# Energy for Poverty Alleviation in Sahel

*Intelligent Energy Project*

*Project Newsletter , 09/A, Lisbon, , November 2006*

**Renewable energy resource assessment –**
**a literature based survey/study for the 9 Sahelian countries**

Renewables constitute a reliable and environmentally sound long-term alternative for practically all African countries and many have abundant and unexploited biomass, solar, wind and hydro resources. What is still unclear is the extent to which renewables can assist in addressing the energy needs of Africa's poor—mainly due to the lack of reliable and accurate data regarding renewable energy potentials

In this newsletter issue of the IE4Sahel project we present the major findings from the extensive literature study/survey carried out during the project, in order to assess the RES potential (mostly theoretical) for each source (wind, solar, biomass, hydro & geothermal) in Cape Verde, Mauritania, The Gambia, Senegal, Guinea Bissau, Chad, Mali , Burkina Faso and Niger.

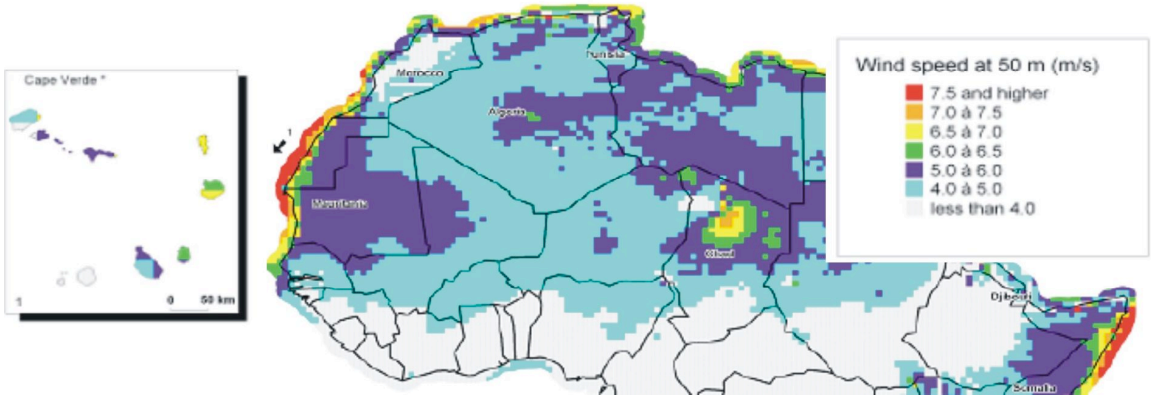
Due to the impossibility to conduct extensive field survey, we tried to deliver the best possible literature survey for the potential energy sources in each country. This proved quite challenging as the amount of reliable and up to date studies regarding resource estimation for the Sahel is extremely limited.

## Wind energy

The theoretical wind energy potential (average wind speeds m/s) was investigated for the 9 Sahelian countries, and is summerized in the figure below and in the tables presented in the following page.

The countries with the most significant wind resources in the Sahel are: Cape Verde, Mauritania and Chad, while in Senegal wind energy offers poor potential due to the very low wind speeds and the abrupt variations in peak wind conditions, but it can be harnessed however for water pumping purposes

**Graph 1 Wind Speed in Sahel. Source: Helimax Énergie (1)**




Supported by the European Commission under the Intelligent Energy - Europe Programme

**Table 1 Theoretical Wind Potential source: (Helimax)**

| Country | Theoretical Wind potential m/s |
|---|---|
| Burkina Faso | n.s. |
| Cape Verde | 4 to 7 (see detailed table below) |
| Chad | 7 - 7.5 Central |
| The Gambia | n.s. |
| Guinea Bissau | n.s. |
| Mauritania | 5-6 Greater Part<br>4-5 NE & S<br>6-7 W. Coast |
| Mali | n.s |
| Niger | n.s. |
| Senegal | 2-3 overall<br>5-5.9 (Dakar-St.Louis) |

**Table 2 Theoretical Wind Potential Cape Verde detail (Helimax)**

| Cape Verde | Theoretical Wind potential m/s |
|---|---|
| Fogo & Brava | <4 |
| S.Antao | 4-5 N. Coast<br>6.5-7 E.Coast |
| S.Vicente, S.Nicolau, S.Lucia, Branco & Raso | 5-6 |
| Santiago | 4-5 SW<br>5-6 N & SE |
| Maio | 5-6 S<br>6-6.5 N<br>6.5-7 E |
| Boa Vista | 6-6.5 N-half<br>6.5-7 S-half |
| Sal | 6.5 |

Since Cape Verde is basically an archipelago consisting of 10 islands and 5 islets, divided into the windward (Barlavento) and leeward (Sotavento) groups, more detailed data is provided for this specific country in the table 2. The 6 islands in the Barlavento group are Santo Antão, São Vicente, Santa Luzia, São Nicolau, Sal, and Boa Vista. The islands in the Sotavento group are Maio, Santiago, Fogo, and Brava. All but Santa Luzia are inhabited

In Cape Verde and Mauritania, the political interest seems favourable for the development of small scale wind projects and the context seems favourable for wind energy to be competitive with respect to other available energy sources, in particular for the production of electricity in isolated grids. The technical feasibility of wind projects of small or medium size is likely (electrical grid, electrical load, etc.).
In Chad the political stance has not been clearly stated with regards to the development of wind energy projects and the technical feasibility of wind energy projects is non conclusive, at least in the medium term (electrical grid, electrical load, layout of the land, etc.). In addition, other forms of renewable energy are perceived to be either more competitive or more appropriate in the national context (geothermal, hydraulic, bio-combustible, solar photovoltaic) [1].

**Solar energy**

The Sahel is a region that receives a great deal of solar insulation per year and thus most solar energy technologies can be applied with very good results. The main technologies that have been applied are PV technologies for electrification, solar cookers, solar dryers, solar water heaters etc. Despite the Sahel's large solar potential, solar thermal power generation is a technology that requires large investments and it is maybe a rather ambitious target for the poverty-stricken Sahelian countries. A solar power plant of 25 kW was built in Senegal during the 1970's but it was not as efficient as diesel systems and was abandoned.

The theoretical Solar Energy poential (insolation kWh/m2/day) varies from 4.3 to 6.7 (various sources).

**Biomass Energy**

Besides residues (from agriculture and forestry, from other residues like municipal solid waste (MSW) or sewage sludge, from energy crops and biofuels), biomass mainly comprises firewood and is the most important source of energy in the Sahel.

According to the FAOs study, The Role of Wood Energy in Africa [5], woodfuels include all categories of primary or converted wood used for energy: fuelwood, charcoal and black liquor.

**Fuelwood**: Primary wood combusted as it is for satisfying energy needs, it can be used under different forms (direct, indirect, recovered/recycled)

**Charcoal**: energy item that is derived from fuelwood and used to satisfy final sectorial energy demand or even for electricity generation, where relevant. The Carbonization Ratio (Tons Wood/1 Ton Carcoal): is usually 4.35 tons wood for 1 ton charcoal, but in the case of Africa, where the carbonization efficiency is significantly lower, it ranges from 5 to 12.6 tons of wood for 1 ton of charcoal.

**Black liquor**: specific wood-derived fuel that is recovered and used as fuel for paper manufacturing. The derived energy comes from the lignin removed from the wood pulp.

Africa is the most intensive user of woodfuels, in per-capita terms, with an average annual per-capita consumption of 0.77 m3, or 0.18 toe (tonnes of oil equivalent). In Africa, almost all countries rely on wood to meet basic energy needs. The share of woodfuels in African primary energy consumption is estimated at 60% to 86%, with the exception of North African countries and South Africa. On average, about 40% of the total energy requirement in Africa is met by fuelwood.

The use of wood and other biomass for energy purpose in rural areas maybe sustainable or not, depending on the relative density of the population and of the vegetation, and on the local management of the forestry resources.. The major problem is the dreinage of wood from periurban and urban areas, that can cause local deforestation around the cities and also pressure on the environment of much farer locations.

Another important issue is the conversion of biomass in useful energy. The traditional techniques are often low efficient and emitting dangerous gas for health. Dwellings are small and biomass burning for cooking inside the house (rather than in the exterior like in rural areas) leads to increase respiratory diseases affecting mainly women and children.

**Biomass Data Availability & Quality Issues**

The lack of precision in the estimates of both supply and more particularly, demand of fuelwood in

**Table 2: Land Area, Forest Area, Fuelwood production and Charcoal production. sources FAO and WEC**

| Country | Total Land thousand sqkm | Forest Area thousand sqkm | Fuelwood production (thousand tonnes) | Charcoal Production (thousand tonnes) (FAO) |
|---|---|---|---|---|
| Burkina Faso | 274 | 71 | 9200 | 110 |
| Cape Verde | 4 | 1 | 100 | |
| Chad | 1259 | 127 | 1700 | 301.3 |
| The Gambia | 10 | 5 | 700 | 45.6 |
| Guinea Bissau | 28 | 22 | 300 | |
| Mali | 1220 | 132 | 5700 | 93.1 |
| Mauritania | 1025 | 3 | 200 | 125.5 |
| Niger | 1267 | 13 | 3100 | 409.8 |
| Senegal | 193 | 62 | 3300 | 110.7 |

The data shown on Fuelwood production reflect as far as possible those reported by WEC Member Committees in 2000/2001; if information was not available from this source, estimates for 1999 were projected from FAO time-series of fuelwood production [5]. Also the charcoal data is from [5]

most Sahelian countries makes the estimation of "Shortfalls" and "Surpluses" an exercise clouded by uncertainty. The most current and probably most reliable and collective set of data is that of the World Energy Council (WEC) that has also derived estimates from the FAO study - The Role of Wood Energy in Africa, presented in the following tables. It is important to show what the FAO reports - under the Executive Summary chapter [5] - with regard to data quality issues:

*1. Woodfuels have not been included as a basic sector in Africa's planning processes.*

*2. Such targets are obstructed by the scarcity, limited scope, and poor quality of existing data.*

*3. The FAO database is the only source of data that includes almost all African countries and provides continuous time series for each country.*

*4. However even the FAO database presents estimates rather than actual figures - no detailed sectorial figures.*

*5. The FAO insists upon the necessity of a relevant effort aiming at improving knowledge on woodfuel demand and supply, as well as on its economic and social role, that should clearly be undertaken. Specifically through sustainable and systematic data collection, compilation and analysis processes, with a unified approach and with the involvement of the major international organizations in this field.*

**Biomass over-consumption issues and future resource scarcity**

The general consensus on biomass availability in almost every Sahelian country is that consumption of woodfuels continues to grow at a higher rate than the average annual increment of forest cover, for example in The Gambia, annual fuelwood consumption surpasses wood production by more than 100,000 m3 [8] and the 1st National Communication also reports that the natural forest cover continues to be altered by forest fires .

**Agricultural residues**

Agricultural residues are abundant in the region and very valuable for energy production. For example, the Sugar producing countries (Burkina, Chad, Mali, Senegal) .have large quantities of bagasse available for energy production as a surplus from the internal sugar mills needs. Other agricultural residues comprehend Groundnut, Sporgum, Maize, Millet, Rice, Manioc, Cotton, Watermelons. In Mali Jthropa oil has become an important energy source for the villages served by the Multi Functional Platforms (MFPs).

The Jatropha curcas, is a shrub that grows in southern and western Mali, that is drought resistant. Jatropha seeds contain about 35% of non-edible oil, which could be extracted and used as a substitute for diesel oil in diesel engine. In 1996, Mali had about 10,000 km of Jatropha hedges with a growth rate of 2,000 km per year, which represents a then potential of 5 million litres of oil [9].

**Hydroelectric energy**

Water resources in the Sahel are relatively limited, the major sources that are already being exploited, with large hydro installations on the Senegal River and Niger River and to some degree the Gambia River.

The Manantali Dam

The Dam is the latest big dam built in the region, and serves three countries: Mali , Mauritania and Senegal. The big international project is managed by Eskom Energie Manantali (EEM) on behalf of the River Senegal Development Organization (OMVS) Interconnected Network (RIO). The infrastructure is composed by:

1. the Manantali Interconnected Network (RIMA) with the following features:

• A hydroelectric power station with an installed capacity of 200 MW;

• 12 high-tension posts;

• 1700 km of high-tension lines: 225 kV, 150 kV and 90 kV;

• An average power generation of 807 GWh /year

2. the national networks of 3 countries: Mali, Mauritania and Senegal

| Hydropower - Status of Development at the end of 2002<br><br>source WEC 2004 | In Operation Capacity MW | In Operation Production TWh/year | Gross Theoretical Potential TWh/year | Technically Exploitable capability TWh/year | Economically exploitable capability TWh/year |
|---|---|---|---|---|---|
| Burkina Faso | 32 | 0.079 | 1 | N | N |
| Cape Verde | | | | | |
| Chad | | | N | N | N |
| The Gambia | | | | | |
| Guinea Bissau | | | 1 | N | N |
| Mali | 114 | 0.5 | >12 | >5 | |
| Mauritania | 18 | 0.05 | | | |
| Niger | | | >3 | >1 | 1 |
| Senegal | 38 | 0.01 | 11 | 4 | 2 |

An agreement between the States defines the sharing of power generated at Manantali among the 3 countries: 52% in Mali, 33% in Senegal and 15 % in Mauritania [10]. Mali receives approximately 420 GWh/year.

According to the literature survey carried out during IE4Sahel, the major findings from various sources, regarding available resource potential for hydro, are summarized below: :

**Geothermal energy**

The only geothermal resources are located in East Africa. The East African countries of Tanzania, Djibouti, Malawi, Burundi, Ethiopia, Zambia, Comoros, Eritrea, Kenya, Rwanda, and Uganda all lie in the highly volcanic East African Rift.

There is no geothermal potential detected so far in the Sahel region. There may be low temperature heat, maybe in deep aquifers, but there have been no measurements so far, probably due to the cost.

**References:**


**1. Hélimax Énergie Inc. (2004). Strategic Study of Wind Energy Deployment in Africa - Strategic Plan for Wind Energy Deployment in Africa (Executive summary). Presented to African Development Bank, Côte d'Ivoire. Montreal, Canada.**

**2. Sarr, S. and J. P. Thomas (2005). The role of renewable energy in the development of productive activities in rural West Africa: the case of Senegal. Final Report, "Renewable Energy Technology Working Group" Global Network on Energy for Sustainable Development. Enda-TM**

**3. World Bank (1999). Project Appraisal Document on a Proposed Credit in an Amount of SDR 12.5 Million and a GEF Grant in an Amount of US$4.7 Million equiv. to the Republic of Cape Verde for an Energy and Water Sector Reform and Development Project. Report No. 19143, Energy Unit, Country Department 14, Africa Region.**

**4. I. Youm et al. (2000). Renewable energy activities in Senegal: a review, Renewable and Sustainable Energy Reviews 4 (2000) 75-89. Elsevier.**

**5. FAO (1999). World Energy Today for Tomorrow (WETT) – The Role of Wood Energy in Africa. Rome.**

**6. World Bank 2000 'African Development Indicators 2000' World Bank, Washington**

**7. WEC (2004). Survey of Energy resources 2004. World Energy Council.**

**8. Sallah, Y. M. A. (2000). EC-FAO Partnership Programme (1998-2002) - Project GCP/INT/679/EC Data Collection and Analysis for Sustainable Forest Management in ACP Countries - Linking National and International Efforts. Woodfuel review and assessment in Gambia.**

**9. Edjekumhene, I. (2003). Status of Renewable Energy and Energy Efficiency Systems in West Africa. Background Paper (1st Draft) Prepared for the West African Regional REEEP Consultation Meeting in Accra, Kumasi Institute of Technology and Environment (KITE), Ghana.**

**10. Kazadi Beneki TSHIBINGU 2004. Eskom Energie Manantali Presentation to NARUC: Bamako July 26-30, 2004.**

**11. A. Bartle (2002). Hydropower potential and development activities, Energy Policy 30 (2002) 1231-1239. Elsevier.**

**12. World Bank (2003). MALI - Mali Household Energy and Universal Access Project (HEURA), Report No. PID11607, Africa Regional Office.**

**13. Small Hydro Atlas website: http://www.small-hydro.com**




**Project Schedule**

The project is scheduled to be developed until mid-2007, with the realisation of two main Workshops, from where the project team already ask for interested parties to mark in your agenda.

1st Workshop - 3 - 6 October 2006 – Niger

2nd Workshop - May 2007

Besides these two Workshops the project is also committed to involved institutions to build a permanent network between the professionals

| | | | |
|---|---|---|---|
| Istituto Superior Tecnico<br>RGESD - IST<br>Portugal | ESD - Energy for Sustainable Development ltd<br>UK | CRES - Center for Renewable Energy Sources.<br>Greece | ARC - AGHRYMET Center<br>Niger |
| Long experienced research team in the field of energy planning and renewable energy systems. | Consultant firm with experience in energy policy and regulation. | The Greek national centre for Renewable Energy Sources, Rational Use of Energy and Energy Saving. | Specialised institution committed with the food security and to help the management of natural resources in the CILSS region.. |

The Project Team
How to contact the Project Team

to have up to date information on the project visit our website - http://ie4sahel.energyprojects.net
to contact the staff, receive the newsletter, contribute with papers or for informations and comments ie4sahel@energyprojects.net

Or use the following form

Family Name.....First Name.....
Profession.....Company-Institute.....
Postal address..... .Postal code.....City.....Country.....
Phone ..... Fax.....E-mail.....

☐ I am interested in the IE4 Sahel project. Send me an invitation for public meetings about IE4 Sahel.

☐ Please add only my name to the mailing list and send me more information about IE4 Sahel

Send to ARC – AGRHYMET Regional Centre P.O.Box 11011 - Niamey – Niger Fax: + 227 73 29 78 or to IST – RGESD - Mch. Dep. - Pv. de Mecânica I, 2º Andar Inst. Sup. Técnico - Avenida Rovisco Pais 1049-001 - Lisboa – PT Fax: +351 - 21 847 5545