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Benin

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Contents

List of abbreviations

ABERME: Agence Beninoise d'Electrification Rurale et de Maîtrise d'Energie
ASECNA: Agence pour la de Sécurité de la Navigation Aérienne en Afrique
CEB: Communauté Electrique du Benin
DGE: Direction Générale de l'Energie
GDP: Gross Domestic Product
GHG: Greenhouse gas
GJ: Gigajoule
GWh: Gigawatt-hour
HDI: Human Development Index
INSAE: Institut National de la Statistique et de l'Analyse Economique
ktoe: thousand tonnes of oil equivalent
kV: kilovolt
kW: Kilowatt
MDG: Millennium Development Goals
MW: Megawatt
MWh: Megawatt-hour
PAE: Plan d'Action Environnementale
PFSE: Projet de Fourniture de Services d'Energie
PIP: Programme des Investissements Publics
PRBE: Programme Régional Biomasse Energie
SBEE: Société Beninoise d'Energie Electrique
SONEB: Société Nationale des Eaux du Benin
toe: tonne of oil equivalent
UNDP: United Nations Development Programme
WAGP: West African Gas Pipeline
WAPP: West African Power Pool

Executive summary

Energy is an essential factor for a country's development. Countries with access to numerous and abundant energy sources usually have noticeably higher per capita GDP, have higher per capita income levels and greater life expectancy, etc., than those that lack such access to energy services. Without energy it is impossible to increase a country's productivity, to give impetus to its development, reduce poverty or achieve Millennium Development Goals.

In Benin, as in most poor countries, biomass (firewood and charcoal) remains the dominant source of energy, followed by petroleum products and, to a lesser degree, electricity. Severe fluctuations in fossil fuel prices compromise domestic capacity to develop energy access, whereas the fuels used contribute to climate change.

Benin remains vulnerable in the face of climatic changes that will modify trends and disrupt patterns of agriculture.

However, the country has a huge and untapped energy potential. Sustainable access to energy will be possible if this is developed by combining policies and practices that address the issue of climate change.

Since Benin ratified the United Nations Framework Convention on Climate Change (UNFCCC), the country has begun to incorporate climate change concerns into its development objectives.

This report has been written to contribute to better integration of environmental issues into energy policy. In particular, the report provides an assessment of Benin's vulnerability and proposes measures aimed at increasing the resilience of its energy systems.

The main measures are:

- reduction in the pressure on forest resources by promotion of renewable energy and efficient fuelwood technologies; and,

- improving the population's access to a range of energy sources (petroleum products, electricity) especially in rural areas.

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Publications

- Benin's energy balance 1996−2001.
- Writing and publication of first, second and third Benin Energy Management Reports: 1999; 2000; TBE-2001.
- Study of the impact of energy on Benin's industrial development (for the Ministry of Industry with UNDP funding, 2000).
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Publications

- Benin's energy balance, 2002 to 2005
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- HELIO International Reports 2001 to 2007

Country Overview

Population: 8,294,941 (2008)

Urban population: 46.1%

Rural population: 53.9%

Human Development Index: 0.437 (2005)

Access to electricity: 23%

Per capita GDP: USD1,500 (2007)

Main agricultural produce: cotton, maize, cassava (tapioca), yams, beans, palm oil, groundnuts, cashew nuts, cattle

% of land cultivated: 2.3% (2005)

Oil production: 0 bbl/day (2005)

Brief Description of Benin

Benin is a tropical West African country between the Equator and the Tropic of Cancer (between the northern 6°30' and 12°30' parallels and eastern 1° and 30°40' meridians). It is bounded to the north by the Niger River, which separates it from the Republic of Niger; to the north-west by Burkina Faso; to the west by Togo; to the east by Nigeria; and to the south by the Atlantic Ocean.

The country's surface area is 114,763 km², extending 700 km north-south; width varies between 125 and 325 km.

The country has two climatc zones. The south: sub-equatorial region has the following seasons:

- a main rainy season between April and July
- a minor dry season from July to September
- a minor rainy season from September to October, and
- a main dry season from November to March.

In the norther there is a Sudan type climate to the north, with the following seasons:

- dry season from November to May

- rainy season from June to September.

The country has great agricultural potential, with 8.3 million hectares of available cultivatable land.

Benin has a population of 8.056 million, with an annual growth rate of 2.6 percent (2008). 37 percent of the population lives below the poverty line (2007).

The country has some small deposits of extractable resources such as limestone, marble and gold and has forestry resources. Benin's main crops are cotton, maize, cassava, yam, beans, palm oil, groundnuts and cashews. Industrial production is mainly in the areas of agri-food, cotton processing and production of cement and textiles. Agriculture accounts for one-third of Benin's GDP, industry for 15 percent and services more than half.

GDP has grown by 5 percent on average in the last seven years, with a per capita GDP of USD1,500 (2007). Benin remains an under-developed country dependent on subsistence agriculture, cotton production and regional trade. Its export products are cotton, cashew nuts, shea butter, textiles, palm products and seafood. The country imports foodstuffs, capital goods, and petroleum products. Benin's main trading partner is China, accounting for one-fifth of export revenues and 47 percent of imports. The lack of electricity resources continues to have a negative effect on the country's economic growth, in spite of the fact that the government recently introduced measures to increase energy production within the country. In 2005, Benin used 588 million kWh of electricity, generated 106 million kWh and imported 595 million kWh. All of its petroleum product needs are covered by imports.

From the energy point of view, the country faces serious environmental risks necessitating the introduction of measures.

Risks include:

- Overexploitation of forest resources causing their depletion, with resulting ecological consequences.
- Vulnerability of the country to the changing value of the dollar and variations in crude oil prices, since all petroleum products are imported and electricity use is increasing.
- Low degree of penetration of renewables other than firewood and charcoal, representing around 60 percent of total final energy consumption.

Benin's Social Situation

The average household in Benin has 5.6 members. The country's population is predominantly female and has been so since the 1980s. The proportion of females is around 51.5 percent. Females enjoy better health than males: life expectancy at birth is 61.3 years, against 57.2 years for males. Where literacy is concerned, adult females (15 years and more) fare less well: in 2002, their literacy level was 21.9 percent, against 45 percent for males.

At the national level, improvements in adult literacy have been remarkable: the level rose from 26.9 percent in 1992 to its current level of 32.6 percent. This improvement has, however, been to the detriment of females, since their literacy level has increased at 1.3 percent, less than the increase for males (1.5 percent). The trend is the same for levels of education: lack of schooling amongst females dropped from 80.6 percent in 1992 to 65.6 percent in 2002, compared to 61.7 percent to 43.9 percent for males.

Benin's women are increasingly active in the informal sector. In 2002, the percentage of economically active females was 49.3 percent of the female population, against 42.6 percent in 1992. The numbers of economically active females has increased at 4.6 percent annually.

Amongst them, 96.8 percent are active in the informal sector, with only 1.4 percent active in the formal public sector and 1.4 percent in the formal private sector.

Benin's women represent the majority (at least 60 percent) in professions where females tend to predominate (midwifery, itinerant vending, pottery, hairdressing, housework and typing). There are few women in traditionally male dominated sectors such as driving, maritime jobs, welding, shoe repairs, metal work, briquette making, electricity, surveying, technical aspects of civil engineering, glazing.

Children are one of the most vulnerable groups of society. Since adoption by the UN of the Convention on the Rights of the Child, in 1989, increasing awareness of issues relating children's survival and development has been evident on the part of successive governments. Increased awareness has resulted in the ratification of most of the conventions in favour of children. Improving the conditions of children's lives has thus become a development priority for the government. The child population (0−17 years) is predominantly male, with 105 boys for every 100 girls, unlike the country's total population, where there are 94 males for 100 females.

Where drinking water supply is concerned, only two children out of 10 under five years of age (19.9 percent) have access to drinking water in Benin, and 17 percent live in households using water from the *SONEB* (national water company). Infant mortality (children under 5 years of age) in Benin is 90 deaths within the first year for every 1000 live births and 14.64 before the age of five.

The press in Benin enjoys a great deal of freedom, leading to the existence of a large number of media. Approximately 40 daily newspapers are published in Cotonou, the country's economic capital. Benin's some 8 million inhabitants can listen to national

radio and more than 70 private radio stations and watch four private television channels.

Most journalists active in these media have learned their trade 'on the job'. Unfortunately the media are economically weak and susceptible to corruption. They receive a small budget from the State and there are few advertisers. Journalists are often, in fact, students who are looking for work. According to the organisation '*Reporters Sans Frontières*', Benin ranked 23rd in the world for freedom of the press in 2006. It should be noted, however, that this situation eroded significantly in 2007 where its ranking dropped to 53rd. Ranking of Benin in relation to some other African countries is shown in Table 1:

Table 1: Ranking of some African countries for freedom of the press

Country	Benin	Burkina-Faso	Ghana	Niger	Nigeria	Senegal	Togo
Rank 2007	53rd	68th	29 th	87 th	131st	83 rd	49th
Rank 2006	23rd	70th	34th	95th	120th	77th	66th

Source: http://www.rsf.org, consulted in April 2009.

Given the level of increase of Benin's urban population, urbanisation is of prime concern. The urban population, which was 39 percent in 2002, is estimated to be 45.8 percent in 2012. This is resulting in a significatnt reduction in the rural population. The growing urban population, attracted mainly by the contrast between urban and rural life, will raise problems of available labour for agriculture which is still highly labour intensive in Benin. It is therefore necessary to envisage the modernisation of agricultural methods and to introduce spatial planning that is based on promotion of development of the country's various regions that is integrated, balanced and sustainable.

Table 2: Summary of basic country data

Basic statistics	Year	Unit value
Physical area		
Area of country		114,763 km²
Population		
Total population	2008	8,056,394 inhabitants
% of which is rural		57%
% of which is under 5 years old	2002	19.3%
	2002	
Population density	2007	70 inhab./km²
Economically active population	2002	
as % of total economically active population		66.2%
female (%)		32.7%
male (%)		33.5%

Basic statistics	Year	Unit value
Economy and development		
Gross Domestic Product value added in agriculture (% of GDP) GDP per capita	2007	USD5,020 million[1] 23.1% USD640[2]
Balance of trade (USD) % change from 1990 to current year	2000−2006	46.88 %
Human Development Index (and ranking)	2005	0.437 – rank: 163rd
Human Poverty Index (and ranking)	2005 (UNDP HDI)	47.6% – rank: 100th
Environmental Sustainability Index	2005	Benin has ratified most of the international environmental agreements
GHG emissions	1995	54,155 tonnes CO_2eq
Access to potable water (less than 500 metres)	2002	20%
Infant mortality	2002	9 % However, it should be noted that the gross mortality level was 1.257% in 2002. In 2008 it was estimated at 1.09%[3].
Literacy as % of population Females (%) Males (%)	2002	 32.6% 21.9% 45%

Benin's Key Vulnerabilities

Benin's main environmental problems stem from the mismatch between its consumption of natural resources and their rate of renewal.

Degradation

The most visible manifestations of environmental degradation are the depletion of the forest cover; erosion, in all its forms, throughout the territory; a general lowering of water quality; and unbalanced urban development.

Forest depletion is caused by, amongst other factors, the predominant consumption of firewood for household use, leading to overexploitation of the forests and reduced sustainable production of fuelwood to meet demand. The country is therefore highly vulnerable in terms of the external sources on which it relies for supplies of commercial energies (petroleum products and electricity).

[1] FCFA2,510 billion. USD1 = FCFA500.
[2] FCFA320,000. USD1 = FCFA500.
[3] Estimated data. Source: http://perspectives.usherbrooker.ca/bilan/tend/BEN/fr

The extensive agriculture practiced in Benin is also a cause of depletion of vegetation.

Oil Imports

All of Benin's petroleum products are supplied from outside the country and 85 percent of its electricity is imported. The small proportion of electricity generated is, for the most part, from thermal sources and therefore largely dependent upon petroleum products. The low level of diversity of external supply sources for electricity should also be noted, raising the problem of possible variability in the supply of hydroelectricity imported from Ghana. As a result of its high level of dependence on external sources for its energy supply, the country is very vulnerable to fluctuations in the value of the dollar and oil prices on the international market.

Air Pollution

Transport is a major source of air pollution due to the predominate use of old (ten years or older) two wheeled vehicles, which are the main source of transportation. High pollution levels are observed at some road intersections, with CO concentrations of 18 mg/Nm^3 (almost twice the norm). Ozone levels are also high and, in some places, exceed the admissible threshold. Carbon monoxide (CO) levels outside of the towns are ten times lower than those recorded at major road intersections.

An initial analysis of the main economic costs relating to environmental degradation has indicated an annual cost to the nation of between 3 and 5 percent of its GDP (PAE, 2001).

Climate Risks

The main climate related risks identified within Benin's territory are drought, floods and encroachment of the sea/coastal erosion. Their impacts are severe and result in degradation of natural resources, displacement of populations and disruption of economic activities (especially agriculture). The resulting economic and social costs are increasingly heavy in a situation where agriculture is the major activity of 70 percent of the economically active population and contributes 36 percent to GDP, produces 88 percent of income from exports and provides 15 percent of the State's income.

Benin's Current Level of Vulnerability

Environmental

Indicator 1: Changes in rainfall patterns

Year	Average rainfall (mm)
1990	239
2007	254
Change in rainfall + 6%	

ASECNA data

The rainfall pattern changed by 6.3 percent between 1990 and 2007, going from 239 mm to 254 mm. Average rainfall in 1990 was 239 mm, whereas in 2007 it was 254 mm (ASECNA data). At certain localities, drought, flooding and especially encroachment of the sea and coastal erosion are observed.

Indicator 2: Variation in temperature

Year	Average temperature
1990[4].	21–25 °C
2006[5]	20–25 °C

Increase between 1990 and 2006	% increase/reduction
1°C	-5 %

ASECNA data

In 1990, the average temperature in the country varied between 21 and 25 °C; in 2007, it varied between 20 and 25 °C.

Economic

Indicator 1: Proportion of households acquiring access to electricity in the past two decades

The number of households with access to electricity increased annually by approximately 11 percent from 1990 to 2005. Rural areas did not, however, benefit proportionally. In 2005 the urban level of electrification was 51.8 percent, against 1.7 percent in rural areas despite the fact that the rural population makes up around 60 percent of the total population. Realisation of this gap led the government to

[4] National communication DRC, November 2000, p.95.
[5] PAN, op.cit, pp. 7-8.

introduce a national rural electrification programme in 2005. The programme aims at a rural electrification level of 36 percent by 2015, and 65 percent by 2025. Effective implementation of this programme should contribute to improving the country's overall electrification level.

Households with electricity in Benin

	1990	1995	2000	2003	2005	Average annual growth (%)
Number of households with access to electricity	66,526	109,879	119,117	265,408	305,706	10.7
Total number of households	776,271	918,983	1,065,000	1,182,018	1,320,543	3.61
Percentage of households with access to electricity (%)	8.6	12	18.7	21.3	23.20	

Sources: Société Beninoise d'Énergie Électrique (SBEE) Activity Report, 2005 trading period. Benin's rural electrification policy

Indicator 2: Level of increased energy autonomy

Benin is a large net energy importer. All of its consumption of petroleum products is met from imports, as is 85 percent of the electricity consumed. Between 1990 and 2005, energy imports grew more rapidly than final energy consumption: 11 percent for the imports verses 5.5 percent for final energy consumption.

Given this high dependence on external energy supplies, the country is very vulnerable to fluctuations in the value of the dollar and to oil prices on international markets.

In response the government has developed an energy policy that includes adopting diversification of supply source targets, especially in the development of biofuels; generating of electricity from animal, agricultural and household wastes; construction of the Adjarala dam, common to Benin and Togo; and development of sub-regional inter-connections; etc. Implementation of a coherent energy management policy could also lead to a reduction in energy imports.

Benin's imports of non-renewable energy and final energy consumption

	1990	1996	2000	2003	2005
Total non-renewable energy imports (GJ)	10,215,792	13,796,218	24,065,601	46,126,647	52,923,892
Total energy consumption (GJ)	42,370,416	53,459,533	69,962,056	86,405,755	90,514,094
Share of non-renewable imports in final energy use (%)	24	26	34	53	51

Sources: Société Beninoise d'Énergie Électrique (SBEE); Communauté Électrique du Benin (CEB); Energy Management Report.

Extensive efforts remain to be made in the area of energy resilience, since the share of energy imports is growing year on year. However, it should be noted that incentive-

raising measures are being introduced at national level to increase national production levels, especially for renewables (hydropower and biofuels, etc.). These projects will eventually allow energy imports to be reduced.

Technical

Indicator 1: Change in the amount of energy supplied by renewables

Electricity generation from renewable sources and change in share of electricity from renewable sources.

Development of share of renewables in national electricity generating

Year	Hydroelectricity at Yéripao (MWh)	National electricity generating (MWh)	Share of renewables in electricity generating (%)
1996	87	46,978	0.190
2000	1,634	83,981	1.95
2003	1,694	80,223	2.11
2005	752	107,188	0.70[6]

These indicators show that, with the exception of fuelwood, there is still very little use of renewable forms of energy in the generating of electricity. However, at the institutional level, many efforts are being made to promote renewables but results are not yet tangible on the ground.

Benin is currently developing a biofuels production programme that will enter the active phase in coming years, with a five percent mixture of gasoline and diesel consumed in the transport sector. However, the project is currently in the phase of introduction of an institutional and regulatory framework that is favourable to development of biofuels in the private sector. A feasibility study has also been conducted to confirm the possibility of developing a biofuels market in Benin. A national strategy for biofuels promotion is also available.

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

The renewable forms of energy used in Benin are, mainly, fuelwood (firewood, and charcoal), some national **hydropowe**r, and some industrial units generating their own electricity from **biomass residues** (cotton husks, palm husks).

There are also projects that have made it possible to electrify rural localities using solar PV systems, but these are not currently operational due to a lack of post-project management meaning that the systems are not maintained.

[6] Hydroelectricity generating reduced in 2005 because of reduced hydraulicity.

To sum up, the renewable energy consumed in Benin is predominantly in the form of fuelwood (firewood and charcoal); it represented 59.4 percent of final energy consumption in 2005.

The level of penetration of other forms of renewable energy remains marginal.

Consumption of fuelwood per sector of activity

Diversity of renewable energy sources and technologies in 2005	%
Household (cooking)	49.5%
Services sector (hotels, restaurants)	9.9%
Total	59.4%

Social

Indicator 1: changes in prevalence of diseases

	Levels of water-related diseases (%)	Changes (as %) between 1990 and 1998
1990	66.8	
1998	71.83	+5.0%

The numbers of cases of different common diseases (malaria, diarrhoea, respiratory infections and AIDS) have been evaluated for the 1990−1998 period. In these figures, water-related diseases (malaria, diarrhoea) represent 66.8 and 71.83 percent of all of the cases of disease in these two years respectively. The increase in water-related diseases is probably linked to the use of unclean water and to the failure to use impregnated mosquito nets. The increase indicates that bold measures are required to curb the development of diseases linked to unclean water.

Civic

Indicator 1: land reform improvement

In spite of the adoption of decentralised development management (via the creation of municipalities), decentralisation is still incomplete where agriculture is concerned. A rural land act has been introduced but there is no law covering urban land ownership. This has, inevitably, had consequences for information on land, especially regarding fiscal procedures, legal validation, territorial protection, regional planning and economic development.

Changes in land ownership

Year	1990	2007
Number of farmers having permanent access to their land	dna (*)	dna (*)

Number of women land owners	dna (*)	dna (*)

* = dna: data not available.

Indicator 2: change in public participation in the planning process

During the process of decentralisation in Benin, a large number of powers and responsibilities for provision and management of social services were transferred from central ministries to municipalities. For example, the building of primary schools is now a municipal responsibility, whereas remuneration and supervision of teachers remains the responsibility of the ministry. In this context, the ministries (which decide on development financing and policy) and development partners took an interest in the introduction of a system of participatory monitoring of public actions in key areas in the fight to alleviate poverty. Involvement of civil society is now one of the requirements of the process for drafting, implementing, monitoring and evaluating all of the documents relating to the country's development. The advantages of public participation for the process stem from better knowledge of the constraints and forces affecting effective use of financial resources, and from the ability to mobilise local stakeholders.

However, if public involvement is to be a valid instrument for monitoring by citizens efforts must be made to involve civil society organisations, such as NGOs, as much as possible. Capacity building is necessary if these organisations are to play their part to the full.

Energy Situation in Benin

Primary Energy Sources

Primary energy sources in Benin are used mainly in the household sector and include:

- biomass (firewood) used by households for cooking or for production of charcoal by carbonisation;
- solar radiation powering PV modules, mainly used by private individuals to generate electricity for household uses; and,
- hydropower used to generate electricity: this is the case, for example, of the Yéripao (Natitingou) 0.5 MW micro-hydro plant that has been running for around 12 years.

Benin does not import any form of primary energy other than the hydroelectricity included in the electricity imports. The country is, however, well endowed with energy resources.

Hydro

Benin has a high domestic hydroelectric potential with sites such as Kétou (160 MW), Adjarala (147 MW), Kétou-Dogo (108.8 MW) usable for development of large-scale, mini- or micro-hydro schemes. All of the existing sites for hydropower are fully identified. The hydroelectric potential of the dams is evaluated at 1,230 GWh, with a power capacity of 241 MW (Source: DGE 2007).

Eighty-five micro-hydro sites (average power rating <1 MW) have also been identified since 2005, with a guaranteed generating capacity of 194 GWh and potential capacity of 64 MW.

Fossil Fuels

Research has shown that Benin has crude oil reserves that have not yet been evaluated, although some sources (ECOWAS *Livre d'or* and Kouo, 2005), estimate the resources to be 21 million tonnes. Benin has no coal deposits.

Biomass

Biomass constitutes one of Benin's major energy resources. In 2005, the country's forest area was estimated to be approximately 5,845 ha (SIE DGE 2006) with a net firewood supply was estimated at 4.8 million tonnes (1.67 million tonnes of oil equivalent). However, the sustainable supply capacity for forest resources is less than the demand for fuelwood.

Wind

Wind energy: windspeed, measured at an altitude of 10 m, varies between 3 and 5 m/s. The potential is higher in the northern, central and southern parts. A wind map would be useful for exploitation of these resources.

Solar

Average insolation in Benin provides a solar potential of around 3.9 to 6.2 kWh/m²/day. Given the scale of this potential, Benin is planning to use solar energy to improve people's access to electricity, especially in the rural areas. However development of solar PV and thermal solar systems is still embryonic in terms of the quantities of energy produced.

Benin's potential for energy supply diversification will not be possible if the climate were to change significantly in coming years. An increase in temperature could cause:

- Reduced rainfall, leading to a reduction or even cessation of generating by hydroelectricity plants.
- Changes in seasonal patterns resulting in forest resources to become scarcer and thus disrupt the ecological balance.
- Icreased sea levels, which could disrupt operation of electrical power plants and possibly even petroleum product depots.

Energy Demand Problem

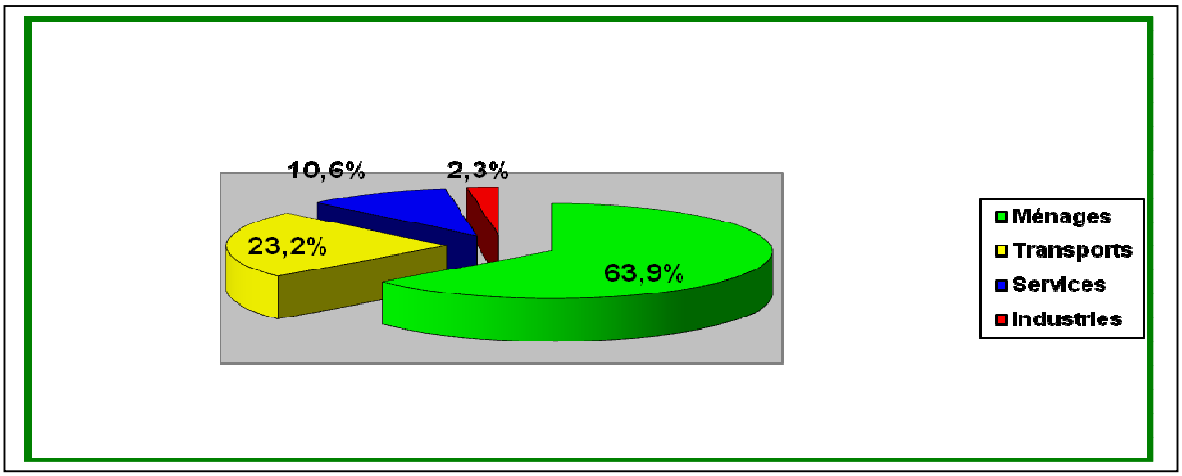
Benin's total energy consumption was evaluated in 2005 at 2,256 ktoe by the *Institut National de la Statistique et de l'Analyse Economique* (*INSAE* − national institute for statistics and economic analysis). With a population of 7,395,040 people, the per capita energy consumption for 2005 is therefore evaluated at 0.305 toe. This is about half of the average consumption for African countries, and four times lower than the world average (source: SIE-Benin report, 2006).

Biomass fuel (firewood, charcoal and plant residues) remains the most common energy source in Benin. In 2005, it accounted for 59 percent of all of the final energy consumed, against 67 percent in 2002. The share of electricity in consumption over the same period barely increased. Conversely, the share of petroleum products went from 31 percent in 2002 to 38 percent in 2005. This is due, amongst other things, to an increase in domestic consumption of gas (increased availability on the market) and an increase in the automobile fleet.

Table 3: Energy consumption pattern per sector of activity in 2005 (in toe)

Sector of activity	Household	Transport	Other services	Industry
Consumption (toe)	1,441	524	240	51
Proportion (%)	63.9	23.2	10.6	2.3

Figure 1: energy consumption pattern per sector of activity in 2005



Ménages = Households, Industries = Industry (figures are decimal, e.g. 10,6% = 10.6%)

The household sector is the largest energy consumer in Benin (64 percent of all final consumption in 2005). This is followed by transport (23 percent), services (11 percent) and industry (2 percent). Energy consumption is clearly dominated by biomass (firewood and charcoal). High consumption of fuelwood is causing progressive degradation of Benin's forests, which are not sufficiently renewed despite various replanting projects undertaken.

Electricity and butane are other forms of energy used by households, although they satisfy only a small part of the household demand. The penetration of butane is still low, especially in rural areas. A national plan and several programmes aim to increase penetration in order to relieve the pressure on biomass resources.

Household consumption of energy services is primarily for lighting and cooking.

Table 4: Household consumption pattern by type of energy in 2005

Types of energy	Biomass	Lamp oil	Electricity	Butane
Consumption (toe)	1,115,595	293,460	24,217	7,533
Proportion of household energy (%)	77.43	20.37	1.68	0.52

Transport

Benin's transport sector is characterised by a vehicle fleet made up mainly of imported used vehicles, a large number of motor-cycle taxis (more than 100,000 in Cotonou) and private and small-capacity motor cycles.

The sector's energy consumption rose from 185 ktoe in 1996 to 524 ktoe in 2005 which was equivalent to a rate of growth of 13.1 percent for the period, higher than that of GDP, which was 4.7 percent. The sector's energy intensity (ratio of its

consumption to value added) is observed to be increasing yearly, indicating a failure within the sector to manage consumption.

Industry

Benin's industrial sector is under-developed. Its contribution to GDP is relatively small (around 15 percent in 2005).

Industrial production in Benin is mainly textiles (activities related to cotton ginning and processing, spinning and weaving) and cement. Other industrial activities include brewing, oils and soaps, and tobacco.

Table 5: Industrial energy consumption pattern by type of energy in 2005 (toe)

Type of energy	Diesel	Fuel oil	Electricity
Consumption (toe)	1,331	39,310	10,114
Proportion (%)	2.62	77.45	19.93

Agriculture and Services Sector

Very little of the country's agriculture is mechanised and irrigation is only slightly developed. The energy demand linked to the sector's probable future development has not been evaluated.

The services sector (private and public) is disparate with many facilities active in the informal sector. It is therefore very difficult to ascertain energy consumption (mainly biomass fuel) without field surveys. Consumption is estimated at 20 percent of consumption of firewood and charcoal by households.

In addition to fuelwood, the agricultural sector also consumes electricity and butane.

Energy Supply

For hydrocarbons, the supply situation is as follows:

- very low coverage in terms of points of sale: a study by the *Direction Générale de l'Energie* (*DGE* − energy management department) estimated one filling station for 40,000 inhabitants and servicing a geographical area of 590 km²;
- structural domination of the sector (around 70 percent in 2006) by products from the informal sector, resulting from illegal imports from Nigeria;
- no crude oil refineries, resulting in 100 percent dependence on external sources for supply of petroleum products.

Where electricity is concerned, two major problems arise (in addition to those of low national coverage and the low level of consumption):

- poor management of voltage stability: variations can be as much as 20 or 30 percent of the rated voltage in urban areas;
- frequent electrical power failures: up to 950 scheduled interruptions to supply observed in 2005 for a total period of 72,226 minutes; more than 1,000 unscheduled interruptions per year for a total period of 37,242 minutes in 2006,

according to the *Société Beninoise d'Energie Electrique* (*SBEE* − Benin electricity company) .

These power losses are mainly due to electricity supply difficulties. In 2006, Benin's consumption of electricity was 660 GWh. The national electrification level (ratio of part of the population actually connected to total population) was 24.71 percent in 2007; the rural electrification level remained low (less than 2 percent) in 2007.

In spite of the efforts made, Benin still suffers from an increasing lack of electricity generating capacity. The country's peak demand is currently around 140 MW and the various external supply sources—electrical energy imported by the *Communauté Electrique de Bénin* (*CEB* − Benin electricity community) from VRA (Ghana) and from the Transmission Company of Nigeria (TCN), and accounting for around 85 percent of supply—and the electricity generated by the thermal plants (*SBEE*) cannot cover the country's needs.

Table 6: Projected electricity demand

	2008	2009	2010	2011	2012
Energy demand (MWh)	833,000	1,061,000	1,183,000	1,313,000	1,453,000
Annual increase in demand (%)		27.3	11.5	11	10.7

Impact of demand on energy supply (2002 – 2006)

Analysis of the country's energy demand between 2002 and 2006, indicates an electricity supply deficit illustrated by Table 15, below.

Table 7: Analysis of electricity demand between 2002 and 2006

		2002	2003	2004	2005	2006
Energy supply deficit (MWh)	Supply	532,682	557,503	577,837	596,139	589,147
	Demand	570,000	617,000	646,000	680,000	702,000
	Deficit	- 37,318	- 59,497	- 68,163	- 83,861	- 112,853
Power deficit (MW)	Supply	83.42	83.84	84.61	99.66	91.33
	Demand	98.00	100.00	100.00	105.00	113.00
	Deficit	- 14.58	- 16.16	- 15.39	- 5.34	- 21.67

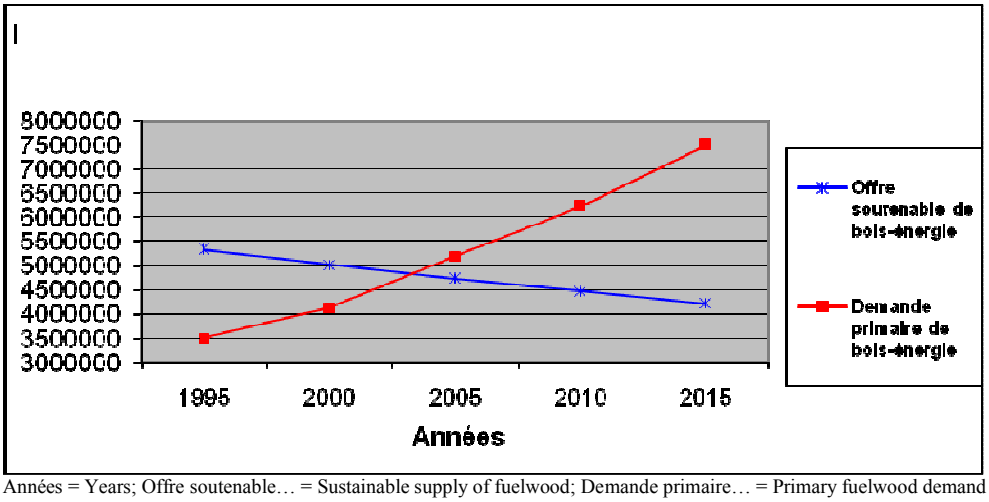
For biomass, the distance currently between the place of production and the market can vary from a few to more than 200 kilometres, depending on:

- accessibility of the forest resources used to supply the major urban areas;

- the size of the market to be supplied, which is a determining factor for profitability of the activity.

Figure 3, below, illustrates the sustainable supply deficit for forests in the face of the demand for primary fuelwood energy.

Figure 3: Projected fuelwood supply/demand balance (in tonnes)



Années = Years; Offre soutenable… = Sustainable supply of fuelwood; Demande primaire… = Primary fuelwood demand

Bilateral and international cooperation – investments

Benin's energy policy includes a regional approach that has allowed the implementation of regional projects such as the West Africa Gas Pipeline (WAGP) project or the West African Power Pool (WAPP).

WAGP project

The pipeline is intended to use some 18 billion m³ of natural gas currently flared in Nigeria. The pipeline—678 km long and at an estimated cost of USD617 million—will supply thermal power plants in Benin, Ghana and Togo, providing a capacity of 3,000 MW after 20 years.

WAPP project

The WAPP will link the ECOWAS countries: Benin, Burkina Faso, Cap Vert, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

WAPP is dependent on two energy sources: gas for thermal power plants; and, hydropower.

The following electrical interconnection projects are expected to come within the framework of WAPP.

- Nigeria-Benin-Togo-Ghana interconnection: 330 kV;
- Nigeria-Niger-Benin- Burkina Faso interconnection;

- WAPP project for building of 400 MW gas turbine plant at Maria Gléta in Benin;
- The *Programme Régional de Promotion des Énergies Domestiques et Alternatives au Sahel* (*PREDAS* − regional programme for household and alternative energy in the Sahel). *PREDAS* is implemented by the CILSS and Sahelian countries with the support of GTZ and the European Union. The project aims to assist countries in designing, adopting and implementing their domestic energy policies.

Programme Régional Biomasse Energie **(PRBE − regional biomass energy programme)** was implemented by *UEMOA* (the West African Economic and Monetary Union) with support from the Netherlands. The aim of the *PRBE* is to assist member countries in designing and implementing projects/programmes with a focus on modern uses of biomass.

There is also bilateral cooperation between Benin and Togo, via the *CEB*, a bi-country institution tasked with supply and transmission of electrical energy in Benin and Togo.

To strengthen the security of the country's electricity supply by diversifying external supply sources, interconnections have been established between *CEB* transmission networks and other countries (Nigeria (TCN), Côte d'Ivoire and Ghana).

Table 8: Current situation of interconnections

	L1: 161 kV CEB (Benin – Togo)	**L2: 330 kV (Benin–Nigeria) CEB-TCN Ikeja West (**)**	**L3: 33 kV (Benin–Niger) CEB-NIGELEC**	**L4: 161 kV CEB-VRA Akossombo-Lomé (***)**	**L5: CEB – CEI (***)**
Nominal capacity of line (MW)	Dna	630	Dna	110	Dna
Actual power carried by the line (MW)	91.33	80	0.683	34 (*)	Dna
Energy carried in 2006 (MWh)	589,147	0	2,097	750,553	272,384
Energy carried in 2005 (MWh)	596,139	0	1 210	634,862	414,631
Cost/kWh		5.5 US cents/kWh	34 FCFA/kWh	Guaranteed energy: FCFA 26/kWh	Dna

* Guaranteed capacity.
** Operational from February 2007.
*** CEB interconnection (Benin and Togo CEB) with Ghana and Côte d'Ivoire.
Dna: Data not available.

Changes to Legislation and Energy Policies

The hydrocarbons sub-sector is regulated as follows:

- Exploration, production and processing activities are governed by Act 2006-18 of 17 October 2006 of Benin's oil and gas code;
- Distribution of petroleum products is governed by a set of legislative texts (decrees and orders) that govern the activity and specify how it is to be monitored and controlled by the relevant public authorities.

Activities in the electricity sub-sector are governed by:

- The Benin-Togo Electricity Code.
- Act 2006-16 of 27 March of Benin's Electricity Code and the texts specifying its enactment.
- Decision A/DEC.5/12/99 of the Conference of Heads of Government of 10 December 1999 on setting up of the WAPP.

Renewables can be divided into two main sub-sectors:

- Biomass energy: use of wood resource for a variety of purposes and gathering of firewood are controlled by legislation on forests and a framework law on environment.
- New forms of energy (solar, wind, etc.), for which there is currently no specific legislation.

There are indications that renewables generate more jobs than non-renewable energies but there is no national report indicating the number of jobs created.

Benin's Energy System

The contribution of each of the different forms of energy is as follows:

Table 9: Total final energy consumption pattern by type of energy in 2005 (toe)

Type of energy	Biomass – energy	Petroleum products	Electricity
Consumption (toe)	1,338,714	866,540	50,628
Proportion (%)	59.4	38.4	2.2

This pattern can be further analysed as follows:

Table 10: Contribution of different types of energy to the country's overall energy balance (ktoe)

Types of energy (toe)	Fuel oil	Diesel	Lamp oil	Gasoline	Butane	Electricity	Firewood	Charcoal	Other biomass	Total
Final consumption	39,310	120,554	303,372	394,934	8,370	50,628	1,190,587	142,984	5,143	2,255, 882
Percentage	1.7%	5.3%	13.4%	17.5%	0.4%	2.2%	52.8%	6.3%	0.2%	100%

As that table above indicates, biomass (firewood, charcoal and plant residues) remains the major source of energy consumed in Benin.

Key Energy Systems

Energy supply is provided from different sources, depending on the form considered.

Electricity

Electricity is supplied by the *CEB* supplying and transmitting electrical energy in Benin and Togo. Electricity is distributed by *SBEE*. *SBEE* also has a little generating capacity that is intended to satisfy demand from regions of the country not connected to the interconnected grid.

There are also some businesses producing their own electricity, using diesel generators or other sources such as wastes from processing of agricultural produce (cotton and palm nut husks, etc.). These 'self-generators' produced 25.12 GWh of energy in 2005.

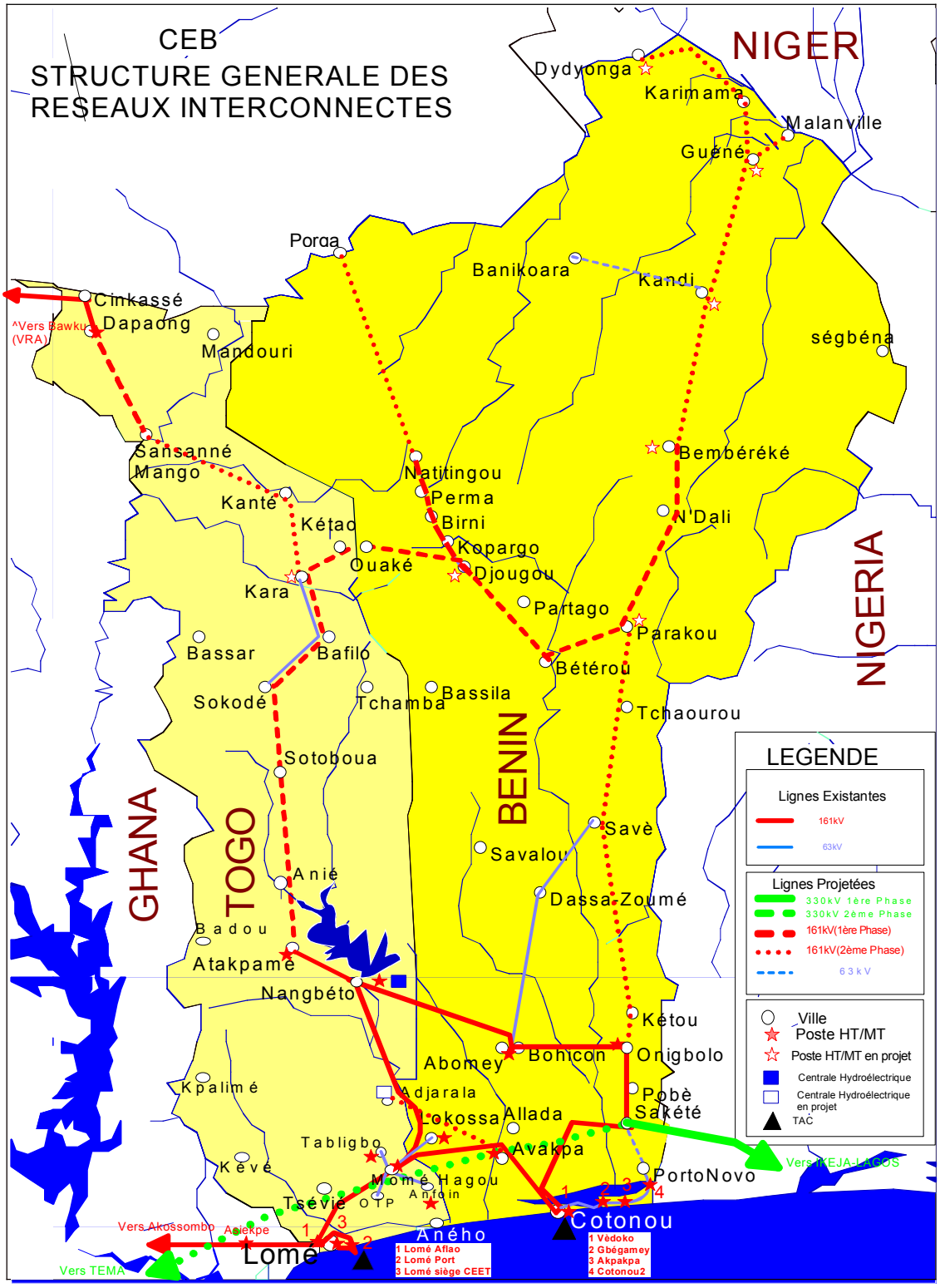
Petroleum Products

Supply and distribution of petroleum products is via State approved companies. The products are distributed through a network of supply stations. There is also an informal distribution network for petroleum products. Petroleum products accounted for 38.4 percent of total final energy consumption in 2005.

Biomass Energy (firewood and charcoal)

Supply and distribution of biomass is mainly through the informal sector. It accounted for around 60 percent of total final energy consumed in 2005.

Figure 4: Electricity distribution network



Lignes Existantes = exisiting lines; lignes projetées = anticipated line development ; Ville = town ; poste HT/MT = High and medium tension distribution stations; poste HT/MT projet =anticipated high and medium tension distribution stations

Energy System Vulnerability

Vulnerability indicator	Calculation
Coal	
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 *Benin does not produce coal.*	0
Oil and gas	
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 *No offshore installation.*	0
2. Share/number of refineries likely to be hit by a storm of more than 70 m/s gusts within the next 20 years *No refineries in Benin.*	0
All fossil fuels	
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 *One plant in Cotonou, at around 5 km from the sea.*	1
2. Additional information: Expected number of droughts that lead to a capacity decrease of thermal power plants by more than 10% within the next 30 years	0
Nuclear	
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 *No nuclear plant in Benin.*	0
2. Number of incidents/accidents since the plant was built	0
Hydro	
1. Expected precipitation change over the next 20–50 years (%) and/or probability of floods in each watershed	Data not available (Dna)
2. Number of multiple-use dams in the country today *Volume of water (m^3) for each dam.*	Dna
3. Describe what % of the water is used for: a. Agriculture b. Energy c. Drinking	Dna

Vulnerability indicator	Calculation
Transmission and distribution indicators	
1. Length of in-country, above-ground transmission and distribution lines (km) a. National lines b. Trans-national lines *A 161 kVA line is planned to link the north of Benin to the southern interconnected grid (interconnection between CEB and TCN - Nigeria).*	HV: 111.11 km MV: 1859.86 km in 2006 LV: 3649.47 km; 330 kV line: 16 km 161 kV line: 560 km 63 kV line: 39.8 km; 20 kV line: 2 km. Na
2. Number and duration of power cuts (differentiate between failures due to weather or equipment failure and those cuts due to rationing) a. Cuts due to bad weather or equipment failure *Cuts due to rationing.* *Average hours of interruption per year (hours/year).*	1,000 unscheduled cuts per year, i.e. 37,642 minutes/yr and 234 programmed cuts per year, i.e. 25,994 minutes/yr 604 cuts/yr 2,824 hours/yr
3. Percentage of energy supply requiring regional transport over 50 km a. % that is transportation of fossil fuels b. % that is transportation of biomass *Non-aggregated data for percentages of fossil fuels and biomass transported are not available.*	
Biomass	
1. Proportion of biomass used for energy purposes (%) in total biomass production a. Agricultural waste b. Electricity c. Heat d. Forest wastes e. Electricity f. Heat *A large part of the biomass collected is used as an energy source (firewood, charcoal).There are also some agri-food businesses generating electricity from their waste but data on these wastes are not available.*	Dna
2. Expected precipitation change over next 20−50 years (%) *In-depth investigations have been carried out with ASECNA but forecasts for precipitation over the next 20−50 years do not exist.*	Dna
Wind	
1. Number of wind turbines less than 1 metre above sea level	0
2. Projected change of average windspeed in the next 20 years based on regional climate models (%)	Dna

Vulnerability indicator	Calculation
Solar	
1. Capacity of solar installations already in place (m²) a. PV (MW) b. Thermal (m²) c. *Village electrification programmes using solar PV have been developed by ABERME but the systems were not maintained. The systems belong to the State.* 1. Describe sites : a. quality of the insulation and of the building on which systems are installed b. type of ownership	0.6 MW
2. Expected temperature increase (°C) in the next 20 years (relevant for PV capacity)	Dna
3. Additional information: projected change in rainfall and cloud cover over next 20 years (%)	Dna

Energy System Resilience

Capacity Indicator	Calculation
Implementation indicators	
1. Domestic capital formation (USD million per year): domestic savings (millions of USD per year) *The level of savings is relatively low: between 1995 and 2000, it varied between 5.6 and 6.5% of GDP.*	
2. Domestic investment in renewable energy (USD million per year)	Dna
3. Number of technical engineers graduating annually as a percentage of the total population	Dna
4. Availability of hazard maps for floods/droughts *Maps not available.*	
5. Existence and enforcement of power plants siting and construction guidelines taking climate change into consideration *Building of plants further and further away from urban centres is not based on analysis relating to climate change.*	No
6. Existence of emergency plans to react to meteorological extreme events and availability of local emergency repair teams *PANA Benin has made the preparation of an emergency response plan a major priority, but it has not yet been prepared.*	

Capacity Indicator	Calculation
7. Domestic availability of insurance schemes *There are insurance schemes in the country but they do not cover natural disasters.*	Yes
8. Existence of citizens' users groups in the energy governance structure (enforcement of participatory decision-making) *Most major decisions are made on the basis of studies shared by all of the institutional actors before implementation. NGOs and representatives of civil society are usually invited into such discussions.*	
Coal, oil, gas, uranium and nuclear fuel sources	
1. Existence and use of a siting map for mines and power plants: a. Areas with storm hazard b. Areas with flood hazard c. Areas subject to drought *Nationally, there are no mines.*	No
2. Implementation of national regulations for thermal power plant siting at sites with sufficient cooling water availability over the next 50 years *There are no national regulations in this area.*	Non
Hydro	
1. Existence of a national plan for optimised operation of hydro plants under projected flow regimes for systems a. is such a plan currently in place? b. If not, has the government decided to have one at a future date? *In-depth studies are conducted each time a large hydro plant is to be built. Studies cover these aspects. However, it should be emphasised that they do not yet include changes in climate.*	Yes
2. Number of dams equipped with desilting gates and/or number of upstream land use management and water catchment plans for each hydro installation *Currently there is only one 0.5 W dam, in the north of the country.*	
Biomass	
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) a. Consistency of funding * does not include municipal waste − this is usully considered in mitigation plans	Dna
2. In-country utilisation of biomass fuels not traditionally used by private enterprises and cooperatives (% of total fuels) *Three agri-food facilities use process wastes. In the public sector, energy recovery from agricultural waste is at the pilot stage.*	Dna

Capacity Indicator	Calculation
3. % of households using improved woodstoves out of total number of households using woodstoves	Dna
Wind	
1. Existence and enforcement of national regulations requiring storm proofing of wind power plants to withstand highest anticipated windspeed *There is no such regulation in Benin. Wind energy is very little developed in the country.*	No
2. Existence of siting maps that detail projected changes in windspeed, floodplains, and areas impacted by sea level rise *The wind resource map does not yet exist.*	No
Solar	
1. Existence of a siting map that details projected changes in cloud cover *Maps do not exist.*	No
2. Existence and enforcement of national regulation requiring storm proof concentrating solar power plants (CSP) to withstand the highest anticipated windspeed *No regulations in this area.*	No

Conclusions and Recommendations

Analysis of the country's energy situation has highlighted several weaknesses in the national energy system.

In the **biomass sub-sector**, the mismatch between supply and demand for fuelwood will likely lead to a deficit in household fuelwood supplies, as well as serious ecological damage resulting from the over-exploitation of the forest resources currently observed.

To remedy this situation, a proactive policy should be implemented to promote alternatives to fuelwood, in particular:

- Development of locally produced forms of energy such as bio-ethanol to meet domestic demand and of other sources of energy such as butane. There is also a considerable potential from the use of agricultural waste and it is important to develop pilot actions for generating of electricity or production of biogas from this source, and to disseminate these technologies, in the light of the results of these pilots.
- Actions should be developed to promote improved stoves in both urban and rural surroundings, to reduce demand for firewood and charcoal.

- Efficient technologies for carbonisation of firewood should be promoted.

In the **petroleum products sub-sector**, the most notable weaknesses identified is the 100 percent dependence on external sources for the country's supply, making Benin vulnerable to dollar exchange rates and fluctuations in oil prices on the international markets.

The following steps should be taken to reduce the country's vulnerability in this area:

- Furthering of the programme of promotion of biofuels, with a view to partially reducing imports of petroleum products (gasoline and diesel).
- Development of better territorial coverage of petroleum product distribution stations and development of the road network, especially in rural areas, to facilitate supply to the population.
- Elimination of the illegal trade in petroleum products.
- Furthering of oil and gas exploration with a view to evaluating the country's reserves and then exploiting them if this is viable. Exploitation of reserves combined with the building of a refinery would help to reduce the level of dependence on imports.

In the **electricity sub-sector**, usable energy resources exist but the country is highly dependent on external supply sources and the population's level of electrification is still low. The following steps would reduce vulnerability in this sub-sector:

- Development of the country's potential by building mini- and micro- hydro plants, for which the potential has already been evaluated, as well as large-scale development of solar energy.

Wind energy is also an interesting option although the extent of the resource is currently virtually unknown. In this area, a positive step would be to:

- Analyse the wind resource and produce a wind map to identify regions offering the highest generating capacities.

It also appears important to re-vitalise the **current rural electrification policy** by developing locally available energy sources, especially solar systems, and an infrastructure management approach that involves communities at the start of the process to help ensure long-term viability of the systems.

Interconnection of the entire territory will also make it possible to compensate for regional losses of electricity supply. To do this, it will be necessary to pursue the existing interconnection projects and to strengthen the existing transmission and distribution systems.

- Introduction of an early warning system and emergency response plans to react to extreme weather events and establishment of local emergency and repair teams.

Other actions that could contribute to increasing the sector's resilience include:

- increasing diversity of supply sources, increasing density of the grid and reducing non-technical losses;
- development of electricity consumption management in all sectors of activity.

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