Promoting rural electrification using small aerogenerators

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Outline

- CIFRES Presentation
- World Energy Context
- Senegal, energy country situation
- Rural Electrification
- EOLSENEGAL programme
- Achievements

Presentation of CIFRES

Centre International de Formation et de Recherche en Énergie Solaire

- **International Centre for Training and Research in Solar Energy**
- **Inaugurated in october 2002**

CIFRES

- **Established within the framework of the ICSC-World Laboratory and the Senegalese government convention**

- **Located within the Polytechnical school premises to promote cross-disciplinary research and to train scientists and technicians**

- **Aims at developing the use of natural resources through appropriate technology transfer**

CIFRES inauguration in october 2002 by Senegalese President , Aboulaye Wade

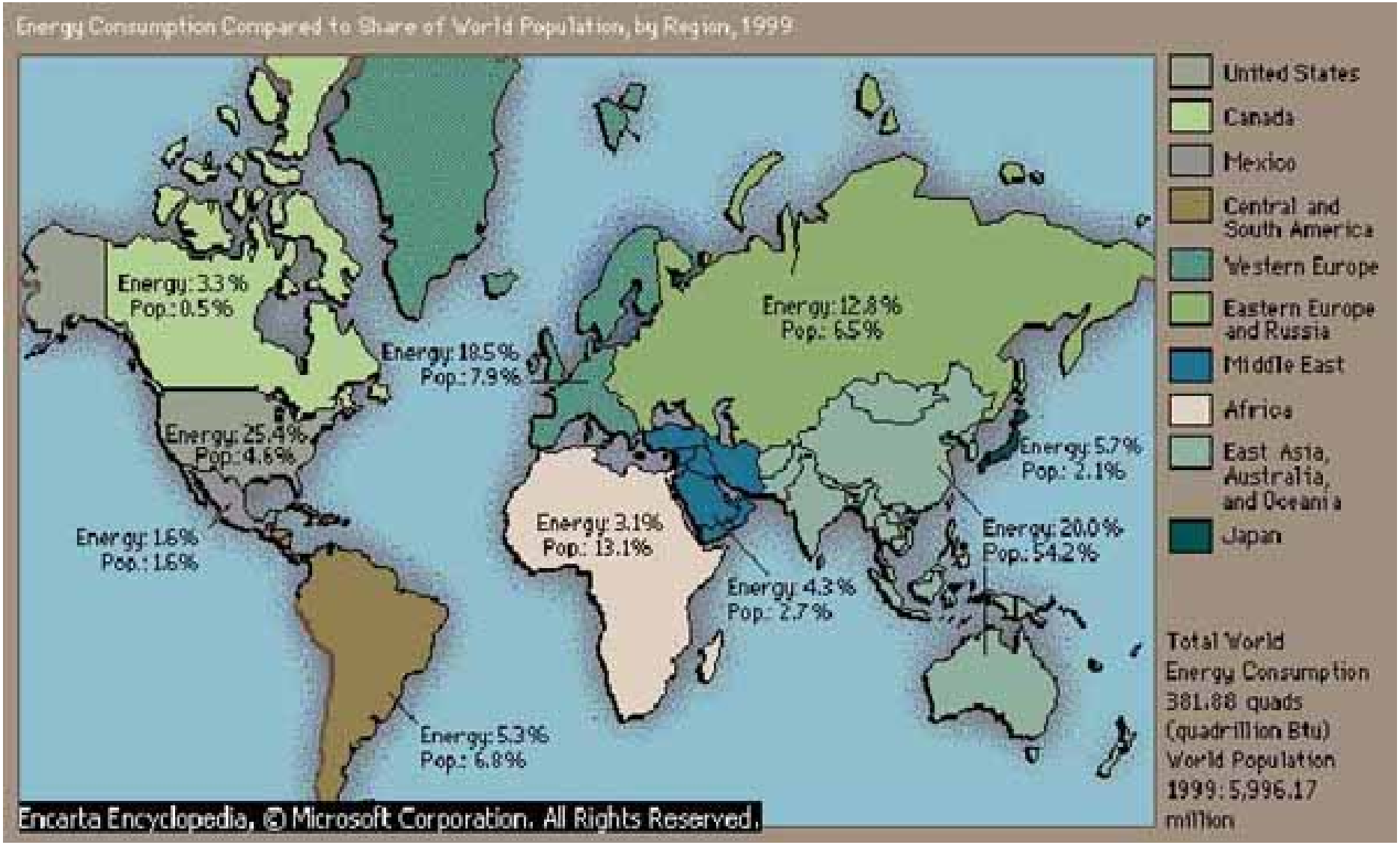
Focus

- Photovoltaic solar Energy
- Thermal Solar Energy
- Wind Energy

WORLD CONTEXT

EARTH AT NIGHT

World energy consumption



Sénégal : COUNTRY ENERGY SITUATION

Source : Système d'Information Energétique (SIE)


Ponta Delgada
Lisbon
Madrid
Barcelona
Rome
Athens
Ankara
Yerevan
Baku
Tehran
Algiers
Tunis
Valletta
Tripoli
Mediterranean Sea
Alexandria
Cairo
Beirut
Damascus
Amman
Jerusalem
Baghdad
Kuwait
Riyadh
Esfahan
Shiraz
Rabat
Casablanca
Tropic of Cancer
Praia
Nouakchott
Dakar
Banjul
Bissau
Bamako
Niamey
Ouagadougou
NDjamena
Conakry
Freetown
Monrovia
Abidjan
Accra
Lome
Abuja
Novo
Malabo
Libreville
Sao Tome
Equator
Brazzaville
Kinshasa
Luanda
Bangui
Khartoum
Asmara
Sanaa
Djibouti
Addis Abbaba
Mogadishu
Kampala
Kigali
Nairobi
Dar es Salaam
Moroni
Antananarivo
Lusaka
Lilongwe
Harare
Windhoek
Walvis Bay
Gaborone
Pretoria
Johannesburg
Maputo
Mbabane
Bloemfontein
Maseru
Durban
Cape Town
Tropic of Capricorn
ATLANTIC
OCEAN
1000 Miles
1000 Km


Mauritania
Senegal
Dakar
Mali
Gambia
Guinea-Bissau
Guinea
Sierra
Leone

Some country figures :

- **Total population in 2011 :** 12,855,153 inhabitants
- **Area :** 196,722 km2
- **Urban population :** 41 %
- **Density :** 48 habitants per km2
- **Population growth :** 2.5 % per year
- **Youth :** 58 % under 20
- **Active population :** 42 %
- **Illeteracy :** 59.2 % (2007)
- **Religions :** 94 % Moslems , 5 % Christians , 1 % traditional religions
- **More than 54 % of this population live in the rural areas**.

http://www.gouv.sn/senegal/index.html

Electrification Rate

Electrification Rate

Ratio between the number of households with access to electricity and the total amount of households in the considered regions.

Urban Electrification Rate

Towns	2000	2001	2002	2003	2004	2005	2006
Dakar	66%	68%	70%	72%	75%	79%	80%
Diourbel	58%	60%	63%	63%	65%	68%	70%
Fatick	44%	47%	53%	55%	63%	68%	74%
Kaolack	53%	55%	59%	59%	68%	72%	76%
Kolda	37%	40%	42%	43%	51%	54%	58%
Louga	55%	56%	60%	62%	75%	78%	81%
Matam	20%	22%	24%	41%	53%	58%	61%
Saint Louis	56%	57%	59%	60%	66%	68%	71%
Tambacounda	45%	46%	48%	51%	55%	59%	62%
Thiès	50%	52%	57%	59%	72%	76%	81%
Ziguinchor	32%	35%	39%	42%	47%	52%	56%
Sénégal	**58%**	**60%**	**63%**	**65%**	**71%**	**74%**	**77%**

Source : *SIE-Sénégal 2007*

❑ Rural Electrification Rate (%)

Conventionnal and PV

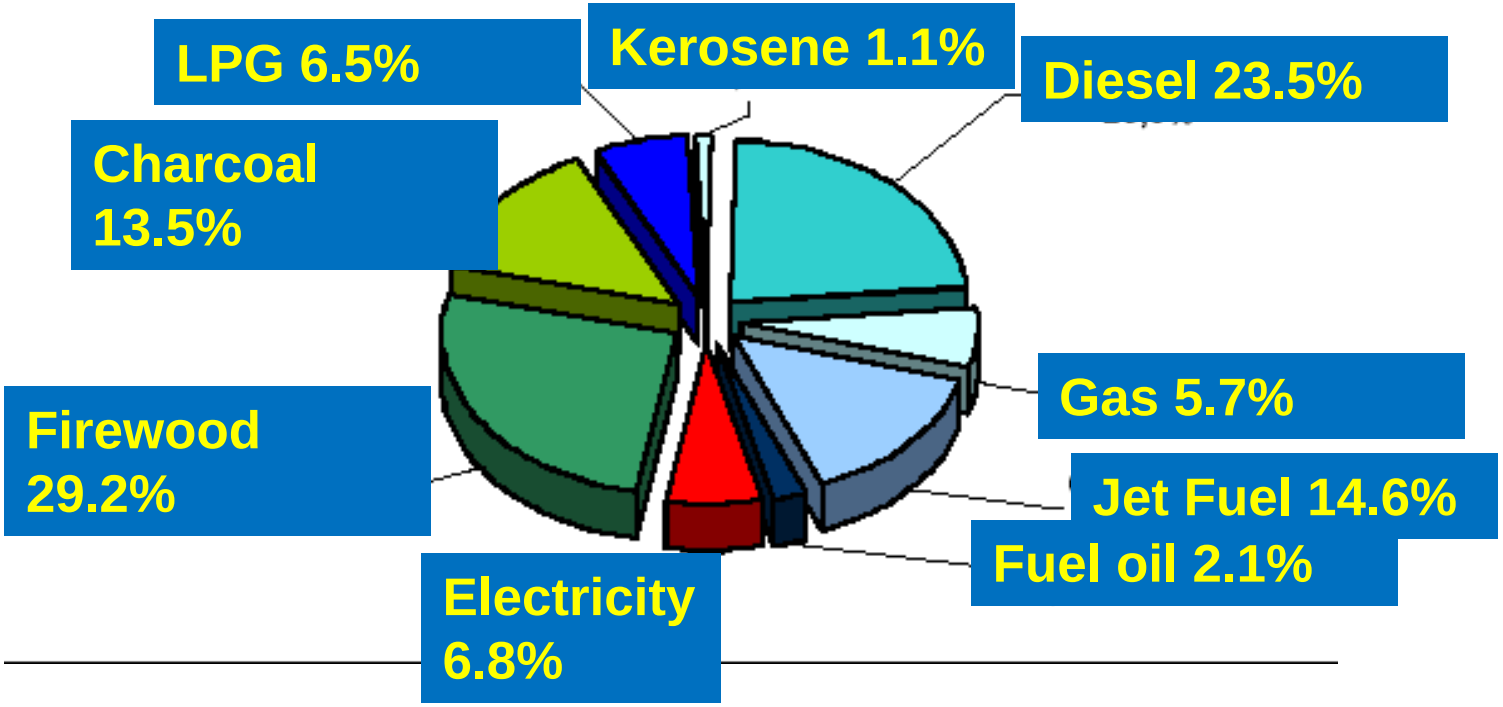
Rural areas in regions

Conventionnel & PV							
Zones rurales des régions	2000	2001	2002	2003	2004	2005	2006
Diourbel	22%	24%	26%	28%	30%	32%	34%
Fatick	12%	12%	12%	12%	24%	25%	26%
Kaolack	5%	6%	6%	7%	9%	10%	10%
Kolda	1%	1%	2%	2%	2%	3%	3%
Louga	8%	9%	10%	11%	11%	12%	13%
Matam	9%	11%	14%	16%	12%	13%	15%
Saint Louis	6%	8%	10%	11%	10%	11%	13%
Tambacounda	1%	2%	2%	2%	4%	5%	6%
Thiès	12%	14%	15%	17%	12%	14%	16%
Ziguinchor	2%	3%	3%	4%	4%	6%	8%
Sénégal	9%	10%	11%	12%	13%	14%	16%

Source : *SIE-Sénégal 2006*

National GRID

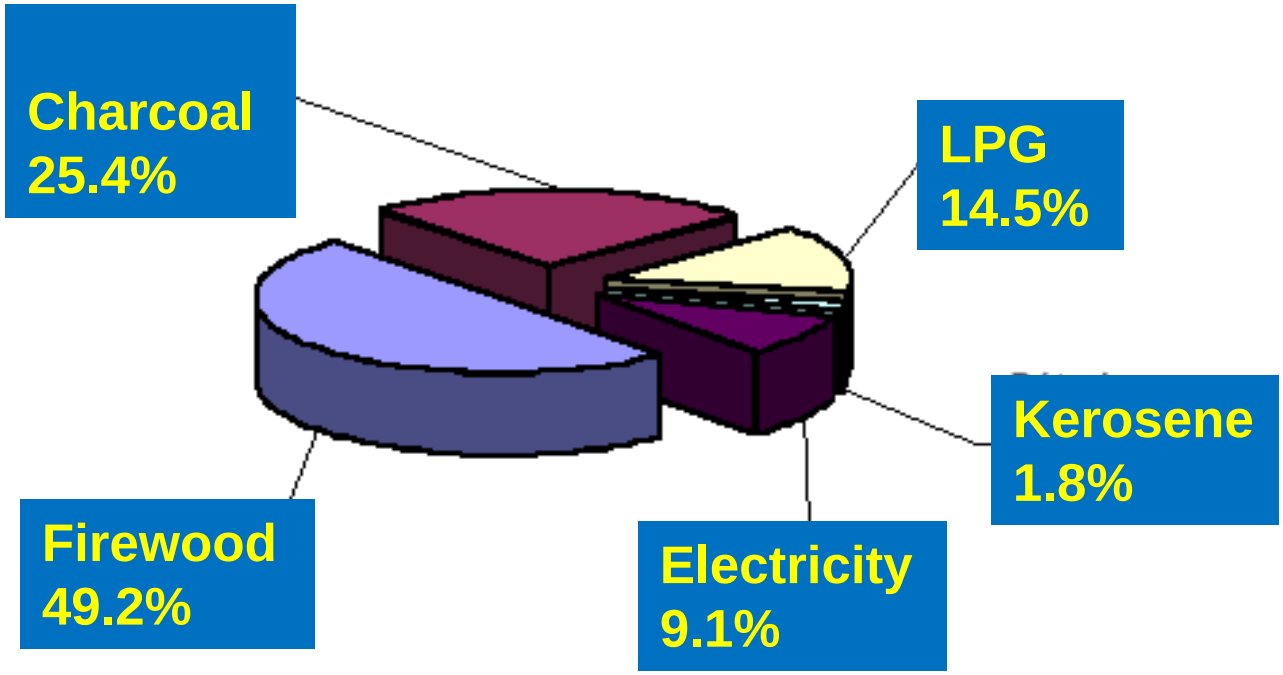
Energy consumption in Senegal



Distribution of the energy by product

- Proeminence of petroleum products : 53%
- Wood products (wood and coal) : 40%
- Electricity share : 7% (very low)

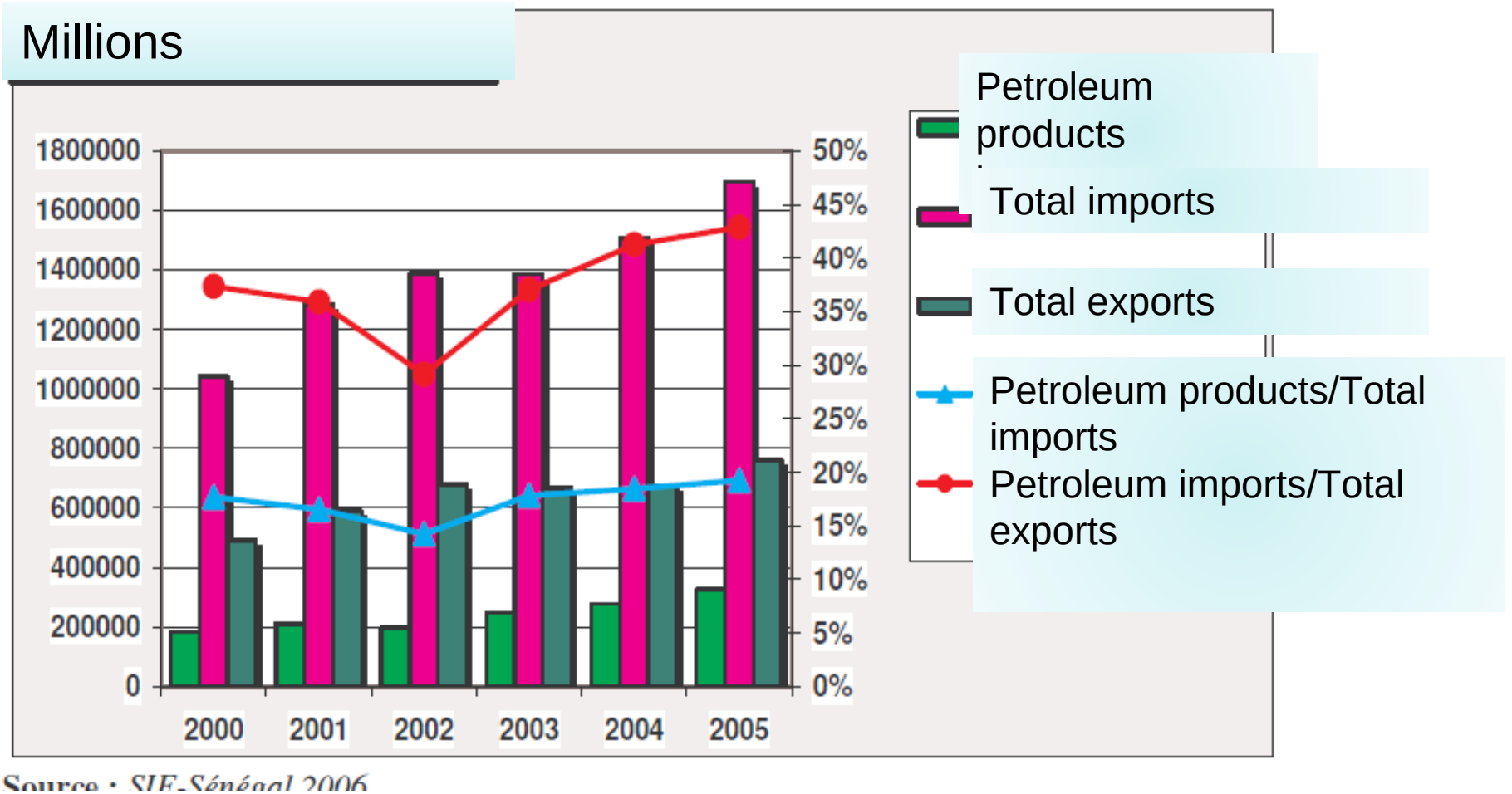
Energy consumption in Sénégal (cont[ed])



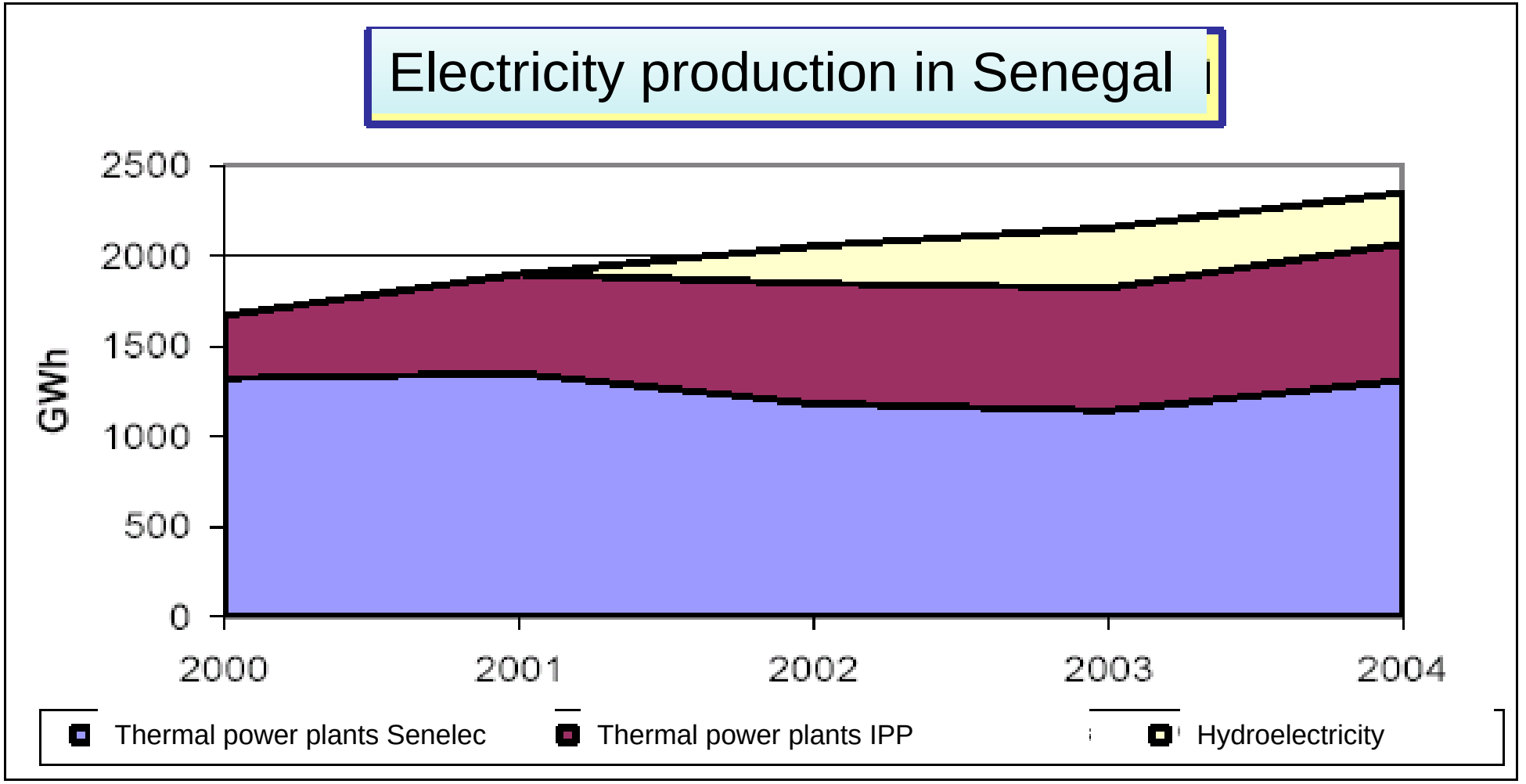
Distribution of the energy in household sector

- 75 % of domestic energy from wood
- 89 % of household energy is used for cooking
- Weakness on the part of electricity : 9%

Evolution of the oil bill in Senegal

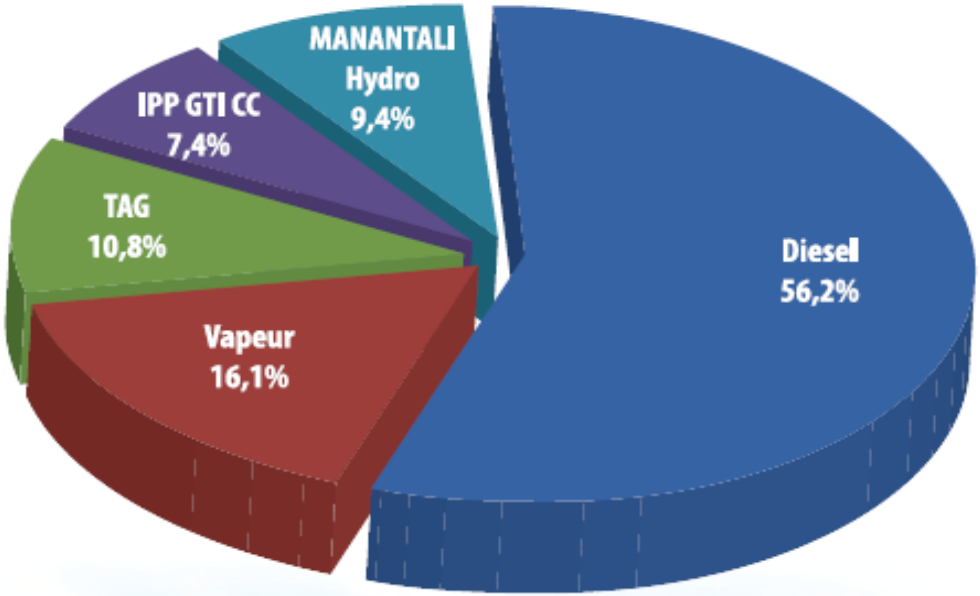


Source : *SIE-Sénégal 2006*



- 88 % of the electicity production come from thermal power plants
- The remainder from Hydroelectricity (Manantali)
- The use of renewable energies is very low

Grid installed power in 2008

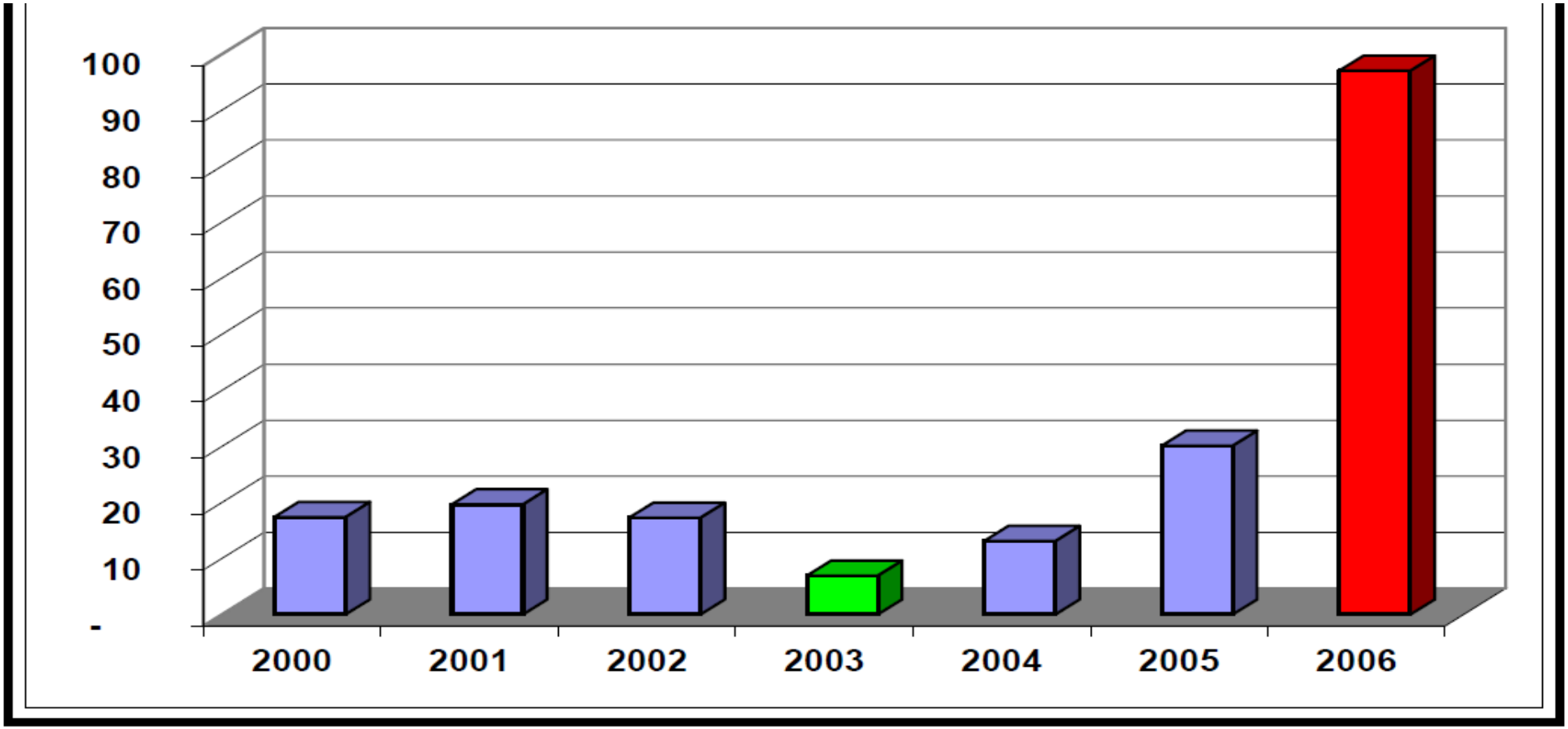


Price	1998	1999	2000	2001	2004	2005
FCFA /kWh	72,27	73,75	74,10	73,30	82,00	120,28
centEUR/kWh	11,12	11,35	11,40	11,28	12,50	18,34

Annual Report. 2008

Senelec
Notre énergie pour vous servir

Production deficit



Source : *SENELEC, SIE-Sénégal 2007*

Two major problems in SENEGAL

- The energy demand mainly depends on the oil imports
- The overexploitation of the natural forests, which provide more than half of the energy consumed, causes fast deforestation

Consequences

- Problems of national independence

  Senegal is widely dependent on oil import

- Economic problems

  Exhange leackage

  Weakness of the industrial sector

  Poverty specially in rural areas (rural exodus)

- Environmental problems

  Deforestation

  Greenhouse Gases (GHG) Emission

☞ Necessity to use alternative energies

Rural Electrification

Rural electrification is the process of bringing electrical power to rural and remote areas.

Electricity is used not only for lighting and household purposes, but it also allows for mechanization of many farming operations, such as threshing, milking, and hoisting grain for storage

In impoverished and undeveloped areas, small amounts of electricity can free large amounts of human time and labour.
In the poorest areas, people carry water and fuel by hand, their food storage may be limited, and their activity is limited to daylight hours.

Rural Electrification

Adding electric-powered wells for clean water can prevent many water-borne diseases, e.g. dysentery, by reducing or eliminating direct contact between people (hands) and the water supply.

Refrigerators increase the time that food can be stored, potentially reducing hunger, while evening lighting can lengthen a community's daylight hours.

Rural Electrification in Senegal

Rural Electrification in Senegal

Based on a recent study in Senegal, rural electrification can be divided into 04 groups (levels of energy consumption) :

Source : Peracod

Demand	Group 1			Group 2			Group 3			Group 4		
	Nb	HO	Wh	Nb	HO	Wh	Nb	HO	Wh	Nb	HO	Wh
Lamps (11W)	3	3H	99	5	3H	165	8	3H	264	9	3H	297
Tape recorder (15W)	1	6H	90	1	4H	60	1	4H	60	1	4H	80
B&W TV (20W)				1	4H	80	1	4H	320	1	4H	320
Color TV (80W)							1	4H	300	1	10H	1000
Refrigerator (100W)										1	5H	300
Fan (60W)												
Congelator (112W)												
Total consumption/day (W) (Wh/day)			**199**			**305**			**944**			**1977**

New Policy

- Rural Electrification, once based on a single approach of extension of the existing grid or installing diesel power generating units, must now make a dominating place with renewable energies for an access of the rural populations to electricity

CIFRES Project : Eolsenegal Programme

Building small aerogenerators in Senegal for rural electrification

Wind energy in Senegal

- A favourable wind potential in a wide band along the coast (wind speeds greater than 4 m/s)
- Mechanical wind turbines implanted predominantly in the north of the country

(water pumping)

- Aerogenerators not enough installed

Obstacles to developing Wind energy in Senegal

- **Technical problems to overcome:**
  - Cut-in speed (to set and maintain the blades into motion) for commercial wind turbines still high
  - Low resilience to erosion (due to sand particles) and to heat
- **Problems related to supply parts:**
  - High costs
  - Not readily available
  - **Limited trained work force:**
  - This induces poor management and maintenance as well as reduces the life span of installations.

Eolsenegal Project

Project features:

- Use of local materials and expertise to build the aerogenerators
- Local management and maintenance
- Low cost products to ensure affordability for rural populations

Eolsenegal Project(2)

Aims:

- To Provide energy for rural areas
- To secure energy self-sufficieny
- To achieve industrial development
- To create jobs and boost R&D in the wind energy sector
- To achieve competitiveness to the fossil

Eolsenegal Project(3)

Aims (2):

- To meet community needs such as schools,offices and street lighting
- To generate community jobs: small units for grinding, processing or properly storing crops
- To provide local services and income sources
- To fight against rural exodus

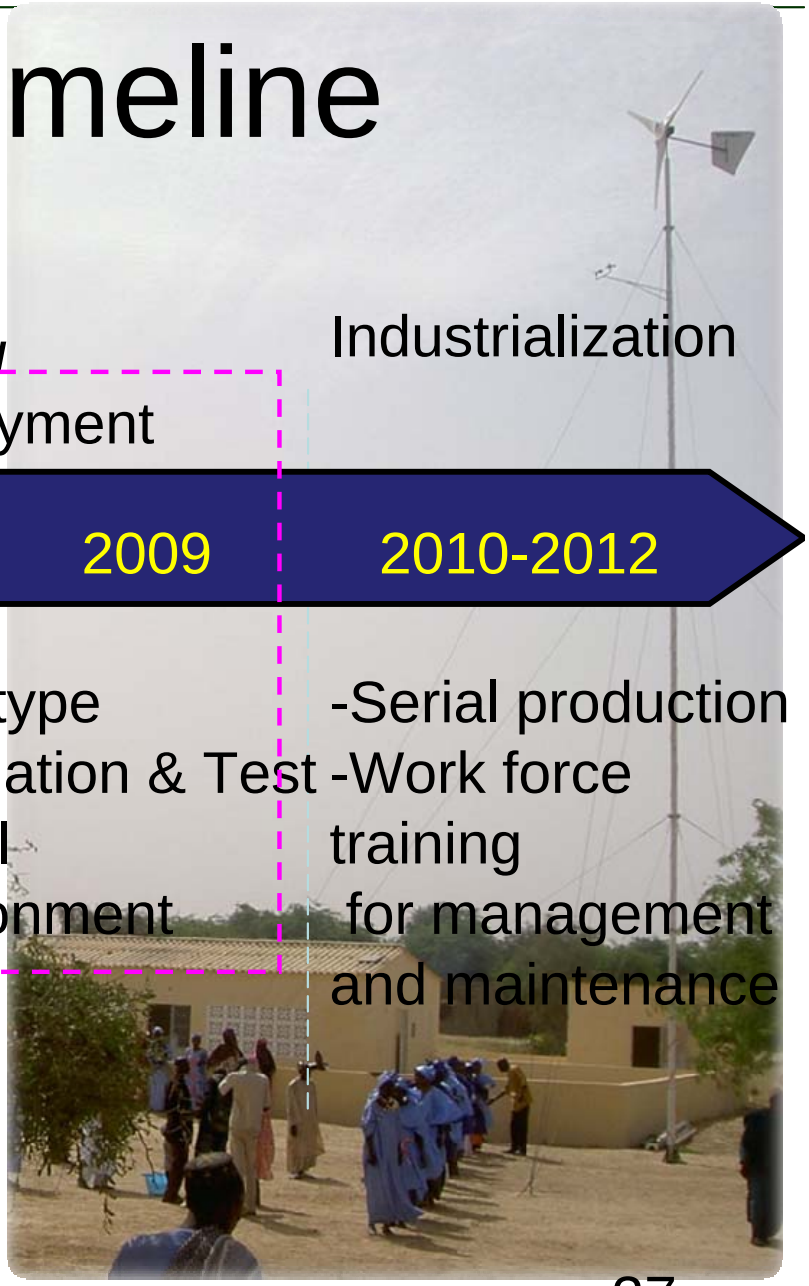
Objective of Eolsenegal programme

The programme aims to launch a partnership with local manufacturers and maintenance operators for small wind turbines

- Wind turbine specially adapted to the wind potential of Senegal
- Entirely manufactured in Senegal
- 95% use of local materials
- Technicians trained for maintenance
- Senegalese market covered first and then extended to all Africa

Programme's Timeline

2006	2007	2008	2009	2010-2012
Feasability Studies	Technical Validation		In *situ* deployment	Industrialization
-wind profile study -aerogenerator design	-Design & Test of Prototype at ESP -Improvements		Prototype Installation & Test in real environment	-Serial production -Work force training for management and maintenance



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Energy Research Centre

Phase I – Feasibility study

- Study of wind potential,
- Designing and optimisation of the wind turbine
- Adaptation to local conditions, economic viability, local manufacturing, maintenance
-

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Phase II – Technical validation

- Testing the first prototype at the Ecole Superieure Polytechnique de Dakar
- Measuring the characteristics of the wind turbine

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Energy Research Centre

Phase III – Pre-release

- Installation in a village in Northern Senegal
  - Ownership of the wind turbine by the villagers
  - Establishment of income generating activities.
  - Training of a technician to monitor the installation
  - Funding of maintenance by users

Phase IV – Industrialisation

- Coming up :
  - Launching the sector of manufacturing and maintenance of wind turbines in Senegal.

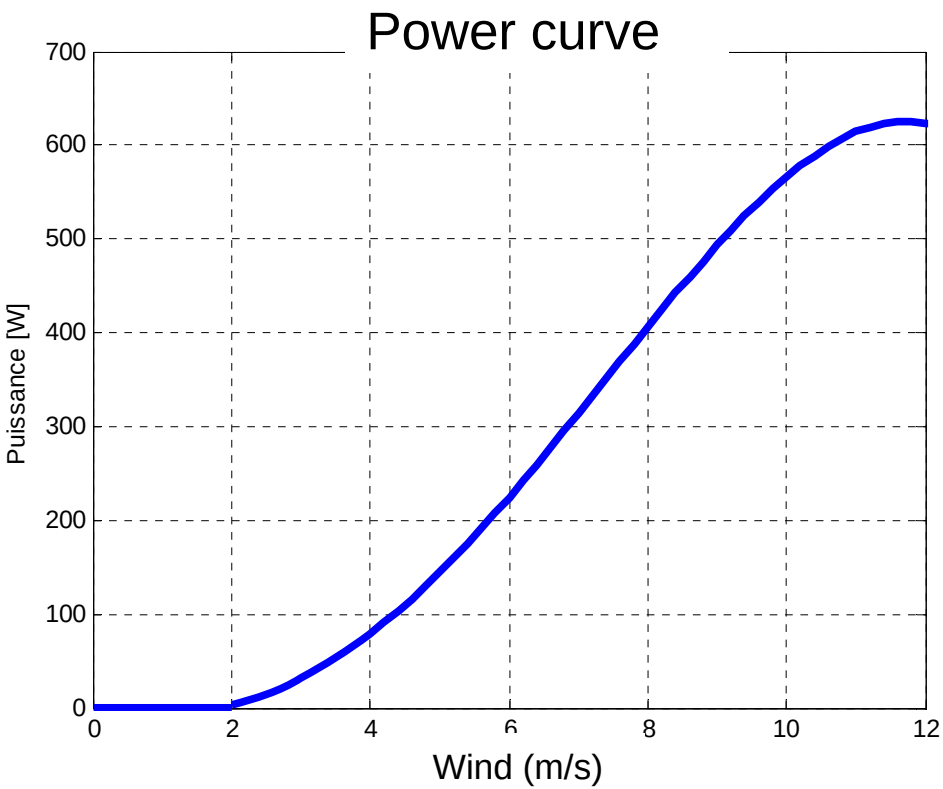
Wind turbine technical data

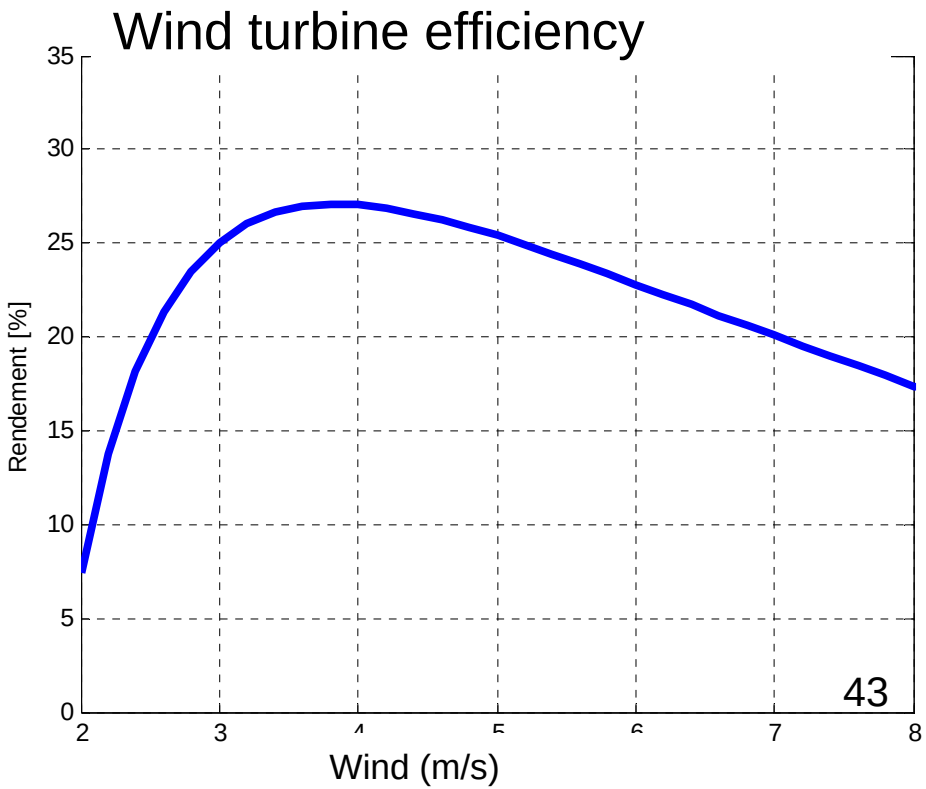
Nominal power	500 W
Blades Diameter	3m
Output voltage	24 V DC
Mast	Guyed 18m
Maximum rotation speed	300 tr/min

Wind turbine technical data

- Starting wind speed (2 m/s)
- Maximum performance for wind speeds from 3 to 5 m/s

➡ Wind turbine suitable for wind energy potential in Senegal





Achievements

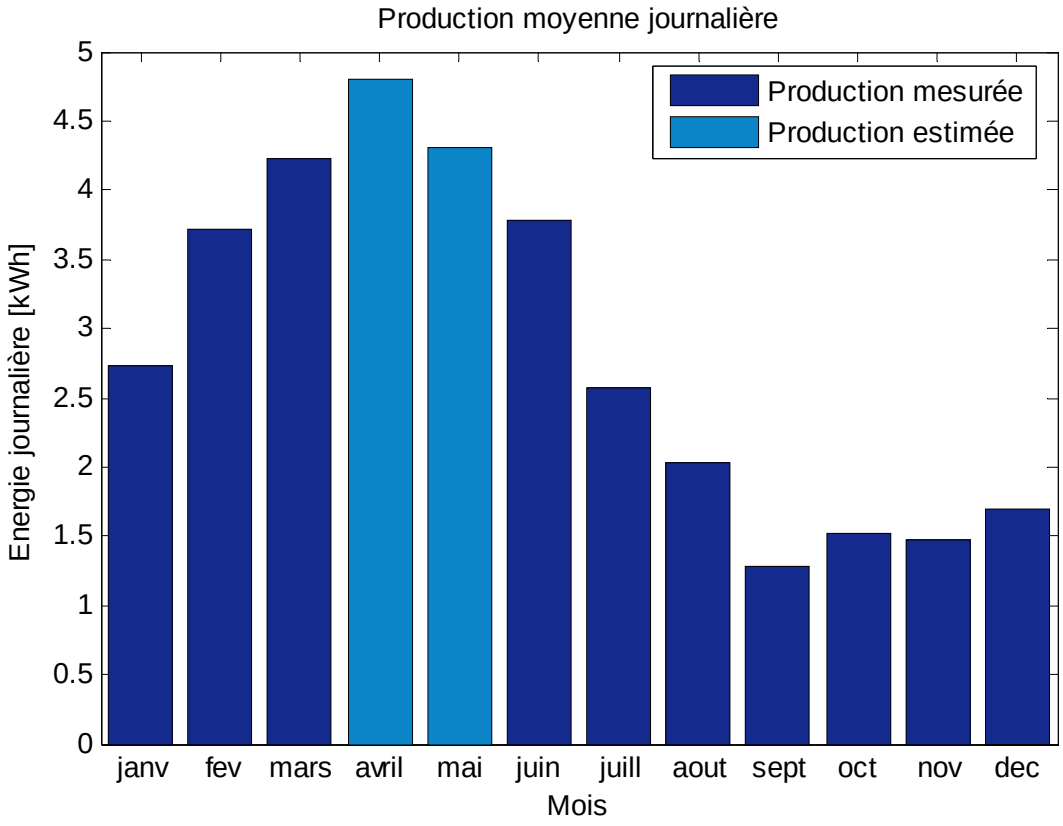
First prototype installed:

- A wind turbine is installed since june 2008 in the village of GOBACK (Northern Senegal)
- Electricity for the school and the village clinic
  - 13 lamps + 4 ceiling fans
  - 4 x 220V outlets
  - 1 domestic battery charger

Wind turbine energy production

- **<u>1000 kWh/year</u>**

  mean wind speed : 4.2 m/s.



Other achievements

- Sendou project (wind pumping and lighting)
- January 2010.
- Sendou village is located north of Dakar in the department of Rufisque.
- Drip-drop irrigation system
- Lighting

  This project is made possible through the partnership between the CIFRES (technical partner), Association for the Development of Clean Energy (ASDEP), Sendou Women Association, and the Belgian Technical Cooperation (BTC).

Other achievements

- **Bayakh project (wind pumping)**

The wind turbine was installed in November 2009

Bayakh is in the Thies Region and the project site is specifically located in the village of Keur Abdou Ndoye.

Drip-drop irrigation system (one hectare area)
Lighting

This project is made possible through the partnership between the CIFRES, Enda ProNat and the Fédération des Agro-Pasteurs de Diender (FAPD)

Other achievements

- Deni Biram Ndao Project (electrification with solar and wind)

The installation was carried out at the beginning of April 2010 The village of Déni Biram Ndao is in the Dakar region around the Pink Lake.

Electrification of the pilot village inhabited by underprivileged children and former prison inmates .

In this project, the turbine is coupled to a photovoltaïc system for the electrification of the village.

The system allows residents to carry out income-generating activities such as poultry farming.

This project is the result of the partnership between CIFRES and Village Pilote NGO.

Other achievements

- **ESP and EPT Project**

Installation of wind / solar platform for high-level training of specialists in the field of solar and wind.

A 500W wind turbine and a 440Wc solar system installed in Ecole Supérieure Polytechnique (ESP) and Ecole Polytechnique de Thies (EPT).

This project is the result of the partnership between CIFRES, French Cooperation,, ESP and EPT.

Other achievements

- Enda Pronat Project

- Development and installation of three (3) wind turbines on sites selected by Enda for lighting and pumping

  This project is in partnership between the CIFRES, Enda Pronat, the French Global Environment Facility (GEF) and ADEME.

Comparative costs

	Turbine	Producer	Type	Power (W)	Output (kWh/y)	Price (€)
	Energy Ball V100	Home Energy	HAWT	500	500	2500
	Enflo 0071	Enflo - windtec	HAWT	500	1700	3294
	Wind Power Generator	ZKenergy	HAWT	600	600	1669
	EolSenegal	CIFRES	HAWT	500	1000	2000

Source :http://www.allsmallwindturbines.com/

Conclusion

- The proposed aerogenerators can help promote the development of rural electrification.

Therefore the technology should be disseminated alongside other alternative energy sources such as the photovoltaic energy and biogas.

- Another quite interesting corollary is the practical involvement of people in rural areas.

Some pictures…

Some pictures…

Some pictures…

Some pictures…

Some pictures…

Some pictures…

Some pictures…

Aerogenerator in GOBACK (near Saint-Louis)

Some pictures…

Thank you