



Energy Systems: Vulnerability – Adaptation – Resilience (VAR)

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Senegal



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Executive Summary

Senegal, Africa's most westerly country, is threatened with drought in its northern part, with coastal erosion and degradation of its natural resources. Our analysis of the Senegalese energy system has identified persistent environmental, technical and social vulnerabilities. The country's energy system is highly dependent on biomass and petroleum products, a situation compounded by the absence of efficient technologies and low density of distribution grid. In spite of a *Lettre de politique du secteur de l'énergie (LPDSE – energy policy letter)* which places greater focus on regulation and more use of new and efficient forms of energy, there is a lack of any regulatory framework for all available forms of energy and a systemic weakness of financial structures to support energy policy. This finding has allowed us to propose technical, financial, regulatory and institutional recommendations, which include:

- increasing storage capacities for petroleum products (gas, LPG and other hydrocarbons);
- creation of the reception infrastructure necessary to reduce supply costs, and adoption of clean technologies;
- increase resilience by introducing a financial system comprising local funds and incentives to use flexibility mechanisms for clean development;
- developing a regulatory framework to promote alternative and renewable energies that makes use of fiscal incentives and energy price regulation; and,
- re-structure the insurance system.

Moreover, in order to benefit from the additional energy potentially available in the sub-region, we recommend the development of grid interconnections for transmission of electricity, and exploitation of the hydroelectric potential.

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Acronyms and Abbreviations

Acronym/abbreviation	Meaning
ADETEL	Association de Défense de l'Eau, du Téléphone et de l'électricité
ASCOSEN	Association des Consommateurs Sénégalais
ASER	Agence Sénégalaise d'Electrification Rurale
ANSD	Agence Nationale de la Statistique et de la Démographie
CRSE	Commission de Régulation du Secteur de l'Energie
DE	Direction de L'Energie
DPEE	Direction de la Prévision et des Etudes Economiques
NDE	Non-distributed energy
LPG	Liquefied petroleum gas
GTI	Greenwich Turbine Inc
IPP	Independent Private Producer
PANA	Plan National d'Adaptation
UNDP	United Nations Development Programme
NMP	Non-metallic mineral products
SAR	Société Africaine de Raffinage
SENELEC	Société Nationale d'Electricité
EIS	Energy Information System
GT	Gas turbine

About the Author



An expert in Environment and on the Clean Development Mechanism (CDM), Mr Moussa Diop has a *DEA* (higher masters degree) in Economics, specialising in ‘analysis of the determining factors of energy poverty’, from the *Institut Africain de développement économique et de planification (IDEP* – African institute for economic development and planning) and a Masters in Environment from Cheikh Anta Diop University of Dakar (*IDEP*).

Trained by *Électricité de France (EDF* – French national power company) in power plant operation, his first post was at Belfontaine, in Martinique, where he was manager of plant water treatment and chemistry. He then became Environmental Engineer for Senegal's *Société nationale d'électricité (Senelec* – power company). He also participated in implementation of the Environment Code in 2001 and in the diagnostic environmental analysis of Senegal's energy sector.

As a member of the *Comité National du Changement Climatique (COMNAC* – national climate change committee), Mr Diop was a participant in the *Plan National d'Adaptation (PANA* – national adaptation plan) and assessed all of the CDM projects relating to energy in Senegal, as well as validating the Energy Information System (EIS). He also has experience of sustainable development and environmental issues relating to energy policy, notably within the framework of Senegal's energy management programme.

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Country Overview

Geography and Climate

Senegal is located on Africa's west coast. With a surface area of 196,722 km², Senegal has 700 km of coastline and is bordered by four other countries: Mali to the east, Guinea and Guinea Bissau to the south. The Gambia, apart from its coastline, is surrounded by Senegal. Senegal is relatively flat, with the exception of the Fouta Djallon highlands near the border with Guinea.

Senegal's climate is characterised by an alternating dry season, from November to mid-June, and a rainy season from mid-June to October. Average rainfall is 1,500 mm in the south of the country, spread over four months and 400 mm in the north, concentrated into one and a half months. The climate is however, somewhat erratic, which has a direct effect on agricultural activities, livestock farming and the agri-food industry, thereby affecting the country's ability to maintain sustained economic growth. Senegal is amongst the countries with the greatest amount of sunshine hours: around 3,000 hours per year.

The main known and exploited extractable resources include phosphate and limestone in the Thiès region and gas in the Diamniadio region.

Economic Situation

Senegal has a population of 11,519,226, of which 51.9 percent is female (ANSD, *Démographie du Senegal*, 2007). Around 40 percent of the population lives in urban areas. The population growth rate is 3.1 percent per year. The six principal ethnic groups are the Diolas, Malinkés, Peuls, Sérères, Soninkés and Wolofs, but there are others (Kobianas, Manjack, etc.)

Real growth in GDP was estimated to be 4.8 percent in 2007, mainly resulting from the dynamism of the tertiary sector, against 2.3 percent in 2006 (DPEE, 2008). The level of activity for the population was 43 percent in 2005–2006, with urbanisation rate of 40.7 percent.

Education—based on the 2000 ten-year plan, completed in 2004—aims to reduce inequalities in access that are based on gender or housing environment (rural, peri-urban or urban). The ten-year plan for education makes schooling obligatory up to the age of sixteen. A new educational link has been forged by the inclusion of infants and the setting up of several regional schools with local catchments.

Senegal's health system ranks 59th for overall performance (4th in the Africa region), according to the WHO. Its organisation is based on a three-tier, pyramidal structure:

- A first line: made up of 50 health districts with 55 health centres which are points of referral for 768 health posts that are focal points for 551 rural

maternity units and 1,384 municipal health units. In theory, the health centres correspond to district hospitals but a lack of technical capacity means that they cannot fulfil their role as referral centres.

- An intermediate level: consisting of 10 regional hospitals in the 'health' regions and 2 departmental (county) hospitals.
- The national level: with 7 national hospitals.

At national level, malaria is the reason for 35 percent of medical consultations, and diarrhoea related illnesses 5 per cent. Malaria accounted for 27 percent of morbidity in 2005, indicating an inadequacy in the area of health education and a lack of health information.

Environmental issues are:

- Strong pressure on forests to satisfy energy needs, weakening of rural systems marked by an annual loss of 80,000 ha of forest. More than 400,000 ha of land suitable for agriculture were affected by bush fires in 2006.
- Increased vulnerability of coastal areas resulting from the high density of economic and other human activities, accentuated by coastal erosion and silting.
- Other issues are inadequate management of the urban environment, with failure to respect areas to be left unoccupied in order to preserve the ecological balance (Niayes, coast, other low-lying lands); obsolescence of the automobile fleet, (this have been alleviated to some degree by a ban on the introduction of private passenger vehicles more than five years old); and non-compliant industrial emissions.

For these reasons, Law N°2001-01 of 15 January embodying the Environment Code, Decree N°2001-282 of 12 April 2001 enacting the Environment Code and the Orders on atmospheric pollution, notably Order NS05-062, all aim to improve management of industry's emission levels.

In the livestock farming sector the head count is around 13,904,845, of which 9,461,567 are small ruminants. Livestock farming accounts for 3.7 percent of GDP, with around 3 million head of cattle. Fifty-six percent of households have livestock.

In the agricultural sector rainfed crops predominate, which remains a cause for concern given the vagaries of the climate and rainfall deficit experienced in recent years. Agriculture employs around 50 percent of the population and its contribution to GDP increased from 20 percent in 1965 to 17.3 percent in 1979 then to 9 percent in 2004. This weak agricultural performance has led the government to promote irrigation and modernisation of crops. Agriculture is practiced with a potential soil resource of 3.8 million hectares, i.e. 385 ha per 1,000 inhabitants, (PANA, 2006).

The surface area used for cereal growing is around 1,068,876 ha, of which 686,892 ha are for millet, 155,919 ha for sorgho, 80,312 ha for rice and 143,769 ha for maize. Groundnut growing occupies 595,000 ha of sown land (ANSD, 2007).

In terms of predominant exports, Senegal produced 331,181 tonnes (in 2007) of groundnuts for oil, a 33 percent reduction in relation to the average over the past five years. Cotton production was 45,138 tonnes, equivalent to the average for the past five years. This reduced production explains the decrease in agriculture's contribution to the Senegalese economy (5.2 percent of GDP in 2007, against 8.1 percent in 2005).

Political and Administrative Situation

Senegal has 14 administrative regions, a refined version of a configuration outlined at independence in Law 60-015 of 13 January 1960. Decentralisation, implemented since 1964, was reinforced in 1990. It confers full independence and local management powers on elected councillors, including some powers that were formerly the responsibility of the central government. Since decentralisation, the role of representatives of the central authority has been to monitor legality.

Senegal has set up institutions intended to guarantee a state that is subject to the rule of law. The constitution enshrines independence of the magistrates and courts, inviolability of personal rights and the inalienable nature of the right to defence.

There are currently some eight political parties, the main ones being: *PDS*; the *parti libéral*, of which Mr Abdoulaye Wade (President of the Republic) is National General Secretary; the *Parti socialiste (PS)*, formerly in power; the *Alliance des Forces de Progrès (AFP)*; the *LD/MPT*; the *Parti International du Travail (PIT)*; *AJ/PADS*; *Rewmi* and *URD*.

To ensure good management of the nation's affairs, Senegal has bodies directly or indirectly responsible for controlling public finances and related bodies such as the *Inspection Générale d'Etat* (state inspectorate) and *Cour des Comptes* (audit commission).

The government's strategy to attain its objectives to defeat poverty is based, partly, on the promotion of decentralised rural development that will involve all of the stakeholders and on sectoral programmes developed by the State. The strategy is developed around the principles of local responsibility, transparency and co-management of community investment in terms of both implementation and maintenance.

The strategy is based on: i) refocusing of the development process on local populations and local authorities, and ii) supporting rural development at the grassroots level.

Energy Policy

Since 2003, the focus of Senegal's energy policy has been on the contribution that the energy sector can make to provision of basic 'social' services, implying education, health and water. These are seen as fundamental elements of the campaign to increase wellbeing and eradicate poverty, while taking into account environmental issues and

with an overall eco-development approach. There are three dimensions of energy policy:

1. Social: widening access to modern forms of energy, especially electricity, in rural areas as a lever to combat poverty.
2. Economic: establishing stable levels energy supply, production and distribution with a view to the country's long-term interests.
3. Environmental: given the fragility of the country's ecosystem, preservation of the environment is at the core of domestic energy management strategies and of consolidation of the sustainable management of ligneous resources by inculcating greater responsibility on the part of local authorities.

The main thrusts of the strategy are as follows:

- Restructuring of the electricity sub-sector: *SENELEC*, the national electricity company, is responsible for transmission and wholesale of electricity, and operation of its generating plants. *SENELEC* can participate alongside independent power producers in calls for tender for the construction of new generating plants. It alone is authorised to transmit electricity over the national interconnected grid (IG) within the perimeter of its concession. The evolving regulatory framework will lead to the emergence of other players generating for *SENELEC* as the sector develops.
- The development of rural electrification: by setting up of a rural electrification agency (*ASER*) with a remit to provide access to electricity for 3.8 million rural-dwelling Senegalese or 365,000 rural households before 2015, against 102,000 rural households at present.
- Development and organisation of the oil sector and increasing of storage and refining capacities.
- Sustainable management of domestic fuels.
- Energy management, via a better policy on energy efficiency and demand side management by *SENELEC*.

General Country Statistics

Table 1: General situation

Basic statistics	Value	Year
Physical area (km ²)	196,712	2008
Cultivated areas (in ha)	2,817,927	
as % of total area of country	19	
% cultivated for domestic purposes use (less than one hectare)	24.6	
Area cultivated for export (ha)	1,303,42.2 ¹	
Population		
Total population (# of inhabitants)	1, 894,343	2007
% of which is rural	59.3	
% of which is under 5 years old	14.7	
Population density (inhabitants/km ²)	58.36	2007
Economically active population (total)	4,411,000	2002
as % of total population	44.75	
female (%)	43.30	
male (%)	56.67	
% Population economically active in agriculture	73.09	2002
female (%)	48.01	
male (%)	52.01	
Economy and development		
Gross Domestic Product (GDP) (in billions current dollar)	8.2	
value added in agriculture (as % of GDP)	5.2 ²	
GDP per capita	914	
Balance of trade (USD)		
% change from 1990 to current year	30.8	
Human Development Index (and ranking)	0.499	2007
Ranking	156	
Human Poverty Index (and ranking)		2007
%	42.9	
Ranking	97	
Environmental sustainability index	nd	
GHG emissions, in GHG CO _{2eg}	9,572.7	
Access to potable water (less than 500 metres) (as %)	90	2004
Infant mortality	61 in 1,000	2004
Literacy		
as % of total population	48.8	1992
female (%)	28,2	2004
male (%)	49.1	2004

Source: (ANSD, 2007; UNDP, 2007; DSRP, 2006)

¹ Summary of cash crops.

² Agriculture made a negative contribution to growth in GDP in 2007, 1.3 points less than in 2006.

Identification of Relevant Vulnerabilities and Associated Indicators

Vulnerabilities are analysed below from the environmental, economic, technical and social points of view and from that of overall governance in the energy sector.

Environmental Vulnerability

Deforestation

The country is faced with unmanaged use of its forest resources and with over-grazing. Recent estimates indicate 6.3 million hectares of natural forest currently exist, against 11 million hectares in 1960. This represents a loss of almost half of the forest in 40 years. More than four million cubic metres are taken from forests each year to meet the need for fuelwood. This does not include exploitation of the mangrove forests.

Biodiversity

The main threats to biodiversity are drought and bush fires which destroy vegetation cover and alter soil structures. Moreover, Senegal is facing over-exploitation of its fisheries as well as proliferation (on the Senegal River) of invasive plant species that have colonised some 1,200,000 m² of water bodies. Loss of wetlands is also observed, resulting from development of peri-urban areas, growing at seven percent per year.

Coastal Erosion

Coastal erosion is observed in all towns along the coast: for example, the town of Saint Louis is experiencing severe erosion of 1.2 m per year (Niang-Diop, 1995). The Langue de Barbarie spit, responsible for the southward deviation of the Senegal River, has been breached seven times between 1850 and 1900 (CSE, 2005). The coast, with its 300 km of sandy beaches, 234 km of mangrove estuaries and 174 km of rocky coastline, is threatened by erosion with around 73 km of vulnerable coast faced with sediment deficit and strong swells.

Pollution

In Dakar, wastewater is discharged untreated into the receptor environments: the Bay of Hann is an example. Other forms of pollution are heavy metals and household waste (the lack of engineered landfills is a public health issue, notably at the MBeubeuss dump).

Dependence on Biomass

The population's high dependence on biomass to meet energy service needs is pushing back the vegetation cover. More than four million cubic metres are taken from forests each year to meet needs. The energy balance indicates that biomass accounts for around 57 percent of primary energy supply. It represents some 45 percent of the country's final energy consumption.

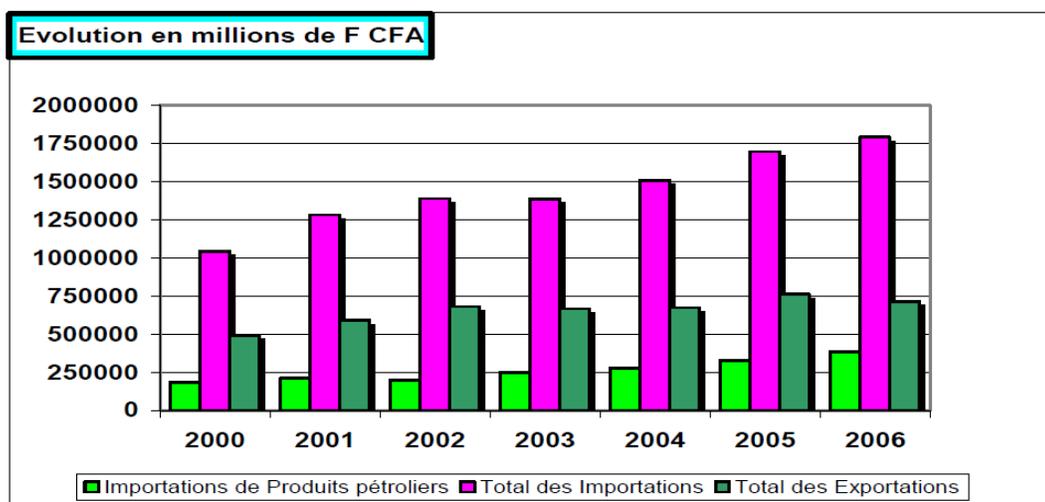
In 2000–2006, a policy designed to introduce butane gas into households had the effect of conserving tens of thousands of hectares of forest (50,000–2,000,000 ha).

Economic Vulnerability

The petroleum product imports/all imports ratio varied between 17.7 percent and 21.4 percent in the 2000–2006 period. The petroleum product imports/all exports ratio went from 37.4 percent in 2000 to 53.7 percent in 2006. More than 46.3 percent of export receipts were used to cover Senegal's petroleum product supply. The cost of importing crude oil and finished products, which was FCFA217 billion³ in 2003, reached FCFA353 billion in 2006, an increase of 52 per cent, for a 6 percent change in demand.

In summary, the country's level of energy dependence, expressed by the ratio between the production of primary energy and the total available primary energy is 42 per cent. Excluding biomass, this remains very low since Senegal imports almost all of its modern energy sources.

Figure 1: Senegal's oil bill and volumes of imports and exports



Source: SIE 2007

Evolution en millions de FCFA = Change, in millions of FCFA; Imports de produit pétroliers = Imports of petroleum products; Total des importations = Total imports; Total des Exportations = Total exports

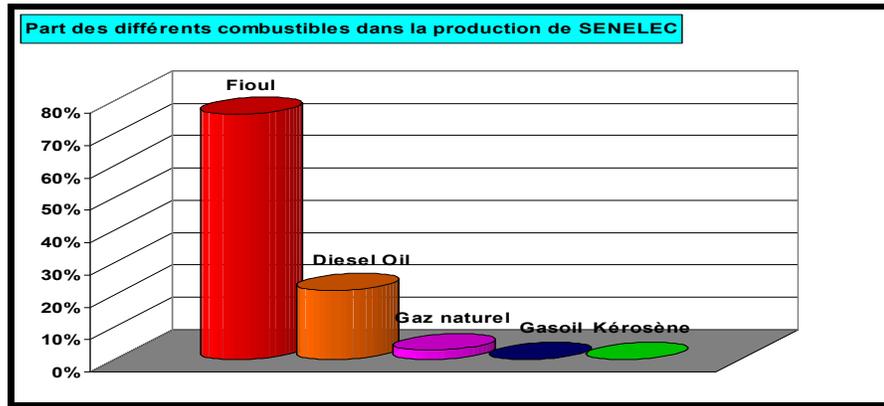
The large gap between the total of imports and the lower total of exports is accentuated by imports of petroleum products.

Technical Vulnerability

The absence of diversification of energy sources, especially for electricity generation is a key vulnerability factor. Ninety percent of electricity is generated in thermal plants and 10 percent by hydropower. Consumption of renewable energy accounts for less than 1 percent. The weakness of the electricity generating infrastructure is an additional factor.

³ Approximate conversion is 1USD = 440FCFA

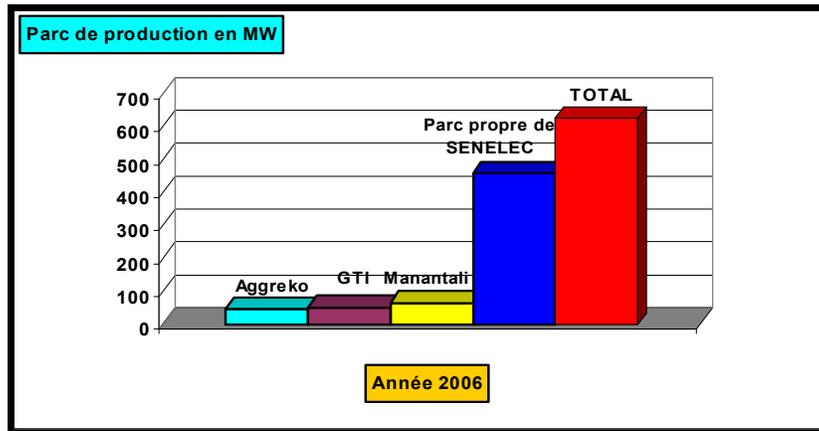
Figure 2: Fuels used by the generating installed base



Source: SIE 2007

Part des différents... = Share of different generating fuels used by SENELEC; Fioul = fuel oil; Gas naturel = natural gas; Kerosène = Kerosene; others ditto

Figure 3: Electricity generating installed base



Source : SIE 2007

Parc de production en MW = Installed base, in MW; Parc propre de SENELEC = SENELEC clean energy base

The electricity generating installed base consists, essentially, of thermal plants. Any structural disruption has repercussions for almost all of the plants. Only the Manantali dam produces renewable energy and, is subject to rainfall fluctuations. Table 2 shows the breakdown of installed capacity and rated power and representing the energy capacity of the production unit in terms of its efficiency and availability.

Table 2: Breakdown of installed capacity per type of plant in 2005 and 2009

Type of plant	2005		2009	
	MW	%	MW	%
Steam	138.7	24.7%	87.5	12.6%
Diesel	208.3	37.0%	407.85	58.8%
Gas turbine (GT)	97.3	17.3%	80.5	11.6%
GTI combined cycle (IPP)	52	9.2%	52	7.5%
Manantali hydropower	66	11.7%	66	9.5%

Source: SENELEC, 2009

In 2005–2009, the installed capacity of the *SENELEC* base underwent a change. It was oriented towards a consolidation of private sector generating—of which the total installed capacity accounted for 26.7 per cent—and a clear reduction in the contribution of hydroelectricity. As a result hydroelectricity production decreased from 11.7 per cent to 9.5 per cent, thereby increasing the share of fossil fuels in the mode of production. Consequentially the generating base has become even more dependent on imported petroleum products.

Social Vulnerability

The poor level of access to modern energy services and low levels of energy consumption (0.2 toe/per capita) and the resultant energy poverty are the major characteristics of Senegalese households. Access to electricity is guaranteed for only a little over 44 percent of households (SIE, 2006). In urban areas, 77 percent of households have access to electricity, whereas in rural areas only 16 percent of households can use this form of energy. Other factors that constitute barriers to the country's ability to emerge, such as the low level of citizens' participation in decision making and corruption, are also observed.

Institutional Vulnerability

There are numerous institutions involved in the energy sector. However, there are many obstacles and problems relating to the sector's regulation and overall governance. In spite of important reforms made in the sector, the delay in implementing reforms already engaged is particularly noticeable (LPDSE, 2008).

- Creation of the *Agence Senegalaise de l'Electrification rurale (ASER* – Senegalese rural electrification agency) which speeded up access to electricity in rural areas (target of 50 percent by 2015). *ASER's* aim is to promote rural electrification by providing electricity sector companies and private individuals with the technical and financial assistance required to support their initiatives in the private sector.
- Setting up of the *Commission de Régulation du Secteur de l'Electricité (CRSE* – electricity sector regulating committee), with a view to establishing conditions for opening of the generating market and for healthy competition, follows on from the need for regulation of the sector and is also in response to the strong pressure of consumer groups on *SENELEC's* tariffs.
- Creation of the PETROSEN company which gave the State increased control of the *Société Africaine de raffinage (SAR* – African refining company), by becoming the major shareholder, and allowed development of exploration in the sedimentary basin.

However, it should be noted that projects for generating of electricity from renewable resources are held back by lack of the regulatory framework that has been under preparation since 2007.

Measurement of Current Vulnerability Levels

Environmental

Indicator 1: Change in rainfall pattern

Year	Average rainfall, in mm
1990	750
2007	675
Change in rainfall between 1990 and 2008	-11%

Source: Service météorologique (Dakar)

Senegal experienced heavy rains in 2005 causing numerous floods in a number of Senegalese towns, and notably in the suburbs of the capital. Research by Gaye and Malou indicate a 5 to 25 percent decrease in rainfall. Changes in rainfall patterns are characterised by a meridional distribution of relative decreases in rainfall. Dryness will increase more in the south than in the north, regardless of sensitivity. Decrease in rainfall will be more pronounced in the south-west (-17 percent with sensitivity 2.5°C) whereas it will be less perceptible in the north-west. (Gaye C. B. 1986; Malou R., Dacosta H. et al. 1999)

There are two alternating seasons in Senegal: a rainy season, from June to October, with higher rainfalls from the south to the north; a dry season from November to May, with temperatures between 22 and 30°C. Average annual rainfall follows an increasing slope from the north to the south of the country, going from 300 mm in the semi-desert north to 1,200 mm in the south, with variations between years. Rainfall variation is more accentuated in the Sudan-Aahelian climate zone. Average annual rainfall of 1,000 to 1,500 mm/yr in the Sudan climate zone allows growing of rice and of some cash crops.

Indicator 2: Temperature variations

Year	Average temperature
1990	28.1°C
2008	28.7°C
Increase between 1990 and 2008	% increase/decrease
0.6°C	+ 2.09%

Source: Service météorologique (Dakar)

Average temperatures are around 28°C with extremes as high as 45°C in eastern Senegal and 20°C on 'La Petite Côte'. This variation is accompanied by 3,000 hours per year of insolation, amongst the highest in the world.

At the Saint Louis coast, Dakar, the trade winds blowing along the coast reduce the temperature. In Dakar, the average diurnal maximum is 24°C from January to March and between 25 and 27° C in April, May and December. Temperatures reach 30°C

from June to October, while in southern Senegal the lowest average diurnal temperature is around 24°C; in October, December, February and April, however, the maximum temperatures are between 26 and 30°C.⁴

Economic

Indicator 1: Access to electricity

Level of electrification

	1990	2000	2001	2002	2003	2004	2005	2006
Overall level of electrification (%)	ND	30%	32%	33.5	35%	37.5%	40%	44%
Rural electrification (%)	ND	9%	10%	11%	12%	13%	14%	16%
Urban electrification level (%)	ND	58%	60%	63%	65%	71%	74%	77%
Variation between 2000 and 2006		14%						

Source: SIE 2007

In all, access to electricity is only available to around a little more than 44 percent of Senegalese households. In urban areas, 77 percent of households have access to electricity, whereas in rural areas this is the case for only 16 percent of households.

Indicator 2: Level of increased energy autonomy

Importing and consumption of non-renewables

	1990	2000	2007
Total of imports of non-renewables, ktoe	ND	1,513	2,061.2
Total energy consumption, ktoe	ND	1,949.9	2,656

Source: SIE 2007

Senegal is approximately 23 percent energy independent although if biomass is included this independence increases to 45 percent

Technical

Indicator 1: Amount of energy supplied by renewables

Energy source (ktoe)	1990	2000	2006
Biomass (ktoe)	ND	53.60	58%
Hydroelectricity	ND	0	1%
Solar	ND	0.07	0.01%
Wind	ND	0%	0%
Other	ND	0%	0%

Source: SIE 2007

⁴ www.arcmad.ne

Excluding biomass, hydroelectricity accounts for around only 1 percent of energy produced. Solar systems have been in use by *SENELEC* since 1983, to provide for rural electrification.

In some parts of Senegal solar energy production helps to increase the level of rural electrification from 6 percent to more than 25 per cent; it has allowed the level of rural electrification to be brought from 13 percent to 16 per cent.

Indicator 2: Level of diversity of renewable energy sources and technologies

Excluding the Manantali hydropower scheme, the source for renewable energy within the framework of *ASER's* activities is solar. However solar's contribution remains very low due to the lack of efficient technologies: there is very little solar equipment and solar power accounts for a mere 0.01 percent of supply. Wind/solar projects are under way and there is an intention to make use of the Clean Development Mechanism (CDM).

Social

Indicator 1: Change in prevalence of diseases

Patter of waterborne diseases

Disease	1990	2003		2004		2005		2006		2007	
	ND	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Cholera		48	4%	261	3%	23 325	5%	Nd	nd	nd	nd
Dysentery				nd	nd	303	1%	Nd	nd	nd	nd

Source: Annuaire statistique du Ministère de la Santé du Senegal

Cholera is the most common diarrhoea related disease in recent years. The country has experienced epidemics, but the sensitivity of the disease explains the lack of data after 2006. Dysentery has all but disappeared.

Indicator 2: Changes in employment

Economically active population

	1990	1991	2002
Percent age of population economically active	ND	31.01(%)	44.75%
Percent age of women economically active	ND	45%	43.3%
Percent age of men economically active	ND	55%	56.67%

Source : ANSD – RGPH3-2002

According to the *Agence nationale des Statistiques* (national statistics agency), in 1988, there were 100 economically active people for 103.3 economically inactive persons. Population projections indicate that this will decrease, with 84 inactive people for every 100 who are economically active expected by 2008, dropping to 81 for 100 in 2012.

Civil (Governance)

Indicator 1: Farmers owning or having access to land

Changes in farming in Senegal

	1990	1994	2002	Difference	%
Agricultural households (number)	ND				
Agricultural population (number)	ND	2,720,000	3,224,000	504,000	15.7%
Total population (inhab)	ND	8,137,000	9,855,000	1,718,000	17.43%

In 1994, agricultural activities occupied 33.4 percent of the population; in 2002 this figure had decreased significantly to 32 percent in relation to total population, as a result of the strong rural exodus towards the capital city. This trend should be reversed under recent policies and plans introduced by the public authorities. These programmes aim to create a national dynamic for a mass return of people to the land and for their support, so as to stimulate agricultural activities by hydro-agricultural development programmes, institutional support, rural infrastructure development and prevention and management of crises.

Indicator 2: Change in public participation in planning process

The majority of Senegal's population does not participate in the decision making process, limiting the possibilities for approval of development projects by the targeted beneficiary populations. However, since introduction of the Environment Code, in 2001, environmental impact assessments (EIA) are an obligatory part of the project planning process and introduce inevitable and exclusive participation by the public.

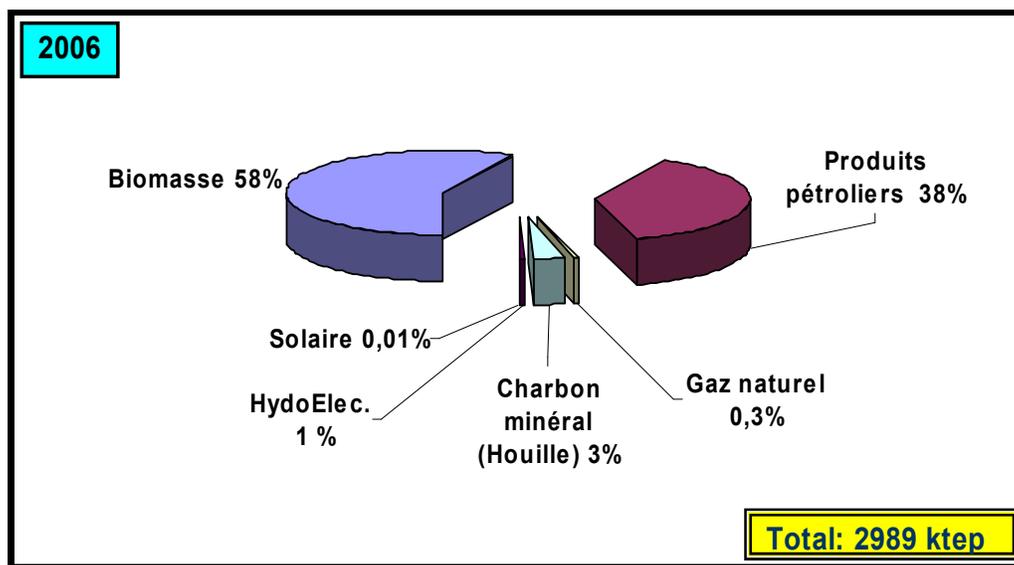
Senegal's Current Energy Situation

The New Energy Policy is based, essentially, on the aim of ensuring Senegal's energy supply, under optimum conditions and at lowest possible cost, for households and the major sectors of the economy, while widening the population's access to modern energy services (DE, 2008).

Energy Analysis

Energy Demand

Figure 4 illustrates the predominance of biomass over other forms of energy, explained by the fact that most consumers are rural and meet their energy needs from the forest.

Figure 4: Domestic supply per energy type

Source : SIE-Senegal 2007

Biomasse = Biomass; Solaire 0,01% = Solar 0.01%; HydroElec. = Hydro; Charbon minéral (houille) = Coal (bituminous); Gaz naturel 0,3% = Natural gas 0.3%; Produits pétroliers = Petroleum products; Total: 2989 ktep = Total: 2,989 ktoe

The Manantali dam, common to Mali, Mauritania and Senegal, produced 234 GWh in 2006, i.e. around 10 percent of Senegal's production of electricity.

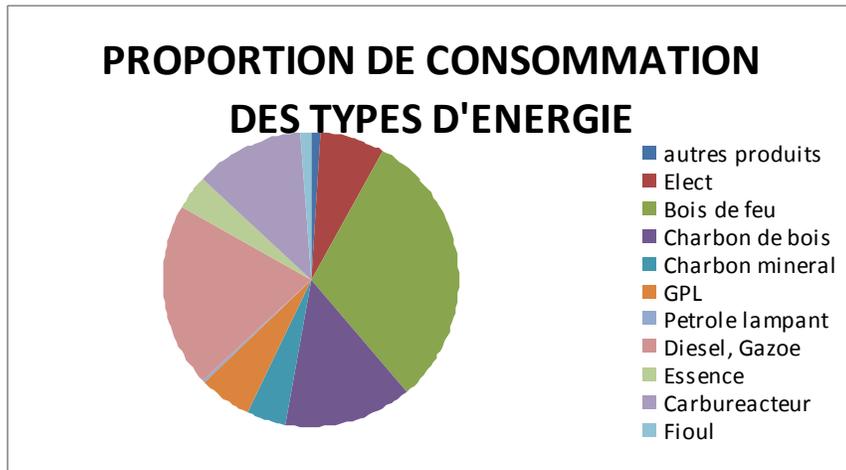
Electricity is generated mainly from thermal sources, using fossil fuels, with a total supply capacity of 2,439 GWh. This dependence makes the sectors an easy target during fluctuations in international hydrocarbon prices and exchange rates. This is compounded by the rise in petroleum consumption by *SENELEC*, which amounted to nearly 500,000 tonnes and equal to around 49 percent of national demand in 2006.

Refinery production has been slowed by frequent stoppages of industrial activity: as a result the amount of crude oil refined has reduced significantly and power plants are obliged to turn to international sources of supply and thus face higher costs.

Energy Consumption

Senegal's final energy consumption went from 1,972 ktoe in 2005 to 2,303 ktoe in 2006. Consumption of biomass and of hydrocarbons still predominates, accounting for 45 percent and 44 percent respectively. The share of electricity is seven percent and that of coal has risen to four percent because of consumption by cement plants. Final per capita consumption for the country's inhabitants is 0.2 toe. This is illustrated in the chart found in Figure 5, below:

Figure 5: Final energy consumption, per energy type



Source : SIE 2007

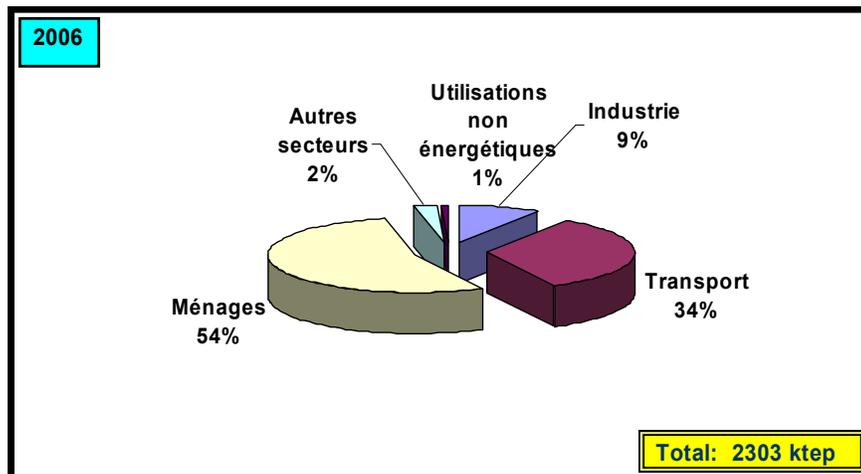
Proportion de consommation... = Proportion of consumption per energy type; autres produits = other products; Elect = Electricity; Bois de feu = Firewood; Charbon de bois = Charcoal; Charbon mineral = Coal; GPL = LPG; Pétrole lampant = Lamp oil; Diésel, Gazole = Diesel; Essence = Gasoline; Carbureacteur = Jet fuel; Fioul = Fuel oil

The same observation for biomass which predominates in final consumption over petroleum products in particular; this situation is due to supply and distribution constraints.

Final Consumption by Sector

Most of the modern energy consumed is used by households (54 per cent), by transport (34 per cent) and by industry (9 per cent). These proportions are the result of exclusive household consumption of firewood and charcoal. Both of these fuels are often used for cooking. Lamp oil is used for lighting in peri-urban and rural areas. The household sector consumes 54 percent of the energy produced in the country and, in particular, 70 percent of the low-voltage electricity.

Figure 6: Consumption pattern per sector



Source : SIE 2007

Autres secteurs = Other sectors; Utilisations non énergétiques = Non-energy uses; Industrie = Industry; Transport = Transport; Ménages = Households

The household and transport sectors rank first for distribution and, together, accounted for 83 percent of total final energy consumption in 2005. The residential sector is predominant in the structure of final energy consumption, with 54 per cent, followed by transport, accounting for 34 percent of total consumption. The predominance of the residential sector arises from its consumption of virtually all of the ligneous fuels to meet household energy needs.

If conventional forms of energy (excluding biomass) are considered, transport is in first place in the sectoral breakdown, with a share of 56.6 per cent. High energy consumption in the transport sector is explained by the predominance of road transport which accounts for more than 50 per cent.

In the industry sector, non-metal mineral products, mainly from cement plants, account for more than 50 percent of consumption.

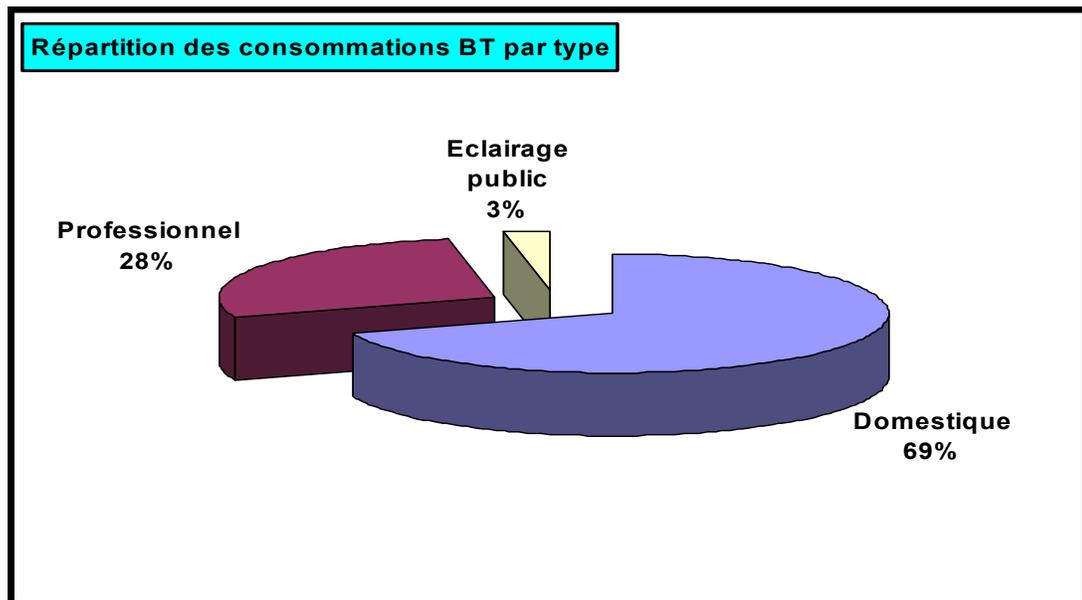
Electricity Consumption

The purpose of the transmission grid is to carry high-voltage electricity (90 and 225 kV) from the generating plants to centres of consumption. In Senegal, the transmission grid comprises a national and a supranational grid.

The national grid extends over 327.5 km of 90 kV lines with only eight 90/30 kV substations with a total installed capacity of 1,127 MVA.

The supranational grid has 945 km of 225 kV lines and three 225/30 kV substations. The medium-voltage lines, and those for distribution, extend over 6,761 km.

Figure 7: Low-voltage distribution



Source: SIE 2007

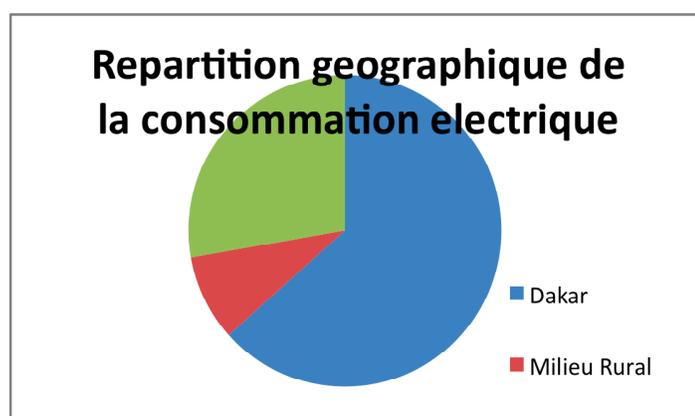
Répartition des... = LV consumption by type; Professionnel = Professional; Eclairage publique = Street lighting; Domestique = Household

Table 3: Breakdown of electricity in urban areas

Urban areas	2000	2001	2002	2003	2004	2005
Dakar	65.9%	68.0%	70.1%	72.3%	75.4%	78.6%
Diourbel	57.9%	60.0%	62.6%	63.1%	65.3%	67.6%
Fatick	44.1%	46.8%	53.0%	55.3%	62.5%	68.0%
Kaolack	52.6%	55.5%	58.8%	59.2%	67.7%	72.3%
Kolda	36.8%	39.8%	42.3%	42.9%	50.6%	54.0%
Louga	54.8%	56.5%	59.6%	61.7%	74.6%	77.9%
Matam	19.8%	22.1%	23.6%	40.8%	53.0%	57.8%
Saint Louis	55.6%	57.1%	58.9%	59.7%	66.0%	68.3%
Tambacounda	44.6%	46.1%	48.2%	51.4%	54.8%	58.6%
Thiès	50.0%	51.9%	56.8%	59.4%	71.7%	76.3%
Ziguinchor	31.7%	34.9%	38.8%	41.5%	47.0%	51.9%
Senegal	58.0%	60.1%	62.9%	65.1%	70.6%	74.1%

Source: SIE, 2006

Urban centres have greatest coverage, especially the capital Dakar where the average level of coverage (78.6 percent) is above the national average for urban areas which is 74.1 percent. This observation figures in the framework of the geographical breakdown of electricity consumption in urban and rural areas.

Figure 8: Geographical breakdown of electricity consumption

Source : Thioye, 2005

Repartition ... = Geographical breakdown of electricity consumption; Milieu rural = Rural areas

SENELEC's electrification programme covers 28 percent of Senegal's households. The focus is mainly on urban areas, to the detriment of the rural zones. Urban centres are better covered, especially the capital, Dakar.

Organisation of the Sector and Related Energy Policy

In terms of laws governing the sector, the ministry responsible for energy is preparing and implementing a general sector policy established by the President. The main missions it defines are to:

- establish the sector's legislative and regulatory framework;

- develop the general sector policy, including the overall framework for tariffs;
- carry out global sector planning and set specific targets for electrification in a *Plan National d'Electrification* (national electrification plan); and,
- promote rural, peri-urban and urban electrification and (in collaboration with the ministry responsible for finance) establish the government's contributions and loans for rural, peri-urban and urban electrification.

The *CRSE*, an independent authority, was created by Law n° 98-29 of 14 April 1998 on the electricity sector, amended by Law n°2002-01 of 10 January 2002. It has the following remit:

- to promote rational development of available electricity supply;
- to monitor the economic and financial balance of the electricity sector and preserve its economic conditions;
- to ensure conditions of financial viability of the companies in the electricity sector;
- to promote competition and private sector participation; and,
- to look after consumers' interests.

ASER's mission, in compliance with the requirements of Article 30 of Law n°98-29 of 14 April 1998, is to promote rural electrification by providing electricity sector companies and private individuals with the technical and financial assistance required to support their initiatives in the private sector.

ASER develops rural electrification programmes on the basis of a plan established by the ministry responsible for energy.

Organisation of the Electricity Sub-sector

Under current legislation, generating, transmission and wholesaling are handled by *SENELEC* which continues to operate its generating plants and can participate, alongside independent power producers, in calls for tender for building of new electricity generating plant. *SENELEC* alone is authorised to transmit electricity over the national grid and to distribute and sell it within the perimeter of its concession. However, it should be noted that other players will appear as the sector develops. These will be independent rural operators acting outside of the *SENELEC* perimeter.

Percent age Contribution to the Energy Mix

Biomass accounts for the highest percent age of the energy mix: 58 percent. Recent disruption in the availability of LPG and severe fluctuations in the price of the barrel of oil have significantly altered the mode of consumption of households and of industry, and have also influenced the availability of energy from *SENELEC*.

Table 4: Contribution of each system to the energy mix⁵

Source	2006
Biomass	58%
Petroleum products	38%
Coal (bituminous)	3%
Hydroelectricity	1%
Natural gas	0.3%
Solar	0.01%
Wind	0%

Energy Systems

Biomass

Biomass consists, mainly, of charcoal and firewood. No biomass is used, however, to generate electricity (0 per cent). All of the biomass consumed is used to produce heat: 1,733.6 ktce consumed in Senegal in 2007.

The strong pressure on forests has resulted in 3,937,500 m³ of fuelwood being taken from them, causing degradation of 16,0817 ha of forests and producing 6,700,757 tonnes of firewood.

The lack of efficient technology for final use of biomass also explains its predominant position in the country's final energy consumption, where it accounts for around 45 per cent.

Table 5: Biomass consumption in urban and rural areas

Area	Firewood (%)	Charcoal (%)
Urban Dakar	2.5	8.3
Other towns	31.6	21.3
Urban areas	15.0	13.9
Rural areas	81.9	8.4

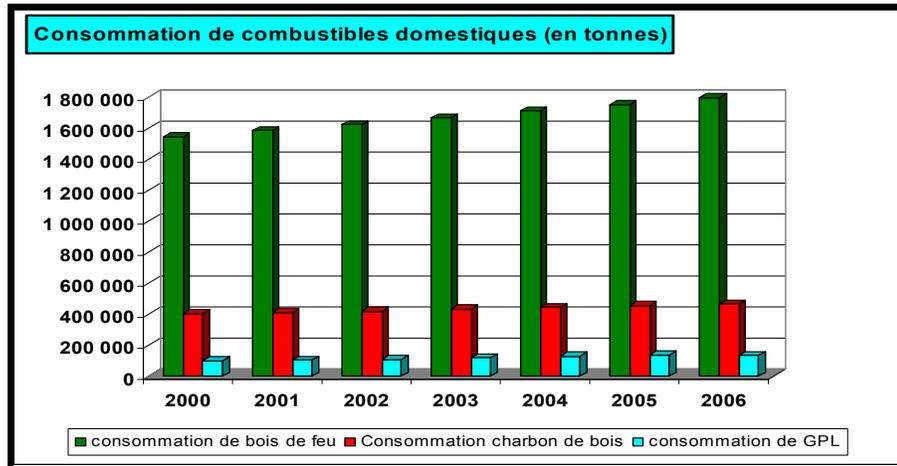
Source: DE 2005

Six times as much firewood is consumed in rural areas than in urban ones. However, this ratio is reversed for charcoal, a more modern energy source.

The rate of increase in biomass consumption has been attenuated by use of LPG. Around 160,000 tonnes of this fuel were used in 2007. LPG is, however, consumed mainly in urban centres.

⁵ Data from SIE Sénégal, 2007

Figure 9: Household fuel consumption



Source: SIE 2007

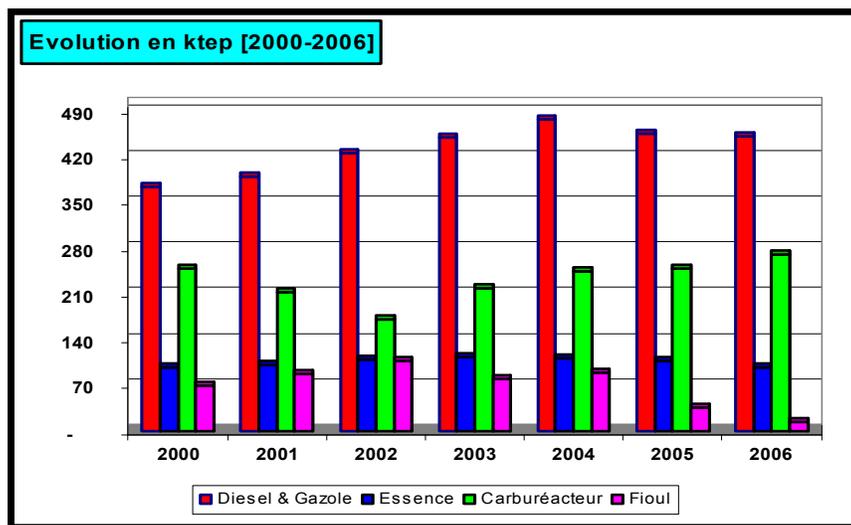
Consommation... = Household fuel consumption (in tonnes); Consommation de bois de feu = Firewood consumption; Consommation de charbon de bois = Charcoal consumption; Consommation de GPL = LPG consumption

Petroleum Products

SAR produces diesel, gasoil, gasoline, jet fuel, lamp oil and butane gas from the petroleum products imported. SAR's maximum refining capacity is 1,200,000 tonnes for a sub-regional need of 3,600,000 tonnes per year, of which 1,600,000 tonnes cover Senegal's domestic market needs.

The infrastructure to receive and handle petroleum products remains under-developed and storage capacities are insufficient. The security stock is below the national strategic level. Involvement of private operators in storage activities has not increased the level given the scale of investment required. The storage question has spurred the government to consider the creation of a new storage centre to meet the requirement for hydrocarbon supply security.

Figure 10: Change in consumption patterns of fuels



Source: SIE 2007

Evolution en ktep [2000-2006] = Change, in ktce [2000-2006]; Diesel & Gazole = Diesel and gasoil; Essence = Gasoline; Carburacteur = Jet fuel; Fioul = Fuel oil

Increase in the petroleum product supply level is closely linked to the electricity and transport sectors.

Electricity System

Senegal's electricity generating system includes: thermal power plants run by *SENELEC*; independent power producing plants; the Manantali hydroelectric scheme; and, systems belonging to independent generators such as Suneor. The main mode of production is thermal mostly using imported fossil fuels. Only 10 percent of production is hydroelectric (utilising dam system common to Mali, Mauritania and Senegal), providing 234 GWh, of energy in 2006.

The overall available electricity supply increased from 1,519 GWh to 2,036 GWh between 2001 and 2006 which is an average increase of between 6 and 7 percent per year. The figure was 2,439 GWh in 2008, of which 2,192 GWh were delivered by *SENELEC*. However, between 2005 and 2007 the increase was hampered by difficulties with hydrocarbon supplies as a result of the high price per barrel and inadequate storage capacity, while electricity demand grew at a rate of 8.4 percent per year.

This increased demand accentuates the problem of maintenance of generating units which disrupts the machines' running cycle and affects efficiency. Of the 459 MW of installed capacity, only 335 MW are available because of obsolescence of some facilities and maintenance constraints. This explains the significant share of independent production: 27 percent of installed capacity is needed to compensate for the energy deficit. *SENELEC*'s energy purchases amounted to around 446 GWh, equivalent to 21.2 percent of the energy carried by its grid.

With annual consumption of almost 500,000 tonnes of petroleum products, *SENELEC*'s needs represented around 49 percent of national demand in 2006. To meet this energy challenge, a project for a coal-fired plant with an installed capacity of 125 MW has been developed (with the support of the World Bank) as far as the post EIA phase.

Most of the country's hydroelectricity is from the Manantali hydropower plant, which is equipped with five 40 MW generators each able to produce an average of 807 GWh of energy per year. Since July 2002, the hydro scheme has been connected to the IG via a 945 km long 225 kV HV line. With around 200 to 270 GWh of energy delivered to Senegal per year, Manantali has made a considerable contribution to improving the quality of distribution and lowering the cost of electricity.

Solar Energy

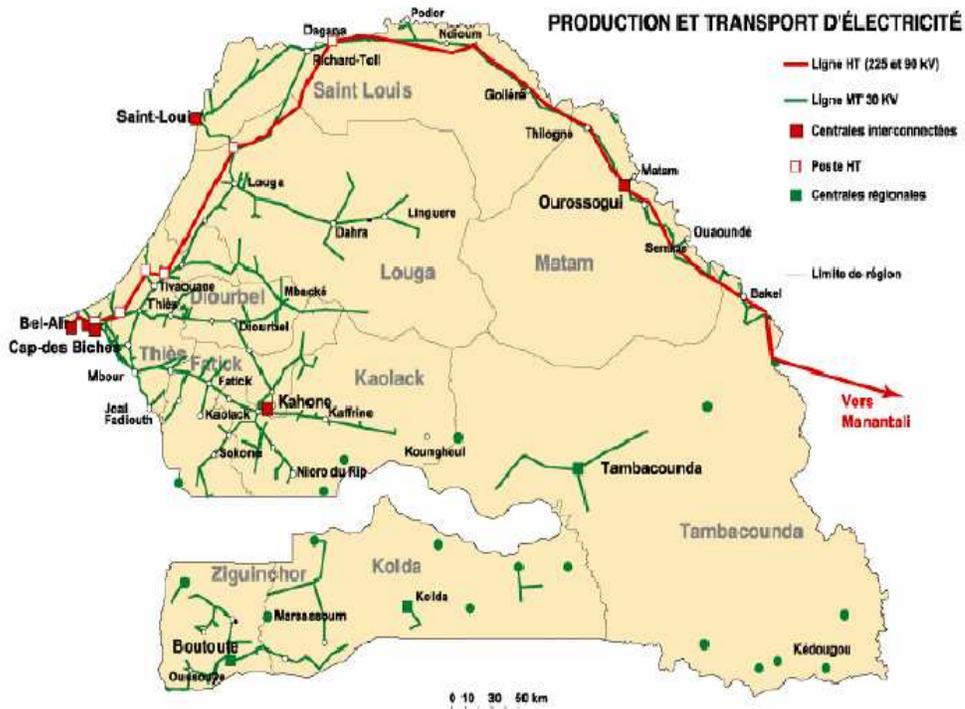
There are fairly large solar plants in some regions of Senegal: the overall level of electrification of the region (solar and conventional) is 25.6 percent. In fact, the region is a showcase for rural electrification using solar power as, in 2004, it benefited from provision of 10,000 solar home systems each of 50 Wp in 297 villages, in addition to the building of nine 10 to 40 kWp solar plants in nine villages with a mini LV grid.

Configuration of the National Energy System

Table 6: Contribution of each System to the Energy Balance

Energy System	Aspects	Share	Breakdown
Biomass	Final consumption per type of energy	45%	Firewood 31% Charcoal 14%
	Energy demand	58%	
Petroleum Products	Internal supply per type of energy	38%	
	Final consumption per type of energy	44%	Diesel and gasoil 20% Gasoline 4% Jet fuel 12% Fuel oil 1% Other petroleum products 1%
Electrical energy	Final consumption per type of energy	7%	
Other petroleum products	Final consumption per type of energy	10,3%	Coal 4% LPG 6% Lamp oil 0.3%
	Internal supply per type of energy	3.3%	Coal 3% Natural gas 0.3%
Renewables	Internal supply per type of energy	1.01%	0.01% (solar) 1% (hydroelectricity)

Figure 11: Location of Senegal's power plants



PRODUCTION ET TRANSPORT D'ELECTRICITE = ELECTRICITY GENERATING AND TRANSMISSION; Ligne HT (225 et 90 kV) = HV lines (225 and 90 kV); Ligne MT 50 kV = 50 kV MV line; Centrales interconnectées = Interconnected plants; Poste HT = HV substation; Centrales régionales = Regional power plants; Limite de région = Regional boundary; Vers Manantali = To Manantali

Energy System Vulnerability

Vulnerability Indicator	Calculation
Coal	
<p>1. Number of coal mine plants located at less than 1 metre above sea level and within the area that could be flooded by a flood with a current recurrence period of 100 years</p> <p><i>Senegal has no coal mines; all of the coal used is imported by maritime transport.</i></p>	0
Oil and gas	
<p>1 Share of offshore oil and gas installations likely to be hit by a storm of more than 70 m/s gusts within the next 20 years (%)</p> <p><i>There are no offshore installations in Senegal.</i></p>	0
<p>2. Share/number of refineries likely to be hit by a storm of more than 70 m/s gusts within the next 20 years (%)</p> <p><i>There is one refinery: SAR (Société Africaine de Raffinage) at the entry to Dakar, not far from the coast in an area not exposed to storms.</i></p>	0
All fossil fuels	
<p>1. Number of thermal (coal, oil and gas) power plants located at less than 1 metre above sea level and within the area that would be flooded by a flood with a current recurrence period of 100 years</p> <p><i>The Cap des Biches plant, on the Petite Côte at Rufisque, is subject to flooding.</i></p> <p><i>The Kahone thermal plant has already suffered flooding⁶ after heavy rain⁷. A coal-fired plant to be built at Sendou, on the Petite Côte, is in the environmental impact assessment phase.</i></p>	03
Nuclear	
<p>1. Number of nuclear power plants located at less than 1 metre above sea level and within the area that would be flooded by a flood with a current recurrence period of 100 years</p> <p><i>Senegal is planning to generate electricity from a civil nuclear programme, in line with a policy declaration of 2006.</i></p>	0
<p>2. Number of incidents/accidents since the plant was built</p> <p>2b. Describe the most significant incidents.</p> <p><i>No accidents. There are no nuclear plants in Senegal at present.</i></p>	0
Hydro	
<p>1. Expected precipitation change over the next 20–50 years (%) and/or probability of floods in each watershed</p>	-17%

⁶ Situation experienced by the author in 1999

⁷ www.unstats.org

Vulnerability Indicator	Calculation
<p>2. Number of multiple-use dams in the country today</p> <p>--Volume of water (m3) of each dam</p> <p>b. Describe what % of the water is used for::</p> <p>--Agriculture</p> <p>--Energy</p> <p>--Drinking</p> <p><i>The Manantali dam has a capacity of 11.5 billion m³. The Diama dam is an anti-salt structure.</i></p> <p><i>(An anti-salt dam prevents seawater from flowing inland and making land unusable for agriculture. However, it also allows dual crop irrigation. The dam can be opened and closed: in high-water periods it is opened to allow normal river flow, in low-water periods it is closed to prevent inflow of saltwater.)</i></p>	<p>2</p> <p>Nd</p> <p>Nd</p> <p>Nd</p>
<p>3. Additional information: Expected additional run-off from glacier melting (million m³)</p> <p><i>Senegal is in the Sahel region. It is not concerned by issues of melting glaciers.</i></p>	<p>0</p>
<p>Transmission and distribution indicators</p>	
<p>1. Length of in-country, above-ground transmission and distribution lines (km)</p> <p><i>The purpose of the transmission grid is to carry high-voltage electricity (90 and 225 kV) from power plants to the centres of consumption. In Senegal, the transmission grid includes a national and a supranational grid.</i></p> <p>1b. Distinguish between (2 sub-indicators)::</p> <p>High (transmission).....</p> <p>Middle voltage lines.....</p> <p>Low voltage lines distribution.....</p> <p><i>Of which 439 km are under-ground lines and 6,322 km of overhead lines:</i></p> <p><i>610 km of bare wire</i></p> <p><i>5,711 km of pre-assembled cables</i></p>	<p>327.5 kms</p> <p>6,827 kms</p> <p>6,761 kms</p> <p>3,511 MV/LV substations and 13 30/6.6 kV sub-stations</p>
<p>1c. Describe any transnational lines</p> <p><i>The transnational grid will comprise:</i></p> <p><i>225 kV Manantali-Matam-Dagana-Sakal-Tobene line.....</i></p> <p><i>The Matam-Dagana-Sakal substations.....</i></p>	<p>945 kms, 03 225/30 kV sub-stations</p>

Vulnerability Indicator	Calculation
<p>2. Number and length of power cuts (differentiate between failures due to weather or equipment failure and those cuts due to rationing)</p> <p>2b. Average hours of interruption per year</p> <p><i>For transmission and distribution, quality of service between 2005 and 2008 was characterised by an increasing number of incidents and resulting non-distributed energy (NDE).</i></p> <p><i>In 2007, the NDE resulting from lack of production (rationing or load reduction)</i></p> <p><i>Rationing because of fuel shortage</i></p> <p><i>NDE:</i></p> <p><i>Number of incidents involves all voltages, showing a rise</i></p> <p><i>For NDE, following development up to 2008:</i></p> <p><i>--On the Dakar grid, especially on the 6.6 kV grid, a number of disruptions due to incidents:</i></p> <p><i>This period corresponds to years of severe rationing due to lack of production and several cable faults</i></p> <p><i>--On the 30 kV grid, between 2005 and 2008, number of interruptions due to incidents almost doubled</i></p> <p><i>--Average increase rate in failures in 6.6 kV and 30 kV grids:</i></p> <p><i>--High-voltage grid, number of interruptions due to incidents:</i></p> <p><i>See Annex 4 for a table showing changes in incidents between 2005 and 2008.</i></p>	<p>2006: 87.5 GWh, 2007: 58 GWh</p> <p>i.e. -32 %</p> <p>-64 %</p> <p>2006-46 GWh 2007-17 GWh</p> <p>2006-3,979 2007-6,810 i.e. +71%</p> <p>2005: 6.236 GWh 2008: 10.372 GWh I.e. + 66%</p> <p>2005: 587 2008: 1,792</p> <p>2005: 1,257 2008: 2,219</p> <p>2005: 16% 2008: 17%</p> <p>2005: 150 2008: 126 I.e. -16%</p>
<p>3. Percent age of energy supply requiring regional transport over 50 km</p> <p><i>10 percent of electrical energy from Manantali hydroelectric scheme</i></p>	<p>36.66%</p>

Vulnerability Indicator	Calculation
3b. % that is transportation of fossil fuels Fossil fuels: --Total installed capacity for fossil fuel energy production in 2009..... --Total installed capacity, all types of energy --With rated fossil energy power	90.8% 592.84 MW 658.84 MWh 548.78 MW
3c. % that is transportation of biomass Biomass --Share of power produced from biomass.....	0% 0 MW
Biomass	
1 Proportion of biomass used for energy purposes (%) in total biomass production <i>All of the biomass is used to produce heat, i.e. 45 percent of 2,303 ktoe consumed in Senegal in 2006.</i> <i>Percent age of biomass used to generate electricity is zero (0%).</i>	45%
2 Expected precipitation change over next 20–50 years (%) <i>In the PANA Senegal study, the south will dry more than the north, for all sensitivities. Reduced rainfall will be felt more in the south-west (-17 % with sensitivity 2.5°C); it will be less perceptible in the north-west.</i> <i>Recent analysis of the rainfall base for the eastern transect (Malou R. 2002; Malou R. 2004) has allowed establishment of future bases for rainfall variability in the east of the country (Kolda and Bakel weather stations) where models predict greatest change. Two phases in the country's past climate change are indicated:</i> <i>A first phase (1) from the beginning of the century to the 1960s/70s. This corresponds to a certain stability in rainfall although marked by greater year-on-year variability. The curve of weighted moving averages over years is stationary, oscillating around a value close to 1,200 mm in the south (Kolda) against 500 mm in the east (Bakel). This is a period that can be considered as a wet climate baseline with regard to subsequent rainfall changes.</i> <i>The second phase (2) extends from the 1970s to the 1990s. It is a period of climatic instability, strongly marked by a continuous decline in rainfall levels. It sought a prolonged drought in the Sahel leading to the current hydrological deficit.</i> <i>A third phase (3), the existence of which it is still a little premature to affirm, but seemingly distinct from the 1990s. Should it persist, it will be the prelude to a period of abundant rainfall, which would tend to confirm the rainfall cycle. The evolution of this last phase is important for the next decades. It should allow significant progress in modelling of the climate process. In the event of a return to normal rainfall level, the trend would be towards establishing rainfall cycles for which it would be important to determine the period. A relatively large reduction in rainfalls in the south of the country is observed.</i>	+17% ⁸

⁸ McSweeney country profiles

Vulnerability Indicator	Calculation																					
Additional information: probability of temperature increase beyond biological heat tolerance of key biomass crops within the next 20 years (%)	+2.06%																					
Wind																						
1. Number of wind turbines less than 1 metre above sea level <i>There are currently no wind turbines in Senegal. A project for a 15 MW farm, near Saint-Louis (northern Senegal) is being studied.</i>	0																					
2. Projected change of average windspeed in the next 20 years based on regional climate models (%) <i>There is a wind map for the north coast, indicating the existence of a wind potential with windspeeds varying from 6 m/s⁹</i> <i>There is a similar project at Gandon (northern Senegal). A 10 MW installation is planned.</i>	nd																					
Solar																						
1. Capacity of solar installations already in place (m ²) (photovoltaic)	2315,06 kWp ¹⁰																					
<table border="1"> <thead> <tr> <th>Type of equipment</th> <th>Installed capacity kWp, 2005</th> <th>Year 2006</th> </tr> </thead> <tbody> <tr> <td>PV plants</td> <td>350</td> <td></td> </tr> <tr> <td>PV pumping</td> <td>393.2</td> <td></td> </tr> <tr> <td>Community systems</td> <td>270.86</td> <td></td> </tr> <tr> <td>Private systems</td> <td>841</td> <td>145</td> </tr> <tr> <td>Telecommunications</td> <td>315</td> <td></td> </tr> <tr> <td>Total</td> <td>2,315.,06</td> <td></td> </tr> </tbody> </table> <p>Source: Enda, 2007</p> <p><i>The total solar PV installed capacity is 2.3 MWp i.e. a penetration ratio of 0.47 in relation to the total installed capacity of the publicly-owned generating base.</i></p> <p><i>Thermal solar: use not yet widespread in Senegal.</i></p>	Type of equipment	Installed capacity kWp, 2005	Year 2006	PV plants	350		PV pumping	393.2		Community systems	270.86		Private systems	841	145	Telecommunications	315		Total	2,315.,06		
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PV plants	350																					
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Private systems	841	145																				
Telecommunications	315																					
Total	2,315.,06																					
2. Expected temperature increase (°C) in the next 20 years (relevant for PV capacity)	6.11%																					
3. Additional information: projected change in rainfall and cloud cover over next 20 years (%)	14.5%																					

⁹ Source: ASER (*Atlas éolien de la grande cote du Senegal – Senegal coastal wind atlas*)

¹⁰ Source ASER 2007

Energy System Resilience

Capacity Indicator	Calculation
Implementation indicators	
1. Domestic capital formation (USD million per year)	2612 ¹¹
1b. Domestic savings (USD million per year)	813
2. Domestic investment in renewable energy (USD million per year) <i>For the entire country, in rural areas, there are 850 kWp of installed capacity controlled by ASER.</i>	0
3. Number of technical engineers graduating annually as a percent age of the total population <i>Senegal is accredited by UNESCO, in terms of numbers of engineers</i>	342/million inhabitants i.e. 0.04%
4. Availability of hazard maps for floods/droughts <i>There is a national geographical information system. Senegal has an Environmental Information System (EIS) in its Centre de Suivi Ecologique (CSE –environmental monitoring centre) managing a database of environmental statistics. The CSE has ecological maps and satellite photographs showing different types of vegetation and damage to the environment.</i>	Yes
5. Existence and enforcement of power plants siting and construction guidelines taking climate change into consideration <i>Most of Senegal's power plants are along the coast at Dakar and Cap des Biches located 25 km from Dakar. They are all threatened by coastal erosion and require protection. Regional power plants are supplied from boreholes and are far from the coast for two of the country's regions. It should, however, be borne in mind that the new plant at Kahone is located in inland Senegal at around 2 to 3 km from the arm of the sea at Kaolack and was flooded in 2001.</i>	Yes
6. Existence of emergency plans to react to meteorological extreme events and availability of local emergency repair teams. <i>A national emergency response plan ("plan ORSEC") has been in existence since 1993, covered by Decree 93-1288 of 18 November. A national plan for disaster management has been under preparation since 2007; it will replace the "Plan ORSEC."</i>	Yes
7. Domestic availability of insurance schemes.	No
8. Existence of citizens' users groups in the energy governance structure (enforcement of participatory decision-making) <i>Association for defence of Senegalese users of electricity and telephone (ADETEL) and Senegalese consumers association (ASCOSEN) These consumer rights organisations participate in orienting their members choices towards candidates whose programmes protect consumers. They calculate tariffs and conduct analyses of foods, with the assistance of laboratories, in order to verify compliance.</i>	Yes

¹¹ Source BCEAO, 2006

Capacity Indicator	Calculation
Coal, oil, gas, nuclear fuel sources	
<p>1. Existence and use of a siting map for mines and power plants taking into account projected storms, floods and drought areas</p> <p><i>Mining (for gold) started in the Kédougou region in 2008. There are maps showing the power plants throughout the territory.</i></p>	Yes
<p>2. Implementation of national regulations for thermal power plant siting at sites with sufficient cooling water availability over the next 50 years</p> <p><i>The regulations are based on Senegal's Environment Code (2001) including requirements for EIA and water policy. In Senegal, facilities classified for environmental protection are subject to licensing. Licensing is subject to there being a radius of at least 500 m around that is free of houses, buildings normally used by third parties or buildings receiving members of the public or areas used for housing or any water course, lake, communication channel or water abstraction point.</i></p>	No
Hydro	
<p>1. Existence of a national plan for optimised operation of hydro plants under projected flow regimes for systems</p> <p><i>The energy policy includes reinforcement of sub-regional cooperation (OMVS and OMVG) within the framework of promotion of hydroelectric plants in partnership with the Republic of Guinea for the future hydroplants at Félou, Gouina, Sambangalou and Kaleta, with respective installed capacities of 60 MW, 140 MW, 120 MW and 200 MW, between 2011 and 2013.</i></p>	Yes
<p>2. Number of dams equipped with desilting gates and/or number of upstream land use management and water catchment plans for each hydro installation</p> <p><i>A programme is planned for channelling and treatment of the water at the Manantali facility: rehabilitation work on the Manantali dam hydro-mechanical equipment and renovation of the water treatment plant. In addition, studies were conducted by OMVS on part of the valley where there were not, to date, any irrigation perimeters. They provided conclusions including some on the effect for recharging of the groundwater and effect on supply, serving as reference for refurbishment programmes.</i></p>	02
Biomass	
<p>1. Research, development and dissemination budget for heat and drought resistant crops, biofuels, agricultural* waste for energy and vulnerability of forest (USD million per year)</p> <p><i>The Institut Senegalais de Recherche Agricole (ISRA – Senegal agricultural research institute) is the centre handling research into crop varieties.</i></p>	USD14,910,047.78/yr (ISRA budget)
<p>2. In-country utilisation of biomass fuels not traditionally used by private enterprises and cooperatives (% of total fuels)</p> <p><i>Senegal does not yet have any biomass plant. However, a 20 MW plant is being constructed for gasification of typha, an aquatic plant invading the Senegal river.</i></p>	No

Capacity Indicator	Calculation
<p>3. % of households using improved woodstoves out of total number of households using woodstoves.</p> <p><i>27% of households use improved stoves. The Government of Senegal has overseen dissemination of 19 000 improved stoves (LPDSE 2003)</i></p>	27%
Wind	
<p>1. Existence and enforcement of national regulations requiring storm proofing of wind power plants to withstand highest anticipated windspeed</p> <p><i>A regulatory framework for renewables is being developed; it should foster the emergence of effective monitoring of regulation of wind power equipment being connected to the Interconnected Grid (IG)</i></p>	No
<p>2. Existence of siting maps that detail projected changes in windspeed, floodplains, and areas impacted by sea level rise</p> <p><i>In 2002, a wind atlas was produced of Senegal's northern coast for the ministry of energy. Average windspeeds are 4–6m /s. The national contingency plan, replacing the current emergency response plan, includes studies of natural disasters such as flooding, and of the areas where disasters might occur.</i></p>	No
Solar	
<p>1. Existence of a siting map that details projected changes in cloud cover</p> <p><i>There are maps showing projected cloud cover, indicating areas of heavy and light coverage</i></p>	Yes
<p>2. Existence and enforcement of national regulation requiring storm proof concentrating solar power plants (CSP) to withstand the highest anticipated windspeed</p> <p><i>There is no national regulation to be enforced. A regulatory and legal framework for promotion of renewables and for energy management is being developed.</i></p>	No

Conclusions and Recommendations

Energy is a cross-cutting sector. The energy crisis experienced by Senegal is proof of this. It has resulted in momentary paralysis of the services and household sectors which together consume more than 75 percent of the low-voltage electricity distributed. Moreover, current energy policy does not take adequate advantage of the country's energy potential—such as wind and solar. The high level of consumption of biomass (firewood and charcoal, external price shocks and the instability of the price of the barrel of oil) have all led to a precarious energy situation.

Using the two sets of HELIO indicators we have been able to determine Senegal's vulnerability and degree of resilience. The indicators have also made it possible to highlight the most relevant aspects of energy vulnerability:

- Environmental: relating to dependence on biomass (58 per cent).

- Economic: more than 53.7 percent of the country's export income is used to pay for petroleum product supplies.
- Technical: the mode of production of electricity is 90 percent thermal (lack of diversity in energy mix). This is compounded by the inadequate storage capacity due to both a lack of reception infrastructure for petroleum products and of refining capacity.
- Social: the population's low level of access to modern energy services and low energy consumption (0.2 toe). Where modern energy is concerned, there is also a concentration of infrastructure in the urban areas, to the detriment of rural and peri-urban areas.
- Institutional: there has been a failure to apply policies and measures to push forward energy development. Removal of the subsidy on butane could also overturn the vulnerability of the biomass sector. The regulatory framework for alternative forms of energy is not yet ready to allow exploitation of the potential of renewables. At current cost levels, it would require USD1 million to produce one megawatt of power from renewables, against USD0.3–0.5 million for thermal sources.

In real terms, the numerous economic, environmental, technical, social and civic vulnerabilities have weakened Senegal's energy system, as illustrated by the government's inadequate responses to 2003 to 2008 external shocks.

Recommendations for Policies and Measures (PAMs)

The following measures could increase the resilience of Senegal's energy system:

Environmental and Biomass

- Implement sustainable forest management by extracting energy from invasive plants and using them as cooking fuel in improved stoves, as well as by fostering participatory forest development.

Economic

- Promote local micro-financing schemes to finance solar systems for lighting, heating and air-conditioning in the household sector, which currently consumes 75 percent of the energy produced by *SENELEC*.
- Introduce a street lighting policy to use solar systems in 30 percent of rural municipalities and communities.
- Strengthen regional cooperation to exploit hydroelectric potential.
- Increase LPG and hydrocarbon storage capacities by building of the infrastructure required to bring about structural lowering of costs.

Production Sources

- Build impoundment reservoirs for dams in order to control water bodies and flood levels.
- Establish and update wind maps using a robust model for long-term forecasts.
- Reduce taxes on energy efficient appliances and solar equipment.
- Map the development of all fossil-fuel and hydroelectric plants, including private generating facilities, GTI and Kounoune Power.

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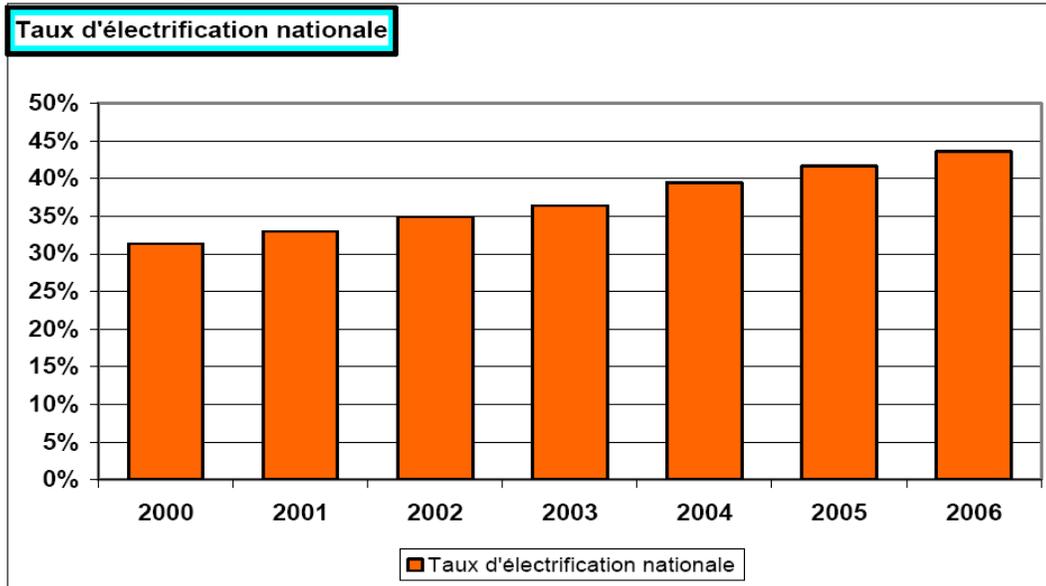
Annex 1: Rated power and installed capacity

Site	Plant	Generators	Date of installation	Type of fuel	Installed capacity	Rated power (gross) (MW)
Manantali	MANANTAL I-SEN	Manantali	2002		66	60
Bel-air diesel	C1 DIESEL	G105	1990	Fuel oil	5	0
		G106	1990	Fuel oil	5	4
	C6 Wartsila	G601	2006	Fuel oil	16.45	15.95
		G602	2006	Fuel oil	16.45	15.95
		G603	2006	Fuel oil	16.45	15.95
Cap des biches	C4 DIESEL	G401	1989	Fuel oil	21	18
		G402	1989	Fuel oil	21	18
		G403	1997	Fuel oil	23	18
		G404	2003	Fuel oil	15	15
		G405	2003	Fuel oil	15	15
St Louis	SAINT LOUIS	G82	1979	Fuel oil	3	2.5
		G83	1979	Fuel oil	3	0
Cap des biches	C3 STEAM	G301	1966	Fuel oil	27.5	20
		G302	1976	Fuel oil	30	18
		G303	1978	Fuel oil	30	20
Cap des biches	C3 TAG	TAG2	1984	Diesel	20	18
		TAG3	1995	Kerosene	24	20
Bel-air	C2 TAG	TAG4	1999	Diesel	36.5	30
IPP Kounoune	Kounoune Power	KP	2007	Diesel	67.5	67.5
Kahone	Kahone 2	G701	2008	Diesel	16.45	15
		G702	2008	Diesel	16.45	15
		G703	2008	Diesel	16.45	15
		G704	2008	Diesel	16.45	15
IPP Cap des Biches	GTI	GTI	2000	Naphta	52	50

Annex 2: Rural electrification

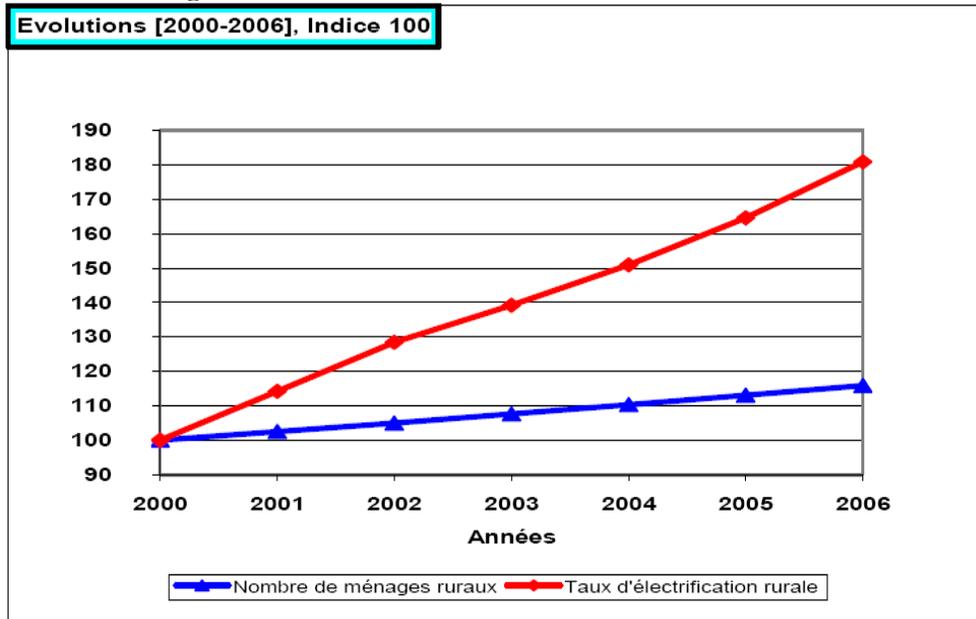
The tables below show the development of rural electrification levels between 2000 and 2006

Table 1: Changes in national electrification level

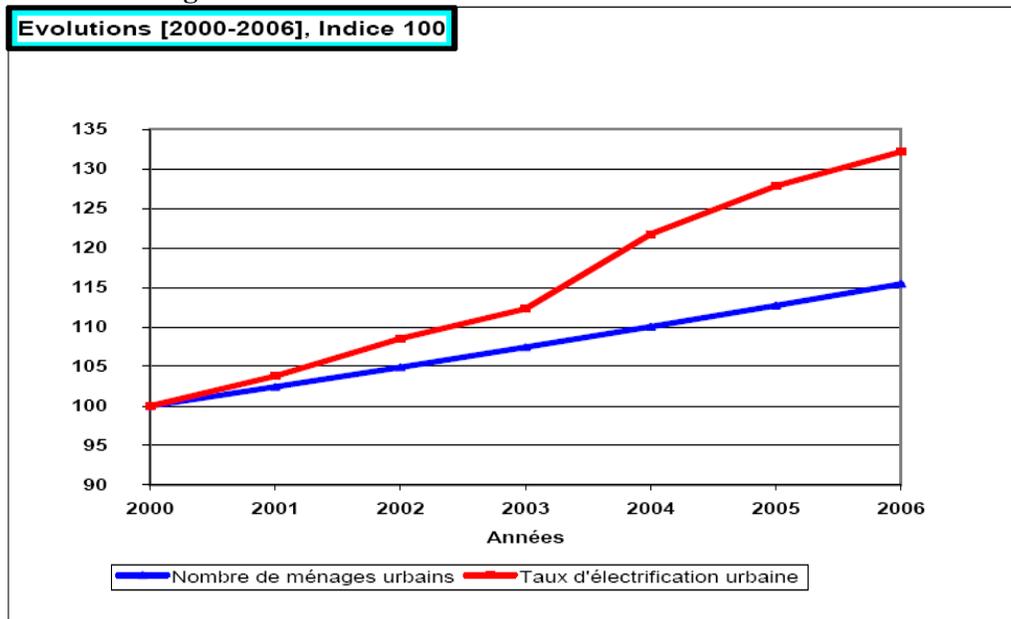


Taux d'électrification nationale = national electrification level

Table 2: Change in number of rural households and rural electrification level



Evolutions [2000-2006] Indice 100 = Change [2000-2006] Index 100; Nombre de ménages ruraux = Number of rural households; Taux d'électrification rurale = rural electrification level

Table 3: Change in number of urban households and rural electrification level

Evolutions [2000–2006] Indice 100 = Change [2000–2006] Index 100; Nombre de ménages urbains = Number of urban households; Taux d'électrification urbaine = urban electrification level

Increase in electrification levels relative to the number of households is more marked in rural areas (63 percent and 12 percent in 2006) than in urban areas (27 percent and 12 percent respectively in 2006).

Annex 3: Rainfall and temperature

Table 1: Average rainfalls (mm)

Moith	Dakar	St-Louis	Zig.
January	0	1	1
February	0	1	0
March	1	0	0
April	1	0	0
May	1	1	10
June	14	7	125
July	88	44	360
August	250	160	530
September	163	100	361
October	45	29	150
November	5	2	8
December	6	3	1

Table 2: Wverage rainfall at main measurement points in representative agro-ecological areas

Year	Height, mm
1990	750
1991	593
1992	576
1993	448
1994	554
1995	669
1996	642
1997	609
1998	593
1999	613
2000	849
2001	737
2002	658
2003	509
2004	762
2005	613
2005	750
2007	675

Table 3: Temperatures °C

Month	Dakar	Saint Louis	Ziguinchor
January	23	22	24
February	23	22	26
March	23	22	27
April	23	22	28
May	24	23	29
June	27	26	29
July	28	28	27
August	28	28	27
September	28	28	27
October	28	28	28
November	27	27	24
December	24	23	27

Annex 4: Power outages (2005 – 2008)

	2005		2006		2007		2008	
	No.	NDE (GWh)						
6.6 kV Dakar	587	720	664	1,615	2,093	2,737	1,792	2,330
30 kV Dakar	1,257	2,694	1,432	2,713	1,772	5,088	2,219	4,317
Sub-Total Dakar	1,844	3,414	2,096	4,328	3,865	7,825	4,011	6,647
6.6 kV Regions	316	264	40	55	89	129	29	54
30 kV Regions	1,669	2,371	1,331	2,552	2,151	4,571	2,644	3,508
Sub-Total Regions	1,985	2,635	1,371	2,607	2,240	4,699	2,673	3,563
90 kV	150	186	158	209	175	890	126	163
Total	3,979	6,236	3,625	7,144	6,280	13,414	6,810	10,372

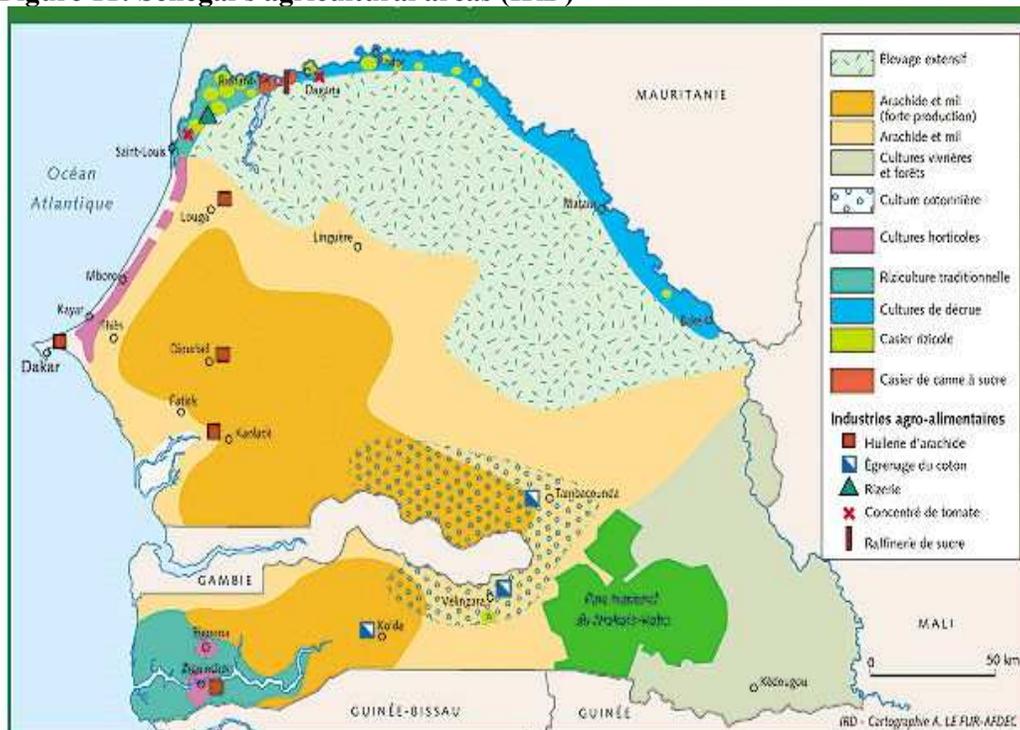
Annex 5: Agricultural vulnerability according to PANA Senegal, 2006

Vulnerability

Senegal has significant soil resources covering 3.8 million hectares, that is 385 ha per 1,000 inhabitants. These resources are far greater than the average for African countries and for the world: 86 and 73 ha per 1000 inhabitants respectively. Breakdown of the usable agricultural surface area per climate zone shows 437,000 ha, i.e. 11 percent of the area, in the zone with rainfall of less than 500 mm. These are the Fleuve and Niayes regions and the northern part of the Groundnut Basin and Ferlo region.

Agriculture is dominated by growing of groundnuts and millet in the Groundnut Basin, followed by extensive agro-pastoral activities in the sylvopastoral areas. There are then food-crop growing areas and forests of the south-east, flood-recession crops along the Senegal River valley and the cotton growing area running along the eastern half of the border with Gambia. Traditional rice growing is practiced on the slopes of the Casamance river basin and there are irrigation perimeters in the delta and middle valley of the Senegal river and in the Anambé basin to the south. Irrigated horticulture is practiced mainly in the Niayes areas.

Figure 11: Senegal's agricultural areas (IRD)



LEGEND

Elevage extensifs	Extensive livestock farming
Arachide et mil (forte production)	Groundnuts and millet (high level production)
Arachide et mil	Groundnuts and millet
Culture vivrières et forêts	Food crops and forest
Culture cotonnière	Cotton growing

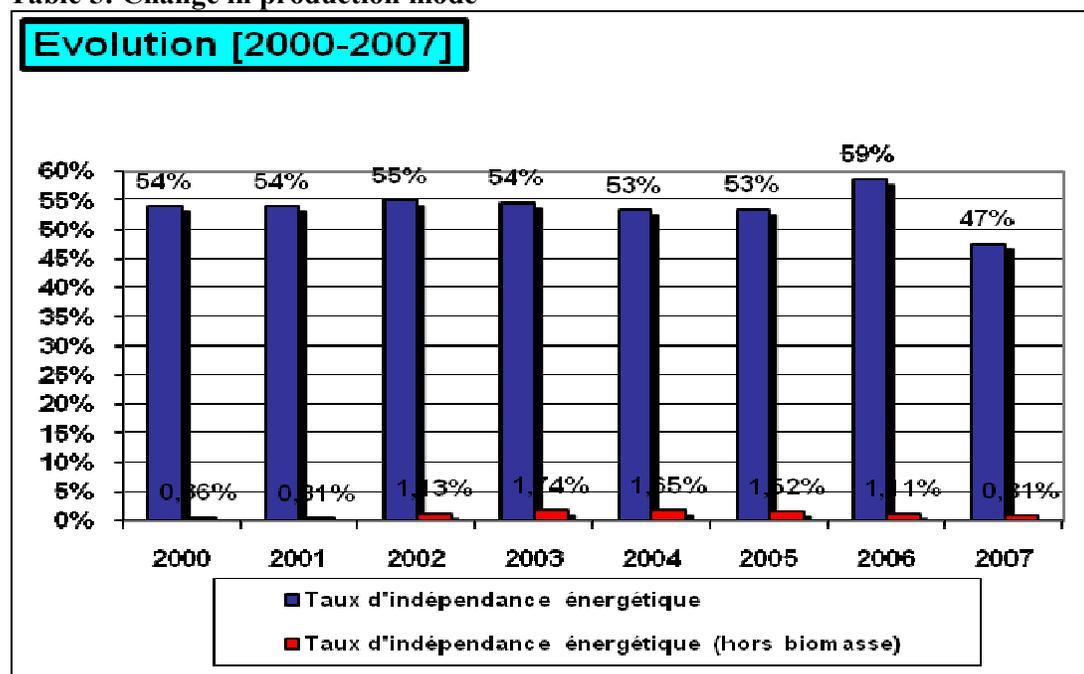
Cultures horticoles	Horticulture
Riziculture traditionnel	Traditional rice growing
Cultures de décrue	Flood-recession crops
Casier rizicole	Rice paddies
Casier de canne à sucre	Sugar cane plots
Industries agro-alimentaire	Agri-food industry
Huilerie d'arachide	Groundnut oil plant
Egrenage de coton	Cotton ginning
Rizerie	Rice plant
Concentré de tomate	Tomato concentrate
Raffinerie de sucre	Sugar refinery

In spite of its high potential, Senegal's agriculture remains rainfall dependent and recent studies have indicated an overall decrease in rainfall of 35 percent in terms of quantity, with a decrease in the duration of the rainy period and of frequency of rainy days between the 1950–1965 and 1970–1995 periods (Diagne, 2000).

In a global study of vegetation, (Tappan et al., 2000) cited by Tieszen et al. (2004) a comparison was made of the woody vegetation on 300 sites between 1982–1984 and 1994–1997. The study found that the combination of drought and long-term reduction in rainfall had significantly affected ligneous vegetation over the northern two-thirds of Senegal. A moderate mortality rate was observed for the least lignified species and high rates for the more lignified in the iron hardpan Ferlo to the north-east. This observation of woody vegetation fits well with recent climate data that indicate increased aridity.

The initial consequence of increasing temperatures and decreasing rainfall will be an increase in water demand by the vegetation for which the deficit will be aggravated. In a study of the north-west of Senegal, Gonzalez (1997, 2001) found that drought favoured extension of sahelian plants from the north, with the sudan and guinean type species retreating to the south. Specific richness has been reduced by 30 per cent.

Table 5: Change in production mode



Evolution [2000–2007] = Change [2000–2007]; Taux d'indépendance énergétique = Energy independence; Taux d'indépendance énergétique (hors biomasse) = Energy independence (excluding biomass)