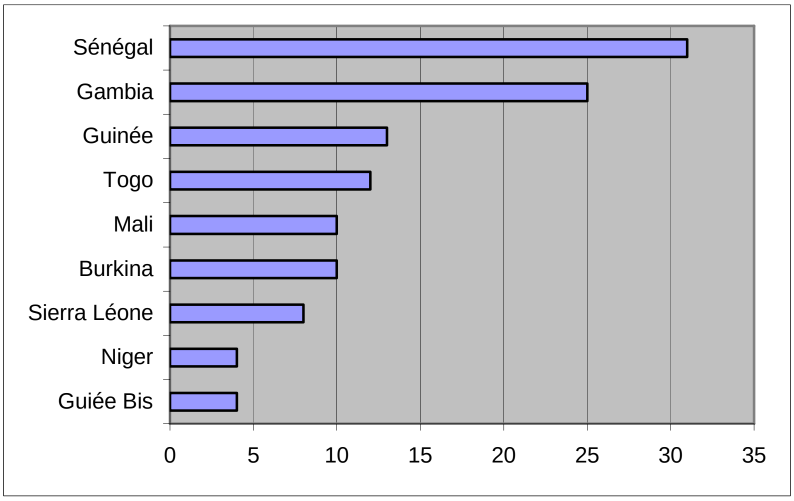
9 WAPP (West African Power Pool) covers, in its initial phase, Nigeria, Benin, Burkina, Ivory Coast, Ghana, Niger and Togo

10 - Statistiques de la Côte d'Ivoire, Direction de l'Energie, 2003 .

the region with the lowest electricity consumption in the whole world. Average per capita electricity consumption was 75.7 KWh in 2001. There are significant differences among countries, with Niger using 34 KWh, Mali 35 KWh and the Ivory Coast consuming 194 KWh per head.

The average rate of access to electricity in all the regions' countries is less than 20% (see Figure 1)

Figure 1: Electrification rates of selected West African countries in 2001



Source: Author's own compilation on the basis of ECOWAS data

1.3 – Renewable energy in West Africa

1. 3.1- Potential resources

The countries of the region have large renewable energy resources and for this reason they can envisage allocating a significant role to clean energy.

Table 2: Renewable energy potential in UEMOA countries.

Country	Solar (KWH/m²/d)	Wind (m/s)	Hydroelectricity (MW)
Benin	Na	na	238
Burkina	5.5	2-4	200
Ivory Coast	4 – 5	Na	1650
Guinea Bissau	Na	Na	Na
Mali	6	Na	1050
Niger	6	2.5 – 5	273
Senegal	5.4	2.5 – 5	1000
Togo	4.5	2-3	224

Source: Author's own compilation, 2004

In spite of the widespread use of biomass in the area, which the poor will in all likelihood continue to gather, there is still not a great deal known about the region's ligneous fuels, and there is little reliable data on the matter.

1.3.2- RET Experiences

The first attempts to disseminate RETs were in the 1970s. With regard to biomass, the Inter-State Permanent Committee on Drought Control in the Sahel l (CILSS) was quick to launch programmes to distribute improved stoves with the objective of easing pressure on the environment. However, the limitations of acting solely on the demand side were quickly evidenced by the work of the Regional Program for the Traditional Energy Sector (RPTES) undertaken under the auspices of the World Bank. This led Sahelian governments to adopt additional measures to tackle supply through participatory management of plant cover and creating new forest resources (forestation and reforestation).

Today, in addition to national initiatives, several sub-regional actions have been carried out in the UEMOA through the Regional Biomass Energy Programme (PRBE) which focuses in particular on adapting biomass to modern uses (biofuel). This new WAEMU programme was devised to bolster the efforts undertaken by the CILSS through the PREDAS[11].

Photovoltaic solar power and wind power did not really make incursions into the region until the 1980s, when they were driven by national projects and sub-regional programmes. The most important of these programmes included:

The Special Energy Programme (PSE)[12] was introduced via bilateral co-operation with Germany's GTZ and several West African countries (Mali, Burkina Faso, Guinea, Niger and Senegal). The goal of this ambitious programme was to develop enhanced local and/or national energy supply from 1983 to 1988. It covered photovoltaic systems (in all countries), micro-hydro (Guinea) and bio-gas (Mali, Burkina Faso, Niger). In Senegal, the programme was applied in a different way – it ran for 10 years under the name of the Senegal-German Solar Energy Project (PSAES). We will examine this project in greater detail in a later case study.

The Regional Solar Programme (PRS)[13] was launched in 1986 (meeting in Praia, Cap Verde) and formed part of regional co-operation between the EEC and the CILSS countries following the Lomé III agreements. This programme aimed to valorise 30-40% of existing wells with flows exceeding in 5 m3/h and also to encourage rural communities to habitually use PV solar power for lighting, healthcare refrigeration (preserving vaccines) and promoting small rural units for battery charging. It set the target of reaching an installed capacity of 1258 KWp by setting up 1090 submersible pumps, 103 surface pumps and 64 community systems[14].

Some 610 pumps and 649 community systems were installed in 2003, with a total power of slightly above 1 MWp. Following some promising early results, this programme was extended[15].

The regional wind programme: this programme was funded thanks to the Canada Co-operation Department and sought to stimulate the development of wind power in the sub-region. It was implemented in Burkina Faso, Mali and Niger. Its results included identifying "pockets

[11] - PREDAS: Regional Programme on domestic fuel and alternative energy in the Sahel.
[12] PSE: The Special Energy Programme was carried out in Mali (1986/90), Burkina (1983/90, Guinea (1989/90), Niger (1985/93) and, in a slightly different form, Senegal (1987 -1998).
[13] - The PRS was initiated by the Inter-State Committee on Drought Control in the Sahel (CILSS) as part of its co-operation with the Euopean Union. It covers Niger, Mali, Burkina, Senegal, Gambia, Guinea Bissau, Mauritania, Cape Verde and Chad.
[14] - Evaluation de l'utilisation des énergies solaire et éolienne en Afrique : Les réalisations au Sahel; Enda Energie ; UNIDO ; June994.
[15] - Steering Committee meeting, Niamey /Niger, September 2004.

conducive to developing wind power with pumps; the assembly of local wind power prototype; and the installation of 9 pumping systems. (there is at least another programme in Mauritania alizes programme see further , it should be quoted although its regional dimension is rather limited.

These sub-regional programmes were backed up by national projects in areas such as photovoltaics, wind power, water-heaters and hydroelectricity.

However, since there are few up-to-date evaluation studies of these (see the most recent one in Appendix A), it is impossible to provide a reliable snapshot of the situation at the sub-regional level to determine the total installed capacity and current operational status of these technologies.

1.3.3 – Lessons learned

The numerous experiences gathered in the area of RETs in West Africa through national and regional projects highlighted the fact that suitable, mature technologies are available and their costs are gradually coming down. These can boost job creation and add value to the national economy; thus helping to eradicate poverty.

- Biomass technology distribution: At first, improved stoves were distributed through public projects, but their spread was later furthered through standard market forces. The artisans who originally benefited from support by the projects took up the baton from the public authorities (in Mali, Burkina, Niger, Senegal, Benin and Togo) in terms of the production and sale of stoves. More and more schemes are spouting up for the participatory community management of woodland resources, helping broaden energy supply and generate wealth.

- Solar and wind pumps have been accepted and gradually integrated into the hydraulic practices (i.e. water pumping, etc;) of villages and pastoral farmers. Furthermore, organisational initiatives have shown that locals are capable of bearing the cost of maintaining these facilities.

- PV solar systems ‘naturally’ complement the extension of electricity grids for rural electrification. However, in planning terms, these two technologies serve different purposes: grids are by definition centralised, while PV systems are necessarily decentralised. This means that sound exploitation of both entails developing local technical and organisational capacities to ensure equipment can be maintained and owned by decentralised communities.

- Solar driers are now a mature technology in the region, and hold much potential for further exploitation. They are produced and used locally for processing and preserving agricultural produce, meaning they offer excellent means of creating added value.

- Building RET technical capacity and increasing demand for their use offers opportunities to develop micro-enterprises.

- Fiscal measures and good funding mechanisms facilitate the development of RET markets.

The time has come to move beyond small-scale projects to really trigger a dynamic to drive the widespread dissemination of RETs by drawing the political, institutional, organisational and financial lessons of previous experiences.

In order to illustrate practices that can be shared, we will analyse the experiences of wind pumps and solar photovoltaic systems in Senegal.

2- Rationale and motivation

In view of the new challenges of sustainable development, the Millennium Development Goals and the increasingly urgent need to eradicate poverty, RETs are now assessed in terms of how they can be harnessed to broaden access to energy services and boost local development.

These new paradigms have shaped the way renewable energy projects are designed, implemented and evaluated. Yet, in West Africa at least, there has been very little feedback on experiences that could be used to inform RET-promotion policies. Projects proceed one after the other without decision-makers really taking account of or deploying the knowledge gained to date. For a while now, the majority of RET-distribution projects have focused on providing electrification for lighting but rarely for providing energy services to fuel productive activities. This trend has meant that rural electrification is often conflated with RETs and thus reduces the potential contribution RETs can make to improving living condition. If RETs are to be seen as tools for holistically boosting local development and combating poverty, it is essential that there be empirical evidence proving that these technologies help create wealth, improve healthcare, create jobs and enhance water supply, i.e. meet the priority needs of the poor (Survey of Senegalese Households, ESAM II).

This work does not purport to analyse all renewable energy experiences in the sub-region. Rather, it will select a handful of examples from Senegal and draw lessons that could help inform decision-making. As such, we will endeavour to take the case of Senegal to chart ways of devising RET-promotion policies in the sub-region.

We have chosen Senegal because:

a) It has a wealth of experiences through regional and national programmes and technological diversity (PV solar, thermal power, wind power, biomass, etc.). In the area of solar PV, for example, Senegal is one of the few West African countries in which we can say that a definite RET market structure is starting to take root. This is distinguished by:

- The significant presence of the private sector both upstream and downstream in the renewable energy sector;
- Decentralised local expertise (technicians from village association and groups) widely available, meaning after-sale service can be offered (see Appendix B);
- The existence of operational, technical, and professional training bodies,
- The existence of a body for setting standards and inspecting the quality of equipment,
- The expression of political will to promote RETs through various legislative and regulatory plans.

b) The launch of energy sector reforms: Energy sector reforms began in 1988 and were tailored to ensure a better and regular electrical supply to economic operators. These reforms were part of an overall strategy to improve the economy through macroeconomic reform. One of the results was to create the Rural Electrification Agency (ASER), which is responsible for rural electrification in a technologically neutral manner, depending on what is most economically feasible. Most WAEMU countries have followed suit and adopted similar approaches to broadening the access of rural populations to energy services.

Box 2: Institutional changes following electricity sector reforms

Country	Date of reforms	Rural Electrification Institution
Ivory Coast	1991	na
Senegal	1998	ASER
Mali	2000	AMADER
Burkina Faso	2000	Energy Fund
Niger	in progress	na
Benin	na	na
Togo	2001	na
Guinea Bissau	in progress	na

c) Decentralisation aimed at fostering participatory local development: The restructuring of the electricity sector was in keeping with the decentralisation process that was launched in the country at the same time, as indeed it also was in other countries such as Mali. This process bestows more power on local elected officials to pursue local development. Since RETs require decentralised management, this approach is ideal for promoting their use.

d) A process of revising the strategic poverty reduction plan in order to better align energy strategies with broader development goals (education, healthcare, agriculture, water and industry). Though it is true that the poor do not rank energy at the top of their needs, the fact is that to a large extent, they require energy services to satisfy many of their basic needs. Wider energy services can only be provided if energy sources are diversified and renewable energy is assigned greater importance.

3 Senegal, Initial assessment

3.1- Characterisation of population and zones

The population of Senegal was estimated at 9,8 million in 2001, with a demoFigure growth rate of 2.69%. This population is very unevenly spread. The Dakar region takes up just 0.3% of the country's total surface area yet it is home to almost 25% of its population – it is by far the most densely populated part of the country with 4,231 people per km².

Table 3: Population sizes, densities and annual growth rates: 1988 - 2001 by region

Region	Population	%	Surface area(Km2)	Pop. density per km²	Rate % 1988-2001
Dakar	2.411.528	25	550	4231	3.69
Ziguinchor	557.606	6	7.339	74	2.57
Diourbel	930.008	9	4.359	207	3.11
Saint-Louis	863.440	9	44.127	19	2.05
Tambacounda	530.332	5	59.602	9	2.43
Kaolack	1.128.128	12	16.010	69	2.52
Thiès	1.348.637	14	6.601	199	2.75
Louga	559.268	5,5	29.188	19	1.00
Fatick	639.071	6,5	7.930	78	1.72
Kolda	834.753	8	21.011	37	2.63
Total	9.802.775	100	196.722	48	2.69

Source: Demographic forecasts: 1988-2015 /DPS

Since independence, urbanisation has been rapidly gaining ground in Senegal, climbing from 23% in 1960 and 43% in 1999 due mainly to the heavy concentration of non-agricultural economic activities in urban areas, primarily Dakar.

This disparity is reflected in energy figures. The Dakar region has the highest electrification rate (61.7%) and consumes almost 65.5 of generated electricity in the country. This goes a long way towards explaining the huge gulf between the urban electrification rate (55.4) and the rural one (7.4%) in 2001.

Widespread poverty particularly in rural areas

If poverty is understood as consuming less than 2,400 calories par person per day or less than $1 per day, the second Senegalese Household Survey (ESAM II, 2001/2002)[16] put the proportion of households living below the poverty line at 48.5%. Another striking feature of this reality is that poverty is especially severe in rural areas (65.2% of individuals, 57.5% of households).

Moreover, poverty is more pronounced in regions where there is little diversification in agriculture and where there is comparatively less urban migration. The regions of Fatick, Kaolack and Kolda (in the centre and north-east) are the poorest, with poverty rates reaching 80%. These areas are also the most important in agricultural terms, but there is very little diversification there, and very few off-season crops. Another apparent fact is that the poorer the area the bigger of size of the household. The average household size of the poorest quintile is 10 people, whereas the size of the most affluent is 7 or 8, according to the 2001 core development welfare indicators.

[16] The first Senegalese Household Surveys (ESAM I) was conducted in 1994, and was updated in 2002 via ESAM II.

3.2- Needs and energy requirements

In order to assess the relationship between productive activities and energy services, we opted to focus on rural zones (14,102 villages).

3.2.1- Energy service requirements and the role of renewable energy

Agriculture is still the biggest economic activity. Rural populations earn most of their income from agricultural activities. These activities are also central to increasing food security by providing raw materials for the agro-industry (groundnuts, cotton, etc.) and is also an outlet for craft products (agricultural material).

Two types of agriculture prevail: rain-based agriculture and flood agriculture. These types of agriculture need energy services in order to increase yields (modernisation, harnessing more water) and fuel processing and preservation.

In rain-based agriculture, renewable energy is of value downstream for cereal processing (grinding, etc.) – PV solar mills and solar driers could be ideal for this.

In the second case (flood agriculture), considerable amounts of market-gardening products (286,740 tons) and fruit products (313,745 tons in 2001) are available each year. However, a large portion of these rot or have to be sold off at knock-down prices owing to the lack of appropriate processing or preservation amenities.

In terms of productive uses, renewable energy technologies could be valuable in the following instances:

- upstream, for effectively harnessing water, where PV solar and wind power could prove especially useful for irrigation and drainage.

- downstream, for processing and preservation, where electricity generation systems (PV, wind) offer many opportunities. For the latter, solar driers and mills are particularly promising in terms of wealth creation and relieving the workload of women.

The agricultural sector is not the only one that could benefit from getting access to more energy services, others include: clothes-making, welding and bird-rearing, all of which often need small rural mechanised units or systems

3.2.2: A sample from a poor community

Studies[17] conducted in 1989 as part of a rural electrification project in an impoverished community in the middle of the country evaluated daily electricity needs for decent domestic conditions (lighting, audiovisual, etc.) and also for production needs (refrigeration, rural trades, cereal grinding, etc) (see Table 4).

[17] The surveys looked at electricity needs in villages with a view to bolstering local development. It did not consider domestic fuels because these are not replaceable in the short-term by electrical services.

Table 4: Electricity demand in a village in the rural community of Diarrére

Village	No. of households	Total	Daily energy needs (kWh)
BIKOL	162	1688	265
SOBEME	59	741	141
MBASSIS	45	606	119
NDOUNDOKH	71	863	149
SANGARE	72	818	152
DOUF	52	798	122
NGODJILENE	80	1008	161
MBETID	100	1182	189
WANDIANA	30	337	90
KHASSOUS	68	773	140
KOTIOKH	100	1253	190
GODEL	93	1235	180
GADIAG	212	2005	396
POULTOK DIOHINE	107	1309	199
LOGDIR	95	1240	184
NGARDIAM	45	617	113
LEM	21	225	75
DAM	21	208	75
MOKANE GOUYE	46	651	Na
MEM	15	205	Na
TOTAL	1494	17762	

Source: - **Sécou Sarr, Libasse Ba** Enda Energy ; 1998

Income-generating activities

The survey highlighted the need for:

- Refrigeration: for preserving food and perishable products. “Some income-generating activities, such as the sale of fish and market-gardening produce, are hindered due to the lack of preservation facilities” – these are the words of a village chief and amply reflect the perceived importance of electricity for production.

- Mechanisation: it has to be stressed that there can be no development in rural areas without increased mechanisation. Income-generating activities demand mechanisation for both processing and developing craft enterprises.

i) Processing agricultural products

- the groundnut sector: for the production of oil and paste, plus hulling, pressing, grinding, steam heating and grilling.
The activities are currently performed with manual presses or mortars, demanding enormous investment of physical energy and time that could be used for other activities.

- the cereal sector
Millet flour, granules and couscous, all of which are derived from millet, are highly sought-after products in Senegal where they form part of the staple diet. Seed

processing (hulling and grinding) is traditionally the role of women and require a lot of energy. In a bid to improve women's living conditions, diesel-based mills and hullers have been introduced. However, the fact that some villages are so remote means the service is often discontinued due to the lack of fuel. Solar mills have very recently made their entrance into this area and it is likely they could help overcome this constraint.

ii) The development of rural craft enterprises: this mainly concerns clothes-making, welding and mechanics,

- Heat: this is critical for processing and preserving agricultural and seafood products. Experiences of solar driers in the food sector and for transforming fresh fish into salted or dried and braised fish in ports have highlighted the potential that renewable energy technologies offer for generating added value.

On the basis of these expressions of energy service needs, we have drawn up the following matrix encapsulating the four priorities identified at national level by ESAM:

Table 5: Priority matrix for households and how they relate to energy services

Poor people's priority needs	Activities	RETs that could be used	Impacts
Access to water	Mechanisation of sinkholes, irrigation, pumping	PV, wind	Improve access, alleviate women's burden, reduce diarrhoeic diseases, sale of water, development of off-season crops and wealth creation
Access to healthcare services	Preservation of medicines – laboratory appliances and audio- and lighting tools made operational – water production – drying medicinal plants	PV, wind, water-heater, solar, solar driers	Widen availability of medicines, improve work conditions for healthcare officers, enhance hygiene in terms of medicinal plants
Job creation for youths	RET training; installation and maintenance of equipment, RET production, development of rural enterprises and services	PV, wind, water-heater, solar driers, bio-gas, biomass (has created more jobs).	Secure youths' future, trigger local development dynamic.
Wealth creation	Cereal grinding, processing and preservation for agricultural and seafood products, commercial services for maintenance of technology	PV, wind, solar water-heater, solar driers, bio-gas and biomass (some 25 billion are generated by this sector)	Income distribution, creation of added value, income creation, revival of demand

Source: Author's own compilation

This table highlights the supply of energy service for rural development activities. They present genuine benefits for the population in terms of economic and time savings and advances in sanitation. The table demonstrates the existence of a range of sectors that help tackle poverty in rural areas.

Nevertheless, it must be stressed that making energy available does not automatically ensure that income-generating activities will develop to the extent that they can earn enough income to lift communities out of poverty. A survey carried out in villages that have received an electricity supply over the last 10 years showed that only 20% of households are connected and very few productive activities have taken root. It is, therefore, essential that support measures be introduced to foster entrepreneurial instincts and capacities amid the poor.

3.3 - The Potential of Renewable Energy Resources

Senegal's renewable energy potential is in four sectors: biomass, solar power, wind power and hydroelectricity.

3.3.1 - Biomass

There are significant biomass resources but they are so far only really utilized using traditional methods both for production and end use. These resources are:

- wood culled from natural woodland : people use this wood for heating and making charcoal. Senegal has 6,205 thousand hectares of forestry resources, of which 5,942 thousand hectares are natural forests and 263 hectares are plantations[18].

- agricultural residue such as groundnut shells, palm kernel shells, bagasse, rice stalks, cotton stems, filao spindles are all resources that could be harnessed to generate energy. Typha Australis in the River Senegal has very recently boosted biomass resources, boasting potential of some 3 million tons of fresh material, or 500,000 tons of dry material. This is equivalent to 150,000 tons of biomass charcoal[19]

Table 6: quantities of agricultural residue (1998)

Type de production	Production (in tons)	Agricultural residue (MS tons)
Groundnut	544,800	871,680
Sorghum	118,300	343,070
Maize	60,300	126,630
Millet	426,500	1,322,150
Water melons	261,300	182,910
Rice	173,700	312,660
Manioc	46,600	88,540
Cotton	40,000	4,400

Source: Ministry of Agriculture; 1998

To this we may add:

- Charcoal and not coal Coal dust appraised at 15 tons per day, or 4,380 tons per annum in the Dakar region alone[20];

- Domestic waste evaluated in 1999 in the Dakar area at 4 million tons. . This is in addition to the existing stock in Mbeubeuss dump, which has accumulated some 6.3 million tons of refuse over the last 25 years[21].

18 - Adaptation to the harmful effects of climate change: the case of sub-Saharan African countries: the impact of climate change on access to energy in rural areas and adaptation in WAEMU countries; Enda, CGSUV; March 2004

19 - Valorisation of Typha as a domestic fuel in West Africa; PREDAS, PSACD; May 2001.

20 - Findings of survey on coal dust and wood in Dakar; Libasse Ba, Sécou Sarr, Enda 2001.

21 - Feasability study on an integrated waste treatment and valorisation in Dakar: Impact on greenhouse gas emissions; Enda; February 1999.

Table 7- Quantity of animal waste

Species	Number	Qty of excreta T DM/D
Cow	2,912,600	18,058
Sheep	4,344,900	4,301
Goat	3,703,200	3,666
Pig	241,100	485
Horse	445,100	650
Donkey	375,800	3,129
Camel	4,000	40
Poultry	20,342,300	1,627

Source: Pastoral Farming Division, 1998
TDM/D= Tons of dry matter per day

3.3.2- Solar potential: annual sunshine of more than 3000 hours and average irradiation of 5.4 kWh/m²/day promises significant opportunities for generating thermal and photovoltaic power in Senegal.

3.3.3- Wind potential: Senegal's coastline stretches over almost 700 km and has a wind pattern conducive to electricity generation. A study carried out on a 200 km-long and 20 km-wide of coastline between Dakar and St. Louis found average wind speed to be 5 to 5.9 m/s at height of 50 metres[22]. In other zones, wind could be harnessed to fuel water pumping.

3.3.4 – Hydropower potential

Senegal is not especially well endowed in hydro resources that could be used to build micro-hydro power stations. There are, however, high hopes of harnessing up to 1000 MW from the Organisation de la Mise en Valeur du fleuve Sénégal (OMVS[23]) and the Organisation pour la Mise en Valeur du fleuve Gambie (OMVG). So far only 200 MW have been exploited through the Manantali hydroelectric power station in Mali, which provides electricity to Mali, Senegal and Mauritania.

[22] Atlas éolien de la grande côte du Sénégal, Valérie Blecua; January 2002
[23] OMVS consists of Senegal, Mali and Mauritania and aims to make use of the River Senegal for energy purposes.

3.4 - Technologies

We will examine two sectors of renewable energy, namely solar photovoltaic and wind power. These two were chosen because their technologies have reached maturity and because they offer significant scope for nurturing wealth-creation activities in rural areas.

3.4.1- The PV sector

PV technology has been making inroads into the country since the 1980s through the efforts of regional programmes (Regional Solar Programme) and national programmes driven by bilateral co-operation (Germany, France, Italy, Spain, Japan and India).

Realisations include family photovoltaic systems, pump systems and photovoltaic power stations (mini-grid) aimed at providing services including lighting, communication (radio, TV, telephones, etc.), drainage, irrigation, refrigeration, etc.

Generally speaking, the penetration of PV equipment has taken place in stages in keeping with the approach of the Senegalese-German project that we are invoking as a case study, i.e.:

- An initial phase for testing the suitability of the technology to local conditions. This took place especially in the 1980s, when numerous small-scale demonstration projects were initiated.

- Pre-distribution phase featuring an active information and public awareness-raising campaign, arranged with the help of state subsidies.
- Commercial phase marked by the involvement of private operators in order to disseminate RETs via market forces.

Commercial and organisational approaches were tested during the phases so as to deduce the best way of distributing equipment and ensuring its sustained use[24]. Independent funding of these systems (credit or cash purchase) by users meant that marketing was followed by the sale of energy services[25].

[24] - Distribution of SPFs in rural areas: Selection of associations and groups and alternative funding sources; Masse Lo; Sécou Sarr; Enda 1993.
[25] - Assembly and Services Centre: salience of a concept and adaptation of local conditions; Sécou Sarr, Libasse Ba; Enda ; ESPL, 1998.

This commercial approach would appear to be more suitable to the means and habits of disadvantaged groups, since budgetary constraints mean poor people tend to make purchases of smaller quantities (they can't afford to buy in bulk) so they pay more for the same services than well-off people do.

Box 3: Energy service sales: The example of the Senegalese-Japanese project on Mar Island[26]

This project was launched and wholly funded by JICA in 1999 and concluded in late 2002. Its goals included implementing an operational and management mechanism for solar home systems (SHS) on Mar Island, which had a population of 4,608 (422 households). The test phase saw energy services being sold to the population and was implemented by:
- a steering committee (MEH, ASER, JICA) responsible for supervising activities; - a private operator (Matforce, a mechanical application company and equipment supplier and fitters), which was chosen for operating and managing the systems. It was also responsible for maintaining the equipment, recovering payments form users, replacing faulty parts and raising users' awareness. For this, a village committee to help raise users' awareness and put on demonstrations was established. For a 55 Wp system worth 450,000 CFA users paid an initial sum of 45,000 CFA francs (10%) and a monthly fee of 3700 CFA francs. A total of 95 SHS were installed and they operated well. Almost all users paid their fees (as of January 2003, there was a recovery rate of 90%). Financial estimates suggests that profitability would be ensured by a minimum of 200 SHS and a monthly rate of 4,100 CFA francs excluding VAT.
This project's impact is first and foremost qualitative. Its contribution to development has been restricted to improving night-time working conditions and study conditions – it did not lead to wealth-creation in the area.

The sale of energy services appeared to be eminently appropriate for the area and this explains why the population were so keen to get hold of SHS. This enthusiasm led to a larger-scale project - ISOPHOTON - being implemented to install 10,000 SHS between June 2003 and October 2004.

Total number of installed PV solar amenities

Table 8 gives indicators of the types of systems installed in Senegal up to 2004.

Table 8: Types of installed power and systems

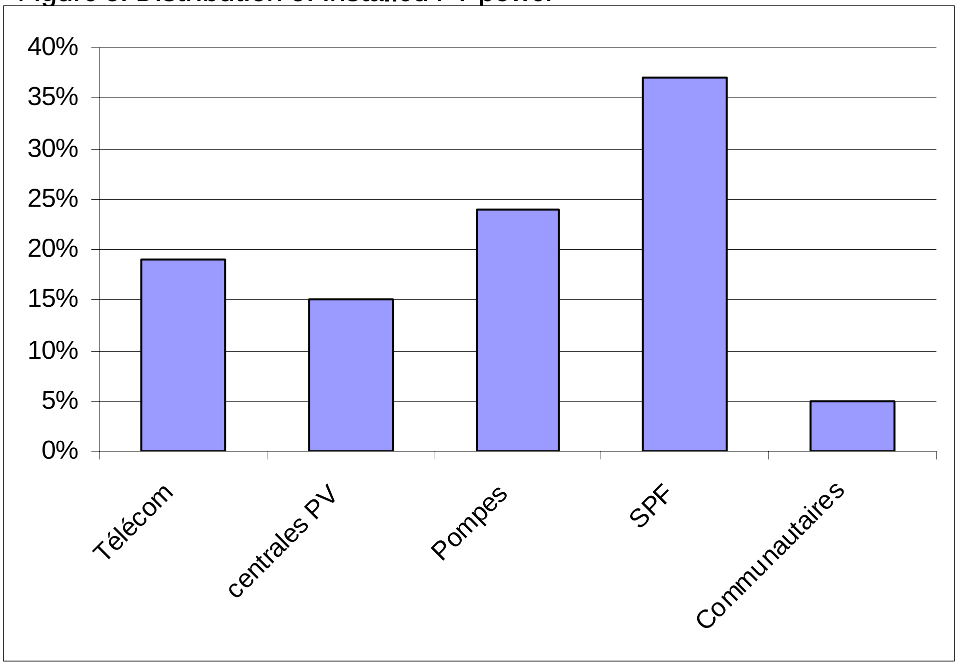
Type of equipment	Power (Kwp)
S. Hybrid PV/aerogenerator	5
PV power station	265
PV pumping systems	328
Desalination systems	65
Research centres, health centres, tourist facilities, cold storage, school infrastructure, batter rechargers	77,26
Telecommunications	315
SHS	600
Total	1 655,26

Source: **DAHOUENON, Mansour Assani. et al** 2004

Breaking down solar power according to application (table 3) illustrates that SHS are used mostly for lighting in houses, followed by pumps used for obtaining water. The former adds to the quality of life, while the latter affords opportunities to develop income-generating activities thanks to market gardening and irrigation.

[26] - Study on the plan to use photovoltaic systems for rural electrification in Senegal: Main report; MEM/ASER/JICA, March 2002

Figure 3: Distribution of installed PV power



Source: Author's own compilation based on data DAHOUENON, Mansour Assani. et al 2004

If we also take account projects such as Isophoton, which plans to set up another 5 solar power stations, 5 desalination and 662 community systems, and the ATERSA one, which envisages fitting 2,648 PV lampposts, Senegal will have an installed PV power of 2.3 MWp by the end of 2005.

Concrete achievements so far in terms of PV include:

- The installation of a quality control laboratory hosted by the Renewable Energy Study and Research Centre (CERER). This tests the quality of modules, accumulators, load regulators and electric ballasts for fluorescent lamps.
- Establishment of a technical committee in the Senegalese Standards Institute.
- Training package for technicians set up as part of the PSEAS and then transferred to specialist training bodies such as the National Professional Qualification Centre (CNQP), the Technical and Professional Training Centre (CFPT) and Infoénergie.
- The development of a partnership between private operators and village associations. The former's role is upstream, where they are responsible for production and/or imports, while the latter are involved downstream, where they look after installation and maintenance. This dual approach optimises installation costs and makes sure systems are operational since there is an effective after-sale service nearby.

3.4.2- The wind power sector

The first trials in this sector met with very mixed results:
In 1983 and 1984, thanks to funding from the government of Argentina, more than 200 FIASA wind-pumping systems were installed. A study performed just three years later found that 60% were no longer operational. The situation then deteriorated even further, with all of the systems falling into disrepair.

The bodies that came after this misadventure were careful to incorporate a maintenance segment into their projects. Accordingly, LVIA set up 120 new types of wind-powered amenities and met with success thanks to:
The reliability of the equipment (60% of the facilities installed in the 1980s are still working today) and the fact that it was owned by the local community, make it an ideal example of North-South technology transfer.
Production and marketing of similar equipment is now entirely in the hands of a local economic interest group (called VEV: Vent, eau pour la Vie), as is the supply of maintenance services. Repairs and replacements are paid for by the village management committees.

Because this project was so successful, we chose it as a case study below.

Another interesting project was Alizé Senegal, which was implemented by a Senegalese engineering firm (SEMIS) in tandem with two French NGOs (GRET and EER) in 1987 after the success of Alizé Mauritania. Its goal was to revamp and disseminate windmills for pumping and rural electrification in northern Senegal.
From 1997 to 2003, the project received a total of 223 orders, conducted 130 pre-selection inspections, chose 41 villages, got 30 joint-investment proposals and finally carried out installations in 28 villages[27].
In addition to insisting that any decision-making process aimed at acquiring a wind system are participatory (whereby discussions are held to raise funding; management committees are formed and ways of using surplus water are planned collectively, etc.), the project introduced a scheme whereby after-sale services are also included in contracts. This represents an innovative way of ensuring maintenance needs are taken into account on an organisational level.

[27] - The 1997-2003 Alizés Senegal project; report on a rural wind-powered hydraulics programme in St-louis et Louga ; SEMIS, GRET, June 2003.

3.5 - Capacity assessment

Several types of players are engaged in promoting the use of RETs: public authorities, research and training institutions, engineering and design departments, private companies, village groups and associations, and NGOs and civil society organisations (see Appendix C).

3.5.1- The institutions with responsibility for energy:

- Ministry of Energy: the Ministry determines the overall policy for the sector and monitors and inspects its implementation via the energy board. The current energy policy has three main thrusts: an economic aspect, whereby it aims to streamline conditions for supplying, producing, transmitting and consuming energy in accordance with the country's long-terms interests; an environmental aspect that strives to respect basic ecological balances; and a social aspect, aiming to widen access to modern forms of energy (ESDPL[28]).

- The Senegalese Rural Electrification Agency (ASER) arose from the 1998 energy sector reforms. It is charged with supporting the implementation of rural electrification development programmes by providing companies and individuals with financial and technical assistance. It also offers partners advice, devises multi-annual rural electrification programmes, draws up invitations to tender for rural electrification franchises, helps operators design their projects and manages the overall funding of rural electrification. ASER's staff has already been recruited and its intervention tools already decided (procedure manuals, technical specifications, funding mechanisms and grant eligibility criteria, etc.). However, work must still be done to overcome the delays in fund-raising which have prevented these mechanisms from becoming operational. Other tasks that must be completed if rural electrification is to develop via a participatory method include supervising emerging operators and raising the awareness of populations and local elected officials.

- The Energy Sector Regulatory Commission (CRSE) is responsible for regulating businesses in this sector. This entails approving and watching over concessions and licencees and ensuring compliance with rules of fair competition to make sure consumers do not get a raw deal. The failure of the privatisation of SENELEC[29] has prevented it from exercising its rule of arbiter to the full, since one of its main activities involved checking the implementation of provisions relating to the SENELEC concession.

- Research and training bodies:
- The Renewable Energy Study and Research Centre (CERER) has been actively pursuing research and development on RETs ever since its foundation. It is housed in Cheikh Anta Diop University and falls under the aegis of the Ministry for Education and encounters quite a lot of difficulty with regard to accomplishing its mission because of a serious paucity of human, technical and material resources. As yet little effort has been made to raise money in other ways, such as by enticing private operators to pay for CERER's services.This is in spite of the fact that it possesses tools that could be of value for rural electrification projects, such as a PV equipment quality inspection laboratory. The Centre's remoteness from the market prevents it from marketing these commercial services that could increase its income.
  Similarly, University Cheikh Anta Diop is equipped with a Renewable Energy Semi-Conductor Laboratory (LSCER). Other research institutions include the Applied Energy Laboratory (LEA) and the Higher Polytechnical School (ESP).

[28] - Energy Sector Development Policy Letter, 1997
[29] - SENELEC: National Electricity Company.

In 1995, responsibility for training installation and maintenance technicians was switched from the PSAES to several training centres, namely the National Professional Qualification Centre (CNQP), the Professional and Technical Training Centre (CFPT Senegal/Japan) and InfoEnergie.

3.5.2 – Other players in the RE field

- Private companies: There are currently 14 private operators in the renewable energy sector. There are mostly involved with imports, assembly and marketing of solar systems. Some deal with the production of RET components (windmills, load regulators, solar lamps, etc.). Their major difficulty relates to their lack of resources, well-qualified staff and links with banks and R&D bodies.

- Associations and village groups: These are active in disseminating solar systems. There are a few such groups across the country involved in installation, maintenance and raising awareness. They serve as key contact and liaison points in the field for both for companies and state bodies. Their biggest problem is that they often lack information on technological changes, are not strongly organised, and are frequently unfamiliar with the latest policies.

- NGOs and other civil society organisations: There is a wide variety of NGOs in Senegal, suggesting that the country is relatively active on development and poverty-eradication fronts. Nevertheless, very few of the organisations are involved in spreading the use of RETs. The handful of NGOs who are active in the energy sector tend to devote their energy to awareness-raising alongside state projects and/or implementing small-scale projects (such as distributing small numbers of improved stoves). The NGO Enda deals with energy policy and even lobbying. It usually does this by creating forums for political dialogue and conducting social/energy studies with a view to compiling an energy data base.
- Broadly speaking, NGOs have sound knowledge of the situations on the ground and apply diverse approaches depending on the context. However policy-makers have hitherto failed to make sufficient use of this knowledge and experience. The lack of attention given to NGO activities means the lessons learned are seldom applied beyond the immediate vicinity of the NGO's operation.

In short, there is a wide spectrum of players in the RET sector but there is rarely much cohesion between them. This lack of co-ordination carries a high opportunity cost – the country has missed chances to benefit from synergies between operators and create added value in the development of other sectors.

4 - Case studies

4.1 - Wind pumping

Alongside wood gathering and cereal grinding, collecting water is one of the most important and hardest chores for rural African populations. The inefficiency or complete lack of appropriate technologies for pumping drinking water compel women and young girls of school-going age to spend much of their time trying to meet this fundamental need. The water accessibility rate (i.e. based on water being available within 1 km) in Dakar is 95.6%[30] but in rural areas, most people have to trek tens of kilometres to fill their buckets.

The consequences of this are all too familiar: relatively few girls attend school (64.8% compared to 73.9% of boys) and women are therefore hit disproportionately hard by poverty in rural areas[31]. Other effects are a rise in water related diseases and, of course, insufficient consumption of water. In 2001, average water consumption in Senegal was 28 litres per day per person : this is below the intake recommended by the World Health Organisation (WHO), which sets 35 litres per day per person as the minimum requirement for healthful living. Consumption in rural areas is much lower than the average.

The deployment of renewable energy, particularly wind pumps, would help alleviate water shortage while also lightening women's workload and paving the way for more wealth-creating activities for marginalised populations. This is one of the goals of the Poverty Reduction Strategy Paper, which aims to introduce energized groundwater pumps.

> Box 4: The PRSP's priority action plan refers to promoting sustainable management of water related amenities. This entails:
>
> - building the capacities of groundwater pump management committees,
>
> - Promoting renewable energy for the mechanisation of groundwater pumps,
>
> - Short-term objectives aims to provide 600 rural communities with mechanised pumps, drill another 500 sink-holes and renovate a further 100.

Through its wind pumping programme, the "Vent Eau pour la Vie" (VEV) programme aims to:

- Serve as a best practice example of North-South technology transfer thanks to effective appropriation by the VEV group
- Prove that RETs can be used to help alleviate poverty by bolstering food security, creating wealth for rural women (by enabling them to indulge in market-gardening, sell water, etc.), and relieving women's work load.

4.1.1- Background to the VEV programme

The precursor for the activities carried out today by VEV (which is based in Thiès 70 km from Dakar) was another project – called "petits miracles à partir de petits projets" ('little projects making little miracles"- launched in the 1980s by the Lay Volunteers International Association –LVIA.)

- Adaptation to the harmful effects of climate change: the case of sub-Saharan African countries: impact of climate change on access to energy in rural areas of WAEMU countries; Enda, CGSUV; March 2004.

[30] - Poverty Reduction Strategy Paper; the Republic of Senegal, 2002.

[31] The first budget survey (ESAM I, 1994) found that 57.9% of households live below the poverty line, consuming less than 2,400 calories per adult per day, which equates to daily expenditure of 393 CFA francs per adult.

Right from the outset, LVIA sought to ensure the technologies were owned and managed by the local population by inculcating the knowledge and skills that would allow them to handle maintenance and installation work. The Senegalese staff who were recruited were immediately taught how to make and install village amenities. After 12 years, the association left and the Senegalese workers took over, forming themselves into an economic interest group called “le vent pour l’eau et la vie (wind for water and life).”

Of the 150 pieces of equipment that were installed between 1980 and 2000, 110, or 75%, are still operational.

4.1.2- Wind energy for water pumping: An appropriate choice

The piece of equipment in question is a multi-blade wind mill featuring pylons 12 to 16 metres high and wheels with diameters of 5 to 6 metres. They have a pump capacity of 5 to 100 metres with flow rates ranging from 950 to 9,000 litres per hour

The windmill is also linked with a reservoir, which feeds irrigation pools, troughs and drinking fountains.

Box 5: Some technical characteristics of the wind system

Mill:	height 12 to 16 m, Wheel diameter: 5-6 m. Nominal power: 500 W Start speed: 3 m/s
Pump:	piston diameter: 60-180 mm piston travel: 14 cm
Material:	wheel: 18 galvanised sheet metal blades tower: steel profiles pump: brass and melting with leather covering

Transmission: alternative movement is secured through a simple rod and lever system.

Regulation: a brake system kicks into action when the wind speed exceeds 8 mps. The wheel turns on its rudder, reducing the size of the surface exposed to the wind and thereby decreasing rotations. The wheel returns to its original position as they wind speed declines.

Weight: 1125 kg

Flow can vary, depending on the depth of the well amongst other factors, from 1,000 to 9,000 L.

Technical data on pump size is available in Appendix D.

The mills are now produced in VEV’s workshop using local materials, except the filter and rudder spring, which are still imported from Italy. In other words, 95% of the technology is made from Senegalese materials. The price of a ready-to-use mill is 5,500,000 CFA Francs, or $8,350.

4.1.3- Pricing system for water commensurate with community size

The price of water in these communities depends on needs: domestic users pay by volume used, and there is a lump sum for market gardening or cattle rearing users.

For individuals, water is charged at 10 CFA Francs per 20 litre basin, or 500 CFA Francs per m3.

For market gardeners, a lump sum payment is required. For example, in the village of Goumsan, a plot of land of 5m^2 requires 320 L per day, and costs 500 CFA a year. The average tariff applied by the Société des Eaux (SDE) (see Table 9), water supplied would have been 30,452 CFA Francs per year, or 60 times more expensive.. Compared with the social tariff applied SDE, water provided by the pump for household needs is more expensive; but on the other hand, it is 10 times less expensive for the needs of market gardening.

Table 9: SDE rates (incl. Tax, in CFA Francs per m3)

Individuals: metres with 15 mm diameter - SB (social band) 0 < consumption < 20 m3 bimonthly - FR (Full band) 21 < consumption < 100 m3 bimonthly - DB (Discouraging band) consumption > 100 m3/bimonthly Average cost	160.72 548.24 629.84 446
Water fountains, public convenience, and not-for-profit religious institutions SB (single band)	233.26
Small market gardeners, industrial market gardeners, parks and gardens - RB (reduced band) 0 < consumption < 3 000 m3 bimonthly - IB (Intermediary band) 3001 < consumption < 20,000 - FB (full band) consumption > 20,000 m3 bimonthly average cost	105.81 149.35 548.24 268

Sources : SDE

4.1.4- A management system entirely in the hands of women.

A village committee has been set up to handle the operation of each mill system. Women are responsible for selling water at drinking fountains. The manager claims one-third of income generated, while the remaining two-thirds are put into a fund for repairs. The fund may also be used to address certain social problems, if consensus is reached. This was the case, for example, when a community used some of the money to pay taxes when faced with threat of refusal to supply seeds to rural people who had not paid the rural tax. Other uses of the fund include contributions to building social infrastructure, etc.

4.1.5- Development of maintenance services to safeguard technological viability

As with all technologies, the windmills can only be used in a sustainable fashion if preventive and remedial maintenance is carried out.

The management committee set up by the local populations is the priority contact for VEV’s technicians. The committee handles the collection and management of money earned from water sales and arranges the maintenance of the equipment and covers any related invoices.

However, sometimes (during the rainy season for example), the cost of maintenance may exceed the means of the village committee. This could cause dramatic water shortages for the community and curtail their income-generating activities; but in a bid to thwart such problems, a more flexible funding scheme has been implemented.

4.1.6- Maintenance funding mechanism based on offering credit to pay for repairs.

In order to help communities pay for repairs when costs are unusually high, the VEV company devised a scheme whereby communities can pay in instalments. This programme has received the financial backing of the African Rural Energy Enterprise Development (AREED), which enables it to keep a stock of spare parts and have logistical means at its disposal in order to facilitate operations in rural areas.

This AREED funding has had a positive impact, increasing demand for maintenance and thereby boosting the operator’s turnover from less than 8,000,000 CFA Francs to more than 30,000,000 CFA Francs[32].

[32] - VEV activity report for July to December 2003, turnover = 27,986,360 CFA Francs

From 1999 to 2003, the average costs of repairs ranged from 43,000 CFA Francs and 105,000 CFA Francs. The average number of maintenance operations was 1.5 per mill per year.

Box 6: AREED, African Rural Energy Enterprise Development

The African Rural Energy Enterprise Development (AREED) programme seeks to expand the provision of energy services by developing local entrepreneurship in Africa.
This initiative entails identifying highly-motivated entrepreneurs capable of designing and funding projects. Launched by the UNEP and implemented in Senegal by the organisation ENDA TM, the programme fulfils the following roles:

- A learning process to identify and design viable projects (AREED identifies entrepreneurs and helps them conduct market analyses and financial risk analyses and draw up business plans, etc.);
- Funding in the form of loans, share holdings or guarantees in order to help activities deemed sustainable to start up. Second-phase projects (those in the expansion stage) may also be funded through multi-lateral environmental agreements.
- Interface between entrepreneurs and local financial institutions so that local financial resources can be raised to fund development;
- Helps foster an institutional environment that fosters emerging energy-service enterprises in order to embed sustainable development.

VEV received some 12,000,000 CFA francs in 2002 to support its windmills restoration and maintenance programme aimed at securing improved potable water supply for rural populations.

4.1.7- Impact of windmills on the development of productive activities.

- Water selling for cattle rearing and household needs usually generates enough income to cover maintenance costs and some money for the system operators (the women who sell the water).

- Development of off-season crops (market gardening): In the village of Goumssan, a youth group practices market gardening that benefits the whole community. Each youth has a specific number of plots to cultivate, and its products are then handed over to women who sell them. This activity not only helps boost food security, but generates income for young people and women.

- Village woodlot: Another community that had a wind mill fitted has created a village woodlot. Sales of poles and fire wood generate income for the economic interest group that runs it (revenue of up to 500,000 CFA Francs).

4.1.8 - Impact on job creation for young people and women:

The number of jobs directly created by a wind system depends on the number of drinking fountains fuelled – i.e. on demand. Some systems fuel just one fountain, while others supply two or three.

Indirectly, these systems boost the capacities of local service-providers and increase the viability of manufacturing enterprises. VEV employs 8 young technicians to deal with servicing and maintenance and also pays for other services (materials, welding, etc.) from craftsmen in Thiés.

4.2 – Photovoltaic solar systems case study

Below we examine the German-Senegalese Photovoltaic Solar Project (PSAES).

The PSAES was launched in Senegal in 1987 and concluded in 1998 after 10 years of operation. During this time it went through many phases, but all with the single objective of testing and distributing PV solar systems with a view to widening rural populations' access to electricity and water.

A host of support measures were applied with the result that the following was achieved:

- 2 solar power stations (mini-grid): one in Diaoulé with a capacity of 22.8 KWp and another in Ndiébel with a capacity of 19.8 KWp. The total number of beneficiaries was 3,000 people (see appendices)
- Installation of 6 solar pumping systems (0.1 to 1.3 kWp),
- 4 mini-solar power stations with capacities of 150 to 1230 Wp for health centres and village tourist camps.
- More than 3,000 50 Wp domestic photovoltaic systems.

Players and role: The following players were involved in the project

Players	Roles
Scientific and Technical Board (DAST)	Co-ordination and supervision
SENELEC	Technical partner for the solar power stations (mini grids)
Hydraulics board	Technical partner for solar pumping
CERER	Research, equipment tests, monitoring
NGO (Enda-TM)	Devised strategies for distributing solar systems, socio-economic monitoring, overseeing associations and groups, interface with project members and beneficiary populations
Village associations	Application of distribution strategy, marketing, installation and maintenance
Beneficiary populations (village management committees)	Decentralised management of operation of community amenities (stations and pumps)
Specialist firm (SEMIS)	Upstream studies to enhance market knowledge and publicity strategy

4.2.1 – Management strategies for the Diaoulé and Ndiébel power stations

Two major aspects must be highlighted: the socially-oriented pricing system and operation and management by the community. Technical data on these are available in Appendix E.

i) Formulation of a pricing system that took account of the poor.
The studies conducted on access to electricity in 5 villages that had an electricity supply from SENELEC for at least 10 years showed that only 25% of households were connected. The underlying reasons for this was simply because the subscription was beyond the means of most rural households.

To address this barrier, tariffs in Diaoulé and Ndiébel were adapted to fit the paying capacities of use groups and to recognize the realities on the ground. Studies revealed that three different user groups could be identified, and so three separate prices were set.

Table 10: Subscription costs

Group	Income source	Cost of access (Euros)
Poor	Agriculture only	4.5
Middle	Agriculture & cash transfers/ payments in kind	9
Well-off	Trades and employees (teachers, nurses, etc.)	22

Source: Author's own compilation

ii) – Community organization and management

Village committees managed the solar power stations. They dealt with protecting the facilities, dispatching bills, compiling requests for connection and extension, eliminating fraud, collecting payments, etc.

Impact:

- Access rate: Access is now 93 and 98% in Diaoule and Ndiebel respectively. Electricity is used for lighting by all connected households, whereas just 2.1 to 2.4% of them use it for productive purposes (selling ice and fresh drinks, engaging in craft) (see table 11).

Table 11- Household uses of electricity at Diaoulé and Ndiébel

	Diaoulé	Ndiébel
Uses of electricity	% of households	% of households
Lighting	93.3	98.2
Radio	42.8	32.1
Television	9.3	7.2
Refrigeration	2.1	2.4
Ventilation	4.3	0.6

Source : Assessment of socio-economic impact of photovoltaic power stations in Diaoulé and Ndiémbel ENDA T.M , 1993

- Most electricity consumption is from the residential sector (80%) as oppose to the commercial sector (12.2%) or community services (7.2%) – see table 12.

Table 12 - Electricity consumption by sector (in kWh): Diaoulé

Period	Jan 1991	Feb/Mar	Apr/May	Jun/Jul	Aug/Sep	Oct/Nov	Dec	%
Commerce	138	195	237	234	246	170	255	12.2
Community Services	147	168	140	141	145	139	172	7.2
Households	1,143	1,729	1,970	1,497	1,603	1,068	2,202	80,0
Total	1,426	2,092	2,347	1,884	1,994	1,377	2,628	100,0

Source : Assessment of socio-economic impact of photovoltaic power stations in Diaoulé and Ndiémbel ENDA T.M , 1993

Table 13: Electricity consumption by sector (in kWh): Ndiébel

	J/F1991	Mar/Apr	May/Ju	Jul/Aug	Sep/Oct	Nov/Dec	J/F 92	%
Commerce	400	226	219	482	283	168	239	8,0
Community Services	1,009	357	261	331	297	260	391	15,5
Households	4,892	2,027	2,306	3,090	1,546	1,031	1,810	76,5
Total	6,301	2,610	2,786	3,953	2,126	1,459	2,240	100,0

Source : Assessment of socio-economic impact of photovoltaic power stations in Diaoulé and Ndiémbel ENDA T.M , 1993

In summary, it was found that access to electricity impacted on efforts to eradicate poverty by making the following possible:

- Develop clothes-making, welding, and local craft businesses;
- Ice and cold drinks sales
- Conservation of vaccines, thereby improving health services
- Swelled school attendance.

4.2.2 - Strategy for disseminating household photovoltaic systems

The success of the implementation of the PSAES, especially when it came to SHS, depended to a large extent on the involvement of village groups and associations. The project began by providing training to these grassroots groups; initiated commercialisation and, finally, forged partnerships with financial institutions and private operators.

i) Training association technicians

The project provided technical training in each of the 12 participant villages in order to build capacities on a decentralised basis and embed a system of maintenance. A total of 30 technicians were trained. Over time, the training modules were transferred to the relevant training centres (CNQP, CFPT), who thereby ensure this system is perpetuated.

ii) Associations introduced to dissemination

Once technically trained, the associations received SHS subsidised by the project; they could then sell them (first on a credit basis then via cash purchase) to their members. This phase was backed up by awareness-raising programmes to improve knowledge of the product.

iii) Interface between association and financial institutions

At the outset financial institutions (credit unions) were very sceptical about financing solar equipment, which at the time was viewed as being non-productive, and also because the associations could offer no collateral. The project put up a guarantee to enable the *Alliance pour le Crédit et l'Epargne pour la Production* (ACEP) provide funding to two groups. A loan at an interest rate of 10% was secured, paving the way for the distribution of twenty facilities. Alas, the operation had to be discontinued because no collateral could be raised once the project ended.

iv)- Partnership between Association and the private sector

In 1994, after the gradual opening up of the market during the "familiarisation" process[33] enacted by the project during the previous 5 years, several companies started to sell and even manufacture various components of the technology (such as regulators and accumulators). This enabled the project to withdraw from commercial activities and attempt to get market forces to take hold by fostering

[33] - Sécou Sarr, Yvonne Faye ; Impacts des programmes d'électrification rurale sur le marché privé photovoltaïque au Sénégal ; PERACOD ; Mars 2004.

partnerships between the association, with the latter specialising in maintenance and installation and the former concentrating on importation.

v) – Consultation Framework for associations and groups

The withdrawal of PSAES from commercial operations could have harmed the associative movement since it represented the loss of an advisory, information and supervision structure. For this reason, Enda Third World helped establish the Federation of Organisations for the Promotion of Renewable Energy (FOPEN).

10 of the 12 associations that were partners in the PSAES are members of this federation, which is in effect a network of rural-based maintenance technicians.

vi)- Other support measures

- The government lifted the tax on solar products[34].

VII- Impacts of this programme

- Development of rural micro-enterprises (about 10);
- Dissemination of 3000 SHS for lighting and communication;
- Development of local expertise capable of providing proximity maintenance services;
- Creation of jobs (some thirty technicians were trained and live of solar services) through installations resultant maintenance contracts;
- Establishment of a quality control laboratory;
- Transfer of training schemes to national training bodies;
- Approval of decentralised methods for managing electricity.

[34]- In 1992, solar products were given exemption on fiscal duties and VAT thanks to decision no. 0706/DGD/DERD/BE. This decision was overturned in 2000 when the WAEMU's common external tarrif came into force.

5 - Barriers to the penetration of renewable energy

In spite of the maturity of some proven or mature technologies, many obstacles still impede the propagation of RETs. We can classify these obstacles into two categories: 1) market constraints, and 2) political, institutional and regulatory constraints[35].

5.1 Market constraints

Renewable energy technologies have made significant advances in terms of technology and organisation in recent years, but a genuine market for them does not yet really exist because of.

- lack of competitiveness of renewable energy compared to conventional types: the initial investment cost is $8500 for a wind systems, which far exceeds most peoples' means.

- lack of funding mechanisms (RET promotion funds, credit lines, etc.) and measures for encouraging use of RETs

- Low demand - this has prevented the emergence of a well-structured national supply capable of fostering the development of the sector. In many cases, operators who get involved in the sector have become disillusioned and abandoned their activities because of the lack of a sufficient market.

- Compartmentalisation of actors – this hinders the development of a mutually-beneficial relationship, and prevents synergies between the strengths of various actors. A prime example is the gap between research and development bodies and private operators. The net result is that research findings are often of little relevance to the needs and demands of the market. This is one of the reasons why there is no RET production infrastructure.

- The insufficient propagation of an appropriate funding mechanism

5.2- Political, institutional and regulatory constraints

- It has to be acknowledged that African countries have designed their energy policies on the basis of supplying modern energy services and have restricted their renewable energy initiatives to disparate isolated or scattered projects. It would be much more fruitful to apply well thought-out policies rather than a series of projects.

- There is a lack of cohesion of intervention methods in the renewable energy field. By always undertaking actions in isolation, the various national and regional institutions, projects and programmes stifle opportunities for synergies.

- Little attention has been paid to RETs by national energy policies;

- Lack of fiscal measures likely to stimulate local production;

- Lack of consultation between actors.

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[35] - The technological stakes of renewable energy in the fight against desertification; Youba Sokona, Sécou Sarr, Jean Philippe Thomas; Enda, April 2004 ; 20 P.

6 – Summary of niches and policy

Today, since there is a new thrust towards poverty reduction strategies that take account of key development sectors (education, health, agriculture, water and industry), it is vital to situate the issue of renewable energy development in the broader context of improving economic actors' access to energy services.

When doing this, it would be a mistake not to recognize the institutional and policy aspects of decentralisation and its relation with local market development, particularly in the context of renwable energy.

In this regard, the various experiences of RET development have exposed some obstacles to penetration which in turn suggest possible interventions under the policy, institutional and financial niches.

- In terms of policy, like most African countries, Senegal has for a long time based its energy policy on providing modern energy services. By concentrating solely on the supply side, they for many years neglected the benefits of renewable energy. Even now, as the new rural electrification strategies are being implemented and emphasis is being placed on cost-efficiency (in the ASER approach), there is no guarantee that the State will take concrete steps to broaden application of renewable energy, notably photovoltaic or wind-powered systems[36].

Basically, we do not discern any vigorous and adequately-funded government policy commitment to harnessing renewable energy for deprived population segments.

In spite of its rich experiences with RET, Senegal seems intent on perpetuating the approach whereby project after project is implemented without any indication of a structured national approach taking shape.

- in institutional terms

As already discussed, a range of players are involved in RETs. Each of these possess disparate types of information relevant to a specific area of intervention and this can be broadly summed up in the following non-comprehensive chart:

Players	Available data
Public authorities	General data on the energy sector and major projects
Private companies	Technical and economic data on RET facilities
Design firms	Data on future and existing projects
NGOs	Socio-economic data on project areas
Research centres	Technical data on the equipment studied
Village groups and associations	Populations' needs in terms of energy, and the benefits and disadvantages of the energy sources used

At present, there is little evidence to indicate that there is a pressing information deficit, since all the data required to inform decisions is, in fact, available. What is more, each player knows how to update their data in their fields of expertise (by conducting surveys, technical and economic data from suppliers, project evaluations, etc.)

However, the fact that all this data is compartmentalised by sector creates a significant 'gap'; all signs point to relatively few spontaneous exchanges between the various players. This is one of the biggest institutional hurdles in the area of RETs.

[36] The political and institutional Framework of the energy sector: some questions; RET re-launch document, Sécou Sarr; April 2004.

There is currently a real need for information pooling and a coherent institutional arrangement to facilitate this.

This is particularly vital to eliminate the duplication of roles currently evident among institutions involved with RETs. For example, Senegal has a Renewable Energy Study and Research Centre (CERER) , which is much like Mali's CNESOLER, Burkina Faso's IRSAT and Niger's CNES. All of these organisation struggle to accomplish their goals because of the dearth of resources.

- Fiscal and regulatory aspects: Senegal was quick to introduce fiscal and regulatory measures aimed at stimulating the use of RETs. The most assertive one was decision no. 0706/DGD/DERD/BE.1 of 4 May 1993, which granted tax exemption to solar material and lifted fiscal duties, customs duties and taxes on added value.
In 2000, however, this measure was rescinded when the WAEMU imposed common external tariff as part of the sub-regional harmonisation of fiscal and regulatory measures. Solar products are now subject to more than 25% tax, made up of VAT (18%), royalty, a WAEMU community solidarity levy, an ECOWAS community solidarity level, etc.

In summary then, there is still a long way to go for regional market integration and for fiscal measures to encourage the establishment of RET infrastructure.

- Financial aspects: the development of RETs is in many cases impeded by the paucity of funding opportunities or bodies, either with regard to small decentralised infrastructures or household services.

As things stand, there is a gap between the demand for energy services and supply. At present, demand, outside domestic needs, needs to be met through a localized, 'multi-service' approach that satisfies:

- the sound running of essential infrastructures for health, education, water provisions, etc.

- the development of income-generating activities such as market-gardening, conservation, product processing, etc.

Energy sector reforms, especially concerning electricity, in West Africa are striving to implement rural electrification agencies whose decentralised activities are incorporated into local development plans. Therefore, there exists a need to find financing for energy infrastructures, a need which is intimately tied to plans to fund local activities.

Similarly, in light of studies conducted on mechanisms for funding household energy services, it is apparent that there is very high elasticity of demand when it comes RETs depending on payment methods and access to credit.

Inspite of these needs, the banking sector is utterly absent from discussions and seems almost entirely oblivious to RETs, restricting itself to providing financing for conventional consumption items, which are rarely available in rural areas. Consequently, there is a need for consumer credit schemes to fund the purchase of domestic RETs: this means opportunities are ripe for the banking sector to broaden their business.

The banking system at present, however, features a number of obstacles that would need to be overcome, including:

- Shortage of expertise for assessing RET projects;

- Poor understanding of investment opportunities in the rural energy sector;
- Exaggerated conception of risk of renewable energy projects

It is clear then, that the absence of a tangible operational framework sustains significant barriers to the development and perpetuation of RETs.

7 - Conclusions and recommendations

The numerous experiences amassed in relation to RETs bears testament to the fact that suitable technologies are available, that there is local management capacity, and that the socio-economic conditions for the dissemination of these technologies are relatively well understood. The technologies diffused can be placed in five main categories -- solar PV, solar thermal, wind, biomass energy, and hydroelectricity – for use in the following diverse applications: lighting, drawing water, conservation and processing of agricultural products, and household and community cooking.

Over the last two decades, a number of projects have been executed in West Africa demonstrating that it is possible to adapt RETs to the local environment. However, the effectiveness of these projects on the fight against poverty was undermined by the fact that they seldom took any account of local development needs and priorities. Instead, they placed emphasis on technical and technological aspects, as if projects were merely an extension of laboratory research.

However, one positive aspect of the experiences is that they proved that technologies are mature and that there are potentially positive impacts on poverty reduction. Both for social services (health, education, drinking water) and for income generating activities, RETs have shown that, without being a mere panacea for development, they can play an important role in achieving the Millennium Development Goals for poverty reduction.

From a technical, organisational and financial point of view, significant strides were made, making it possible to envisage the extension of RET dissemination not on a project-by-project basis but rather through an integrated programme for fighting poverty. This entails transcending the sectorial approach where energy is seen not simply as another sector like education, health and agriculture, but where synergies are cultivated through a multisectoral approach. To achieve this, all the various players active in the different sectors would have to engage in consultations to build concerted and coherent actions that would optimise the use of resources and amplify the impacts of programmes aimed at countering marginalisation and exclusion.

In short, at a time when RETs are mentioned in all energy policies, the combat against desertification, overall environmental protection, sustainable development, the millennium development goals, and the fight against poverty, it is of paramount importance to apply ourselves to the following recommendations:

At the institutional and policy level: Undertake the formulation and implementation of a coherent operational framework that would meet the stakeholders' technical, economic and financial needs. This framework involves three parts:

- The first is the development of an "energy reflex" whereby local planners – especially in countries where decentralization is underway – would better be able to integrate energy technologies with other priority areas such as health, education, water, and agriculture.

- The second is a clearer articulation of intervention mechanisms in renewable energy. Currently, the actors in this domain -- be they national and regional institutions or individual projects and programs -- do not operate in a manner that can take advantage of the synergies that exist between disparate initiatives. Thus, a multisectoral approach would allow a more cohesive and integrated diffusion of RETs in the overall process of development.

- The third favours local production of RETs and the involvement of the private sector and banks.

In sum, establishing a coherent framework would mean the creation of a mechanism with expertise in energy, in charge of renewable energy and energy efficiency. This is as important as, for instance, rural electrification agencies created after reforms in West African countries that intervene principally in a downstream manner (e.g. selection of areas for electrificaiton, monitoring and evaluation of projects). Given that the responsibility of increasing the rate of rural electrification lies with these agencies, their priority is mainly to install electricity-producing devices. The installation of devices that are non-electricity producing such as solar thermal devices, wind pumps, energy efficient technologies, etc. are not at the top of their mind even though they are important.

At the technological level: Implement technical standards and labelling of RETS for the West African sub-region via the work of research institutes. The process of standardization of technologies would take place according to the technical specialization of the country.

At the financial level: Create financing opportunities and mechanisms (promotion funds, credit lines, etc.) for developing RETs. Such a mechanism would work through calls for proposals. From the supply side, micro-enterprises that supply energy services in rural areas, similar to those envisaged by the African Rural Energy Enterprise Development (AREED), should be favoured. On the demand side, incentives should be provided for the use of RETs (i.e. subsidies), and awareness -raising activities and anything else needed for opening the RET market should be promoted

At the information and communication level: Exchanges should be organised at the national, sub-regional and local levels -- this approach is currently lacking. Stakeholders in the development arena as well as consumers at all levels should be sensitised to the advantages of RETs in their various contexts. The net outcome of this action would be the accumulation of experiences that would allow a comparative evaluation of what has been done and of all the technological options.

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APPENDIX

APPENDIX A: evaluation of RET use in West Africa

Amount of PV in selected West African countries in 1994

Country	PV power stations & electrification		Pumps		Communication systems		Refrigerators		Lighting kits	
	nb	kw	nb	kw	nb	kw	nb	kw	nb	kw
Burkina	-	-	80	135	98	138	30	24	450	18
Cap Verde	1	9	1	1, 6	-	-	-	-	-	-
Guinea B	-	-	3	-	-	-	14	-	>30	-
Mali	-	-	250	350	700	150	40	12	300	15
Mauritania	6	nc	2	nc	nc	nc	-	-	400	70
Niger	-	-	62	77	45	60	nc	-	nc	-
Senegal	8	45	53	117	nc	nc	nc	nc	864	43

Sources: Enda - UNID, 1994

Wind power in selected West African countries in 1994

	Number of systems introduced	
Country	**Windmills**	**Electric pumps**
Burkina Faso	>40	-
Cap Verde	>80	nc
Mali	169	2
Mauritania	>60	nc
Niger	37	nc
Senegal	>400	16

Sources: Enda - UNID, 1994

APPENDIX C : Capacity assessment

Stakeholder	Function/Activities	Capacity/status problems	Capacity Development Measures	Magnitude of CD Needs /Priority
1. Legislative authorities, elected officials	adoption of laws, monitoring and inspection of implementation	Weak knowledge of energy	information	High
2. Government macroeconomic and development planners	definition and planning of economic and financial policy, formulation of multi-annual investment programmes, financial and technical supervision of establishments and companies	No instinct to make policy coherent with that in other development sectors, little instinct to incorporate energy into development planning	information and awareness-raising	High
3. Government energy authority or ministry	formulation, planning, supervision and inspection of energy policy	Decision-makers lack information, do not take enough account of energy in their development policies	Improve coverage and quality of physical infrastructure, make more use of human resources, consolidate existing infrastructure and institutions	
4. Energy regulatory bodies	Responsible for regulating activities, handling applications for franchises or licences, ensuring compliance with rules of fair competition, setting specifications, identifying tariffs	Failure of privatisation of SENELEC		Medium
7. ASER	Providing technical and financial support to companies, informing partners, devising multi-annual development programmes, drawing up invitations to tender, support operators with project design, manage financing of electrification, provide commercial energy services	Fund-raising delays; lack of determination to secure energy efficiency	Set up new funding mechanisms, foster so-called 'spontaneous' and local initiatives, make use of renewable energy that do not generate electricity	Medium
9. Energy supply industry	Generate and transmit electricity, ensure customer safety, provide a quality service	Inability to meet demand, succession of negative earnings, failure to renovate existing equipment, inadequacy of technologies, RETs not harnessed enough	Build and develop transmission grids, enhance management efficiency, fund-raising	Medium
10. Entrepreneurs and productive industry	Supply energy to operators	Poor product design, no link with banking sector;	training	
13.Credit institutions	development of micro-credit	Insufficient knowledge of the sector, poor risk appreciation, lack of expertise for analysing RET projects	information, awareness-raising and training	High
14. Civil society/NGOs	Disseminate RETs, raise awareness, support state projects, conduct socio-energy studies	Lack of expertise, insufficient knowledge of RETs	Awareness-raising and training	High
15. Users	Equipment users	Lack of information and knowledge, lack of financial resources for	information, awareness-raising,	High

		making purchases	formulation of credit lines	
16. Energy specialists and consultant firms	Support operators, market studies, put forward standards	Lack of consultation and co-ordination		
17. Academia and research organisations	Carry out research & development	Weak human, technical and material resources, little attempt to cater to private demand, centres are remote and dependent on ministry of education	Resources, networking, interaction with markets	High
18. Training centre	Training technicians	Not enough decentralisation of training sessions, lack of contact with markets	support	Medium
19. Media	Informing	Lack of knowledge of the sector,	information and training	High
20. Associations and village groups	Distribute solar system, raise awareness, fit and maintain, serve as relays in the field	Lack of information on technological developments, low project design capacity, poor knowledge of policies, problems getting access to credit	Training in project design and management, micro-credit, information	High
21. The rural electrification fund	Subsidise operators, support measures	Lack of means	Financial resources	High

Apprendix D: Technical data of wind pumps

Depth (m)	Pump diameter (mm)	Tubing diameter	Litre per hour flow	Strainers diameter
0 – 5	180	2 " ½	9 000	2 " ½
6 – 10	160	2 " ½	7 000	2 " ½
11 – 15	150	2 " ½	6 000	2 " ½
16 – 20	135	2 " ½	4 800	2 " ½
21 – 30	120	2 "	3 500	2 "
31 - 40	100	2 "	2 500	2 "
41 – 50	85	1 " ½	1 800	1 " ½
51 – 65	75	1 " ½	1 200	1 " ½
66 – 80	65	1 " ¼	950	1 " ¼

Source: VEV

Appendix E : Summary of the principal characteristics of the solar power stations at Diaoulé and Ndiébel

Designation	Diaoulé	Ndiébel
Modules	A.E.G. PQ 10/40	A.E.G. PQ 10/50
Type	Poly - Sic	Poly - Sic
Number of modules	560	400
Module capacity	38,4 WC	50 WC
Installed capacity	21,5 kWc	19,8 kWc
Monthly production	2,100kWc	1,900 kWh
Batteries	300/690 Ah in 150 elements	100 V/690 Ah in 150 elements
Undulaters	20 kVA/220 V/50 Hz	15 kVA/220 V/50 Hz
Low voltage network	220V/50 Hz	220 V/50 Hz

Source : Centrales Solaires Photovoltaïques: Rapport Annuel d'Exploitation (1996)