EMISSIONS REDUCTION PROFILE

Senegal

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ENERGY, CLIMATE AND SUSTAINABLE DEVELOPMENT

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Contents

Brief Profile

Full name:	Republic of Senegal	Life expectancy:	55 years (men), 59 years (women) (UN)
Population:	12.8 million (UN, 2010)		
Capital:	Dakar	Monetary unit:	1 CFA (Communaute Financiere Africaine) franc = 100 centimes
Area:	196,722 sq km (75,955 sq miles)		
Major languages:	French (official), Wolof	Main exports	Fish, peanuts, petroleum products, phosphates, cotton
Major religion:	Islam		

Figure 1. Map of Senegal

Economy, Growth and Emissions

Senegal is known as one of the most stable democracies in Africa, and has a long history of participating in international peacekeeping and regional mediation. However, being predominantly rural and with limited natural resources, Senegal is a major recipient of international donor assistance, which in 2000 represented about 32% of overall government spending. The economy is dominated by a few strategic sectors, including fisheries, groundnuts, and services. High rural poverty and limited access to rural infrastructure and basic services have resulted in considerable migration to urban areas, although 58.5% of the population remains in rural areas.[1]

Senegal is heavily dependent on imported oil products (Figure 2), and the country's electric company, SENELEC, has had serious financial difficulties as a result of oil price increases. The government's most immediate effort has been to prepare a 2010-2014 Emergency Electricity Plan aimed at removing the issues related to electricity supply, by ensuring additional power capacity prior to the commissioning of a coal-fired power plant scheduled for 2015.

Senegal's gross domestic product (GDP) was estimated to have grown by 4% in 2011, and this trend is expected to continue over the coming years (Figure 3-5). The increase is mainly driven by private consumption, which itself is sustained by transfers from Senegalese working abroad, and by the industrial and service sectors.[2]

The climate in Senegal is characterized as Sudano-Sahelian, and most of the country lies within the drought-prone Sahel region, with irregular rainfall and generally poor soils. With only about 5% of the land irrigated, Senegal continues to rely on rain-fed agriculture, which occupies about 75% of the work force. The agricultural sector is highly vulnerable to variations in rainfall, which has led to frequent droughts as well as changes in world commodity prices. Senegal is a net food importer, especially of rice, which constitutes almost 75% of cereal imports. The country also imports most of its milk and dairy products. Arabic gum is one of the leading agricultural exports, while the fisheries sector remains Senegal's main economic resource and a major foreign exchange earner.

The largest emitting sector in Senegal is the energy sector, contributing to 49% of the country's total emissions. This is followed by the agriculture sector at 37%, waste at 12%, and 2% stemming from industrial processes. The total amount of these emissions is 16,894 Gg CO_2, however, some 10,587 Gg CO_2 is being sequestrated by the forestry sector (Figure 6).[3]

[1] *http://www.worldbank.org/en/country/senegal/overview*

[2] *http://www.africaneconomicoutlook.org/en/countries/west-africa/senegal/*

[3] *http://unfccc.int/files/national_reports/non-annex_i_natcom/meetings/application/vnd.openxmlformats-officedocument.presentationml.presentation/senegal_snc.pptx*

Figure 2. Total primary energy supply in Senegal in 2006, and electricity produced by source, *SIE-Sénégal 2007*

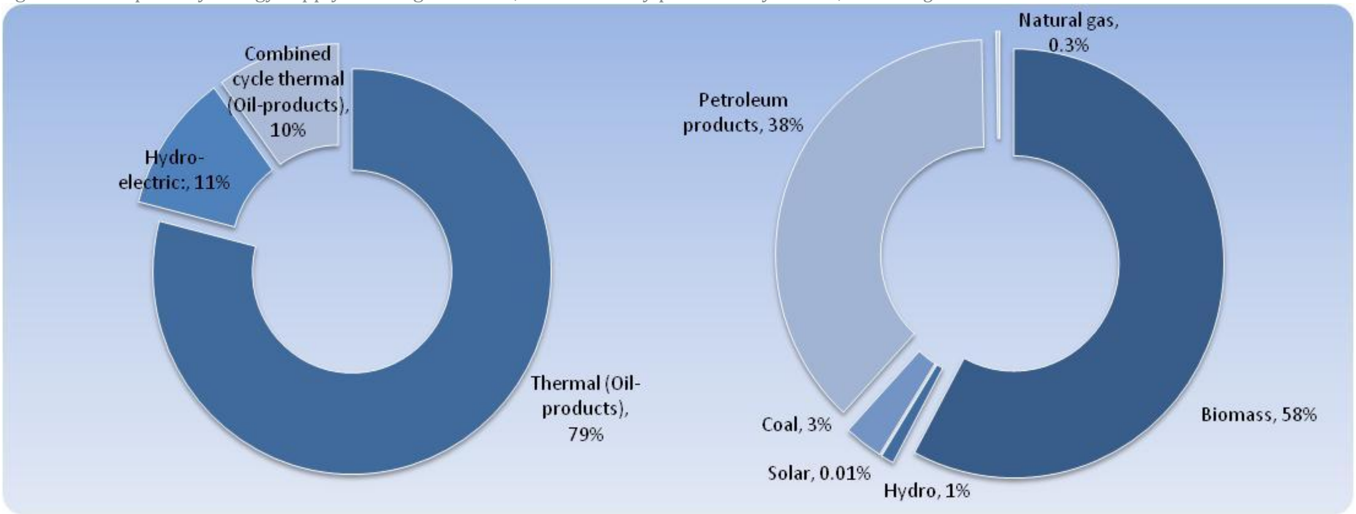


Figure 3. Economic growth since 1990 (GDP percent change)

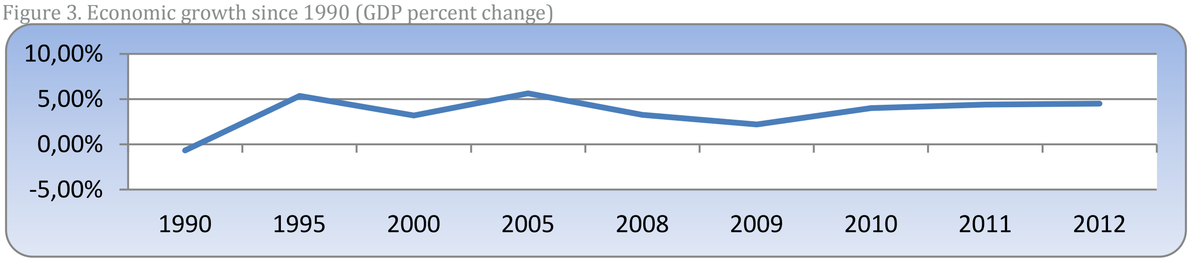


Figure 4. Economic growth since 1990 (GDP USD billions)

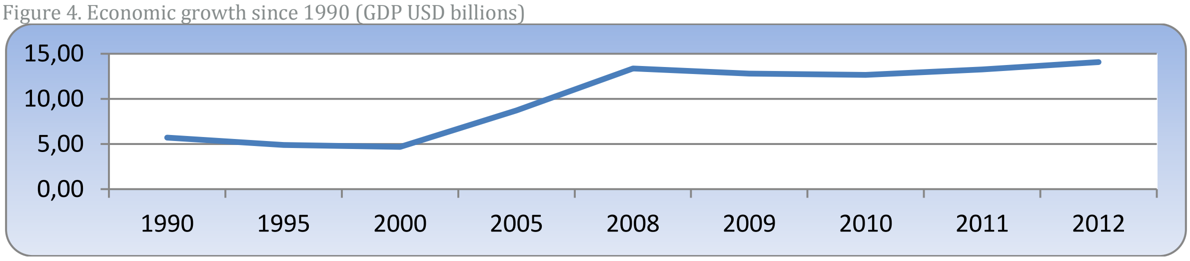


Figure 5. Economic growth since 1990 (GDP in USD per capita)

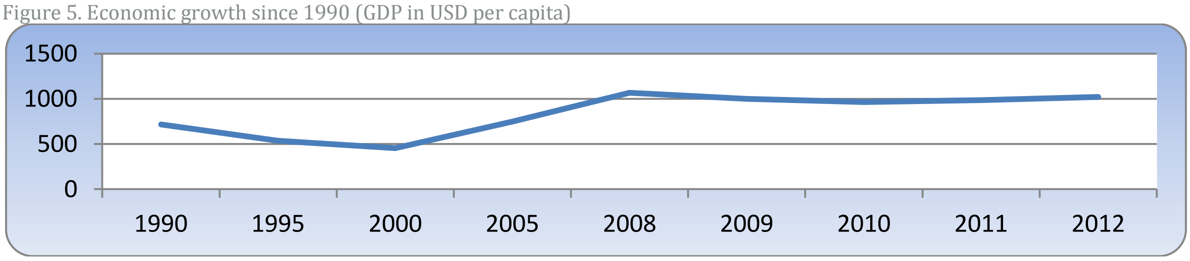
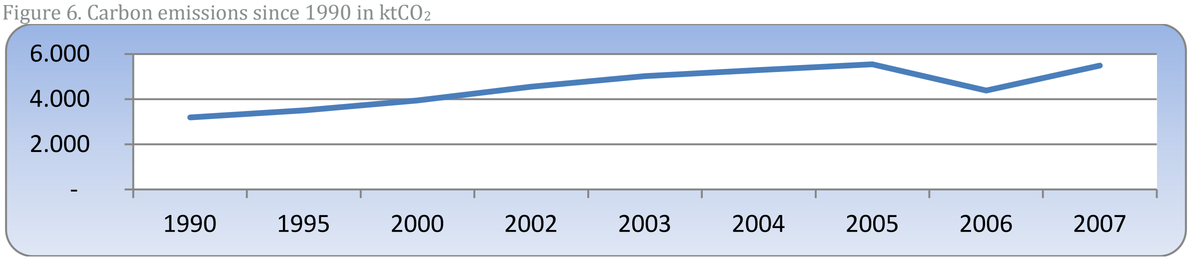


Figure 6. Carbon emissions since 1990 in $ktCO_2$



Status of CDM Development and Capacity Building in Senegal

The potential of the CDM has been recognized in Senegal in recent years, leading to a number of submissions to the EB. To date, Senegal has five "normal" CDM projects, and one programmatic CDM project in the CDM pipeline (one is registered, another is requesting registration, and the last three, plus the pCDM project, are undergoing validation), which places the country in the top 5 in total project numbers among African LDCs.

Name	Status	Type	tCO_2 reduction/ year	Date of submission	Name
Energy efficiency improvement Project of CSS sugar mill	Registered	Bagasse power	37,386	28/12/2010	Energy efficiency improvement Project of CSS sugar mill
M'beubeuss Landfill Methane Recovery Project	At Validation	Landfill flaring	106,730	01/06/2011	M'beubeuss Landfill Methane Recovery Project
Oceanium mangrove restoration project	At Validation	Mangroves	2,262	25/02/2008	Oceanium mangrove restoration project
Partial Substitution of Coal by Jatropha Fruits and Biomass Residues in the Production of Portland Cement	Requests registration	Agricultural residues to power	54,315	01/03/2012	Partial Substitution of Coal by Jatropha Fruits and Biomass Residues in the Production of Portland Cement
Taiba N'Diaye Wind Energy Project, Senegal	At Validation	Wind	196,560	01/04/2013	Taiba N'Diaye Wind Energy Project, Senegal
Promotion of Energy-Efficient lighting using Compact Fluorescent Light Bulbs in rural areas in Senegal	At Validation	Lighting in household	3,835	01/04/2013	Promotion of Energy-Efficient lighting using Compact Fluorescent Light Bulbs in rural areas in Senegal

Overview of CDM Opportunities in Senegal

Agriculture and Forests

Forest Carbon Options

According to recent FAO estimates, Senegal's forests cover an area of 8,513,000 ha, which translates into approximately 44% of the country's total surface land area.[4] Estimates of deforestation, and change in forest cover show that during 1990-2010, Senegal lost an average of 43,750 ha, or 0.47%, per year. In total, this amounted to approximately 9.4% of the country's forest cover (875,000 ha). About 18% of Senegal's forests are classified as primary forest, the most biodiverse and carbon-dense type, while 76% consist of naturally regenerated forest, and the remaining 5% are planted forest.[5]

[4] *http://faostat.fao.org/site/377/DesktopDefault.aspx?PageID=377#ancor*

[5] *http://rainforests.mongabay.com/deforestation/2000/Senegal.htm*

Deforestation in Senegal is mostly a result of clearing for fuelwood, charcoal, and logging, although poaching and wildlife trafficking, as well as hydroelectric projects, have also been blamed for the degradation of the country's forest areas. The loss of forest cover is expected to have led to serious environmental problems such as increased soil erosion, flooding, and periodic drought, having an adverse impact on agriculture.

Afforestation and reforestation of degraded forest lands, and mangrove restoration, present a significant potential for climate change mitigation in Senegal, while generating financial flows from forest carbon activities under the CDM. However, A/R CDM activities have generally remained underdeveloped, compared to other CDM sectors, mainly as a result of the complexity of the A/R CDM procedure, and the limited market demand for A/R CDM credits. Moreover, CERs from these projects are not eligible in the European Emission Trading System, and only tCERs are issued to A/R CDM projects. Nonetheless, Africa holds a significant share in the global CDM forestry sector by hosting 30% of all A/R CDM activities, which represent 8% of CDM activities in Africa[6], altogether reflecting Africa's potential for abatement in the LULUCF sector. Currently, Senegal has one registered A/R CDM project aimed at mangrove restoration.

REDD+ also presents an opportunity for creating financial flows for Senegal's efforts to mitigate GHG emissions, through forest carbon activities. However, in order for the country to prepare and become 'ready for REDD+', Senegal will have to clearly define rules on land tenure and carbon rights, and set up institutions for REDD+ governance. For REDD+ to become successful, the outcome will have to secure clear, tangible benefits, and access to land for forest dwellers and local communities, while conserving Senegal's forests and biodiversity.

Calculating the potential emission reductions from REDD+ activities in Senegal demonstrates that there is mitigation potential, if deforestation is avoided completely. Assuming that the baseline is entirely based on historical emissions, avoided emissions are calculated by multiplying the annual deforestation in Senegal, estimated to be 43,750 ha per year, with 43 tC/ha, which is the approximate amount of tons of carbon stored per ha in the country's forests, annually.[7] Based on this data, and a conversion factor of 1 ton of biomass carbon to the equivalent of 3.67 tCO_2[8], avoiding deforestation, alone, in Senegal has the potential to contribute to nearly 7 million tons in CO_2 emission reductions every year. Reversing the trend and adding forest regeneration to these estimates would increase this number even more. Afforestation/reforestation initiatives aiming to replant 50% of the loss in forest cover during 1990-2010 (875,000 ha), would require the regeneration of 437,500 ha of forest land, which could generate around 69 million tCO_2e reductions every year.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
REDD+ / Avoided deforestation	6,904,188	Historical baseline
Afforestation/ Reforestation	69,041,875	AR-AM1, AR-AM3, AR-AM4, AR-AM5, AR-AM9, AR-AM10, AR-AMS1, AR-ACM1, AR-ACM2

Fuelwood

Wood-based biomass is the dominant source of energy for sub-Saharan Africa, and fuelwood consumption per capita is higher in Africa than on any other continent. Biomass fuels make up approximately 60% of the total primary energy supply, and up to 90% of all household energy needs in Senegal. As seen in Table 1, the majority of the population in rural areas use firewood, while charcoal is mostly used in urban areas.

[6] UNEP Risoe CDM/JI Pipeline Analysis and Database, June 1st 2012

[7] ftp://ftp.fao.org/docrep/fao/011/i0350e/i0350e04c.pdf

[8] http://aciar.gov.au/files/node/8864/TR68%20part%202.pdf

Area	Firewood (%)	Charcoal (%)
Urban Dakar	3%	8%
Other towns	32%	21%
Urban areas	15%	14%
Rural areas	82%	8%

Table 1. Fraction of Senegal population using biomass for cooking, by type of biomass

Firewood

Biomass consumption (wood-energy and agricultural residues) remains the main source of domestic energy, and energy in small-scale commercial sectors. Reducing the demand for firewood is, therefore, a strategy to reduce drivers of deforestation, and an exhaustion of Senegal's natural resources. Such strategies include improved fuel-efficient cook stoves, and alternative-fuels and techniques for cooking and baking, which altogether might have a significant impact on GHG emissions.

Charcoal

Charcoal constitutes the primary urban fuel in most of Africa, and is a major source of income and environmental degradation in rural areas. The production, transport, and combustion of charcoal constitute a critical energy, and economic cycle in the economies of many developing nations.

Charcoal production releases methane – especially in the traditional open pits process. There are three phases in the carbonization process: 1) ignition, 2) carbonization, and 3) cooling. CDM projects are implemented in two different processes: 1) improving the kiln design for better temperature control and greater control of carbonization variables, which reduce methane emissions, and 2) capturing the methane released from the charcoaling plant, and combusting it to generate electricity (e.g. in a gas engine).

Since charcoal production involves tree removal from forests, sustainable wood supply is an important concern and aspect of charcoal production. Therefore, any introduction of efficient charcoal production technologies should only be approved if facilities have allocated dedicated woodlots for sustainable fuelwood plantations. If charcoal is sustainably produced through plantations, and methane emissions are zero, charcoal production becomes carbon neutral, since all emitted carbon would subsequently be sequestered in replanted trees.

The annual charcoal production in Senegal for 2011 was estimated to be 300,000 t.[9] According to a recently registered CDM project, using renewable charcoal from forest plantations, shifting from traditional open kilns to efficient kilns employing methodology AM0041[10], the anticipated methane emissions reduction per ton of produced charcoal is 0.037 tons[11]. This corresponds to 0.777 tons of carbon emissions reduced per ton of produced charcoal, based on the global warming factor of 21. Assuming that project emissions are zero, and that fuelwood is supplied from sustainable plantations, transforming the entire Senegalese charcoal production from a 100% open kiln production

[9] *http://siteresources.worldbank.org/INTCARFINASS/Resources/MainReportLowCarbonEnergyprojectsforDevelopmentofSubSaharanAfrica8.18.08.pdf*

[10] *http://cdm.unfccc.int/filestorage/A/P/Q/APQY8M2DU796JH10G3SKEW5ZR4TBXN/05072010_PDD_Charcole.pdf?t=V298bTZrcmtxfDCc85eDOxwk3EIdOherlYZR*

[11] *http://www.fao.org/docrep/x2740E/x2740e60.pdf*

in the baseline would potentially result in an emissions reduction of 233,100 tCO_2e/year. Such a project might be viable, but significant uncertainties are associated with this calculation, if not on the actual emissions reduction potential and project emissions, then on the current production methods and the outlook for including the entire charcoal production under one CDM activity.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Charcoal production	233,100	AMS-I.C., AMS-III.K., ACM00021, AM0041

Biodiesel

Biodiesel may be produced from vegetable oil, animal fat, or from the cleaning of waste cooking oil. Vegetable oil can be extracted from dedicated plantations, e.g. jatropha, or other oil seeds, such as linseeds or sunflower. Some of these crops are equally usable for food production, while others may be grown on arid lands with little other use. Animal fats can come from slaughterhouses or facilities disposing of dead animals. Most diesel engines can accept solutions of diesel and biodiesel; many may run on pure biodiesel. This pertains to both stationary and mobile engines, i.e. diesel power plants as well as cars, busses, and trucks. In the context of the CDM, biodiesel must be used in a captive fleet, i.e. a (large) number of identifiable vehicles like city busses or the trucks of specific companies, to allow the generation of Certified Emissions Reductions. Alternatively, biodiesel may be used in diesel power plants, which is highly relevant for Senegal, as 57% of the electricity base load capacity is diesel fuelled. The aim of the national program for biofuels, in 2012, was to produce 1,134,000,000 litres of refined biodiesel[12]. If all the produced biodiesel replaced the fossil diesel used in power-generators, the estimated CER would be 2.7 million tCO_2/year. However, not all of the potential biodiesel can replace domestic consumption of diesel, as only about 630 million liters of diesel is consumed annually in Senegal. If all the diesel oil consumed domestically were replaced by biodiesel, the potential emissions reduction would be 1,707,300 tCO_2/year using a 2.71 tCO_2/ton emission factor for diesel.
Three methodologies are relevant, of which, so far, only one has been applied in a registered project, AMS-III.T. The recently consolidated ACM17 is currently being applied in nine projects, under development, while one project follows AMS-III.AK. The main challenge lies within current applicable methodologies requiring biofuels to be utilized for replacement of fossil fuels in 'captive fleets', to qualify for CDM registration.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Biodiesel	1,707,300	ACM0017, AMS-III.AK., AM0041

Ethanol

During a feasibility study carried out by *Union Economique et Monétaire Ouest Africaine* (UEMOA), under the *Biomass Energy Regional Programme* (PRBE), the potential for producing ethanol was examined. Their analysis concluded that 12.5 million litres of ethanol could be produced in Senegal per year from sugar molasses[13]. Utilized in a suitable fleet, the potential emissions reduction could be up to 29,600 tCO_2/year, based on a simple calculation of how much gasoline the amount of ethanol could displace – or already displaces (2.365 kgCO2/liter).

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies

[12] *ENDA 2007; "Biofuels in Senegal, Jatropha program 2007-2012".*

[13] *UEMOA, 2008.*

Ethanol	29,600	n/a

Waste

The CDM covers a wide range of waste handling projects, from methodologies on domestic manure to methodologies for establishing large-scale incineration plants. Waste project types in the CDM are mainly divided into three categories: agricultural waste, liquid waste, and solid waste. Waste management has a great GHG emissions reduction potential. The potential for reductions lies in two different areas of waste handling: proper disposal of organic matter, that would otherwise emit methane (CH_4), and waste incineration, that can serve to replace energy (both thermal and electric) that would have been produced from fossil fuels.

Organic matter, for instance in the form of waste, emits large quantities of greenhouse gasses, primarily methane (CH_4), if not disposed of properly. The potential for the reduction of these emissions lies in various sectors.

Waste in the domestic sector, e.g. from small household livestock units, as well as in the industrial sector and municipalities, is most often left unutilized, to decay, and rarely used for the purposes of fertilizer or burning in open pits. The waste is, therefore, both harmful to the surrounding environment, and often a health hazard. Consequently, a waste management project will be greatly beneficial to local sustainable development.

Bagasse Energy Generation

The Compagnie Sucrière Sénégalaise has a *de facto* monopoly in the Senegalese sugar industry. The company has initiated the CDM project, "*Energy efficiency improvement Project of CSS sugar mill*[14]", thereby utilizing the energy potential from the sugar manufacturing process under the CDM. It is believed that the surplus bagasse can produce heat for on-site use, and deliver excess electricity to the local grid. The project baseline will be the on-site diesel powered heat production, and the electricity replaced across the national grid. The grid emission factor calculated in the PDD is 0.6761 tCO_2/MWh, and the total annual emissions reduction is estimated to be 37,386 tCO_2/year.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Sugar bagasse	37,386	AM36, ACM6, ACM2, AMS-I.D., AMS-I.C.

Biomass Residue Energy Generation

Senegal is rich in groundnuts, sugarcane, rice, maize and coconut production, of which the bagasse from sugarcane is already being utilized in a CDM context. In a survey of the potential energy from crop residues in Africa, carried out by the Institute for Energy Studies, University of Johannesburg, maize, coconut and rice residues were examined in Senegal.
Where sugarcane and groundnuts are gathered and processed on a centralized basis, mainly for export, maize, rice, sorghum and coconuts are produced in small farms, and processed mostly in small local businesses for domestic consumption. In terms of emissions reduction potential, this is problematic as the residues are left on-site as fertilizer, or collected for other residential purposes and, therefore, not emitting methane from an anaerobic decay process. The residues could also be used for heat or power production if the crops were collected and processed in a centralized manner, which is currently not the case.

[14] Energy efficiency improvement Project of CSS sugar mill

The aforementioned report estimates that the potential energy from rice husks is 918 TJ, corresponding to about 15 MW of power capacity, operating 6,500 hours/year with an electrical efficiency of 40%. The rice straws have even more potential with a stunning 7,000 TJ, or a 120 MW power capacity, under the same circumstances. Residues from maize production are estimated to have a potential of 2,284 TJ, corresponding to a power capacity of approximately 40 MW, under the same assumed conditions as above. Coconuts add in with a small power capacity potential of 2 MW. These potentials all add up to be about 180 MW of electrical power potential from agricultural residues, but again, the necessary conditions to realize these potentials are not in place. If one third of the residues were actually collected, and power was produced from it, the emissions reduction potential would be the annual power production (390 GWh) times the grid emission factor (0.6886 tCO_2/MWh), equalling a potential emissions reduction of almost 270,000 tCO_2/year.

Groundnuts are the third largest contributor to Senegal's exports, and the government has tried to keep the processing domestic. The groundnut production in Senegal has been fluctuating a great deal since 2000, when the annual production was approximately 900,000 tons per year. Reaching a low of 265,000 tons in the 2002/03 season, the production has been rising again to as much as 1 million tons in 2010. However, only 25% of the production is sold to the local processor, which forces the rest of the producers to sell their products at the unofficial market for a lower price[15]. This means that only 25% of the total available amount of residues for energy production is available. As an unknown amount of the groundnut is exported with shells, thereby not generating any residues, it has not been possible to estimate an emissions reduction potential from groundnut residues.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Maize residues	270,000	ACM6., AMS-I.C., AMS-I.D., AMS-III.E., AM36

Animal Waste

In Senegal, dairy farming has the potential for providing an additional energy source. Power generation using animal waste through biogas technologies could replace the use of paraffin in lanterns -- a source of CO_2. Domestic household biogas systems, providing biogas for lighting and/or cooking from livestock manure, are becoming increasingly widespread, as the technology has shown itself reliable and suitable for rural areas. The present use of paraffin for lighting is very widespread in Senegal. As only households with more than five cows are suitable for a household system, it is a limited number of households that can use this technology. A survey from 2011 showed that there are approximately 494,291 households in Senegal with five or more cows per household[16]. Since not all households use paraffin for lighting, there might be a correlation between ownership of larger livestock, and use of paraffin for lighting; a conservative assumption on how many use it suggests 350,000 households of the 494,291. Surveys in neighbouring countries have shown the consumption of paraffin for lighting purposes to be, on average, about 0.2 litres per household per day. Overall, the estimated potential for emissions reduction is 159,700 tCO_2/year. Using manure for production of biogas, to replace paraffin, exploits the same resources as assessed above for replacement of fuelwood for cook stoves. While the two options can be pursued in tandem, the total theoretical credit production is not cumulative. The resources can only be utilized once.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies

[15] *"Revitalization of the Groundnut Sector in West Africa", USDA 2010.*

[16] *"Livestock Assets, Livestock Income and Rural Households", FAO, World Bank, AU-IBAR, ILRI 2011.*

Domestic biogas	159,700	AMS-I.A, AMS-I.C, AMS-I.D., AMS-III.H., AMS-III.D., AMS-III.F., AMS-III.I., AMS-III.R., ACM14, AM25, AM80

Wastewater

The most recent available data shows that there are three wastewater treatment plants in Dakar, but only one in operation (Cambérène)[17]. Of the 180,000 m^3 of wastewater that is generated daily in Dakar, 40% is collected in a sewage system[18], whereof 20% is treated in a wastewater treatment plant. Depending on the treatment system, the gathered wastewater emits CH_4 into the atmosphere. CERs could be generated from avoiding this emission, and the collected methane could be used as fuel for a biogas-power system. To estimate the potential emissions reduction, the COD value in intake and outlet of the system must be known. If the outlet COD value is unknown, the IPCC provides default values of the methane correction factor (MCF) for different treatment systems. It has not been possible to determine either what kind of treatment system is presently in operation, or the COD content at the outlet point. A 2004 analysis of the Senegalese wastewater situation stated that the COD value at Cambérène is 1,606 mg/L. If the default value of the methane/COD factor (0.25 kg CH_4/kg COD) from the IPCC is used, and further assuming that the most common African practice in wastewater treatment system is also the prevailing practice at Cambérène, the anaerobic reactor, the estimated potential will be 14,400,000 litres * 1,606 mg COD/L = 23.126 ton COD per day
23.126 ton COD * 0.25 ton CH_4/kg COD * 0.8 (MFC) * 21 tCO_2/tCH_4 * 365 days = 35,453 tCO_2/year.
This is the baseline emission; if the methane were flared, the reduction would then be approximately 33,500 tCO_2/year.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Wastewater	33,500	AM13, AM22, AMS-I.A., AMS-I.C., AMS-I.D., AMS-III.H., AMS-III.O., ACM14, AM25, AMS-III.F., AMS-III.Y.

Landfill Gas/Solid Waste

The only site in Senegal where landfill gas extraction is an option is M'beubeuss Landfill. A PDD has already been made for this landfill, encompassing the capture of 60% of the gas emitted from the landfill, and flaring it on-site. The additional CDM potential here is to generate electricity from the landfill gas (LFG), and deliver the surplus electricity to the grid. As a result of the relatively high grid emission factor of 0.6886 tCO_2/MWh in Senegal, the potential can be quite significant. Assuming that the LFG consists of 50% methane[19], its calorific value is 0.0504 TJ/ton (14 MWh/ton, IPCC guidelines), and the gas engine's electrical efficiency is 30%[20], the potential electricity generated would be 12,446 tons LFG[21] * 14 MWh/ton * 30% = 52,273 MWh/year. The potential emissions reduction from delivering the electricity to the grid would be 104,545 MWh/year * 0.6886 tCO_2/MWh = 35,995 tCO_2/year.

[17] *"Senegal, Country Environmental Analysis" World Bank, 2008.*

[18] *"Untreated Wastewater Use in Market Gardens: A Case Study of Dakar, Senegal" 2004.*

[19] *"M'beubeuss Landfill Methane Recovery Project", PDD.*

[20] *The electrical efficiency and the calorific value of the LFG is very site specific and for the purposes of this calculation default.*

[21] *Average landfill gas captured from 2012-2017, from PDD.*

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Landfill gas electricity	35,995	ACM1, ACM2, AM3, AM10, AM11, AM12, AM25, AMS-I.C., AMS-I.D., AMS-III.G., ACM4, AM25, AM53, AM69

Conventional Power Production

All projects implementing renewable energy technologies, or energy efficient actions for end-consumers, often tend to have a relatively high impact on a wide range of sustainable development areas. The Senegalese Rural Electrification Agency (ASER) has initiated a program, *Programme Prioritaire d'Electrification Rurale*, aiming to scale up the rural electrification rate to 50% in 2012, thereby providing electricity to eventually 3.8 million people or 365,000 households. As of 2011, only 38% of the rural population had access to electricity, and 60-70% in urban areas. The average electrical consumption per capita was 158 kWh in 2008, which put Senegal's average consumption below that of Africa (579 kWh/year).[22]

In 2007, 56 MW of the thermal power production was produced in combined cycle power plants, and 443 MW in single cycle plants. As seen from the CDM pipeline, the average surplus energy generated from shifting from single to combined cycle is 30%. By October 2010, SENELEC stated that central thermal single cycle power plant capacity was 76 MW[23]. Assuming a 30% increase in power production, 7,000 annual operational hours, and the grid emission factor of 0.689 tCO_2/MWh, the potential emissions reduction would then be 109,901 tCO_2/year.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Single cycle to combined cycle	109,901	ACM7

Renewable Energy

Hydro

As the carbon intensity of the Senegalese electrical grid (0.6886 tCO_2/MWh) is relatively high, hydropower is a clear choice. Moreover, the theoretical hydropower potential in the country has been estimated to be at about 4,250 GWh/year. The 194 MW "Manantali dam on the River Senegal" hydropower plant was completed in 2003, sharing capacity between Mali (30 MW), Mauretania (104 MW), and Senegal (60 MW). In 2010, Senegal received 264,000 MWh from the plant. More projects like Manantali are being considered on the Senegal River. If the rest of the 800,000 MWh where to be exploited as a CDM project, the potential emissions reduction would be 536,000 MWh * 0.6886 tCO_2/MWh = 369,090 tCO_2.

Solar

There are many solar options in the country. The sun's energy can be collected directly to create both high temperature steam (greater than 100°C) and low temperature heat (less than 100°C), for use in a variety of heat and power applications.

[22] *"Senegal's Renewable Readiness Assessment report", 2012, International Renewable Energy Agency (IRENA)*

[23] *SENELEC, October 2010.*

Solar PV

As previously mentioned, the rural electrification program initiated by SENELEC, and commissioned by the Senegalese government, will eventually provide electrification to 50% of the rural households (365,000 households). An option for the remaining households could be a household solar PV solution, providing a small amount of electricity for lighting and other low energy consuming appliances, such as radios and mobile chargers. Most micro installations of solar PV are capable of running a lamp or two, a radio and/or a television set; 100-200 W panels with a battery attached are normal. It can be argued that such systems replace diesel generators or kerosene lamps, and thus have a relatively high emissions reduction factor per kWh produced. However, the limited capacity means that a very significant number of panels have to be distributed, in order to achieve a sizeable amount of emissions reduction. Determining based on the CDM Pipeline, very few projects have less than 1 MW installed effect. If this is an indicator, at least 5,000 200 W or 10,000 100 W panels must be distributed, generally, to generate an estimated 2,000 tCO_2e per year (assuming 2,000 full load hours of operation). Such activities may be well suited for programmatic approaches bearing in mind that one household may only contribute 0.2-0.4 tCO_2e of emissions reduction per year.

Assuming that 50% of the remaining 365,000 rural households implemented this technology, the baseline is the use of kerosene for lighting, as is allowed in the AMS-I.A. methodology (although candles are used), and the average daily consumption is set to be 0.5 litres of kerosene per household, the potential emissions reduction would then be 33,300 tCO_2/year.

Wind

Despite the fact that the average wind speeds in Senegal (3-5.5 m/s[24]) are below the needed wind speed for electric generation (6.0 m/s), there are some suitable locations in the coastal areas. The wind potential in Senegal has even induced a CDM win project located in the commune of Taiba N'Diaye, approximately 75 km northeast of Dakar. In the project design document (PDD), the full capacity of the wind farm will be about 125 MW, producing 280,000 MWh/year[25]. When the national grid emission factor is calculated for CDM wind projects a higher value is used, and in the PDD the grid emission factor is calculated to be 0.702 tCO_2/MWh, which leads to an estimated emissions reduction potential of 196,560 tCO_2/year.

On the website for the "*Système d'Information Energétique du Sénégal*" another potential wind power project is outlined. It is the so-called "Gantour project", which aims to install 50 MW wind capacity, and supply the produced electricity to the national grid. It is estimated that when the wind farm is fully operational it will generate 96,667 MWh/year. Using the same grid emission factor as in the CDM project, the potential emissions reduction is then calculated to be 67,860 tCO_2/year.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Hydro	369,090	ACM2, AMS-I.D., AM26, AMS-I.A., AM5, AM26, AMS-II.B., ACM11, ACM12, AM52

[24] *"Analysis of wind data and wind energy potential along the northern coast of Senegal", Dakar, 2005.*

[25] *"Taiba N'Diaye Wind Energy Project, Senegal", http://cdm.unfccc.int/Projects/Validation/DB/18V0B6GGC8S17Y3QQ6U7W4MWQ5DDQG/view.html*

Solar PV	83,300	ACM2, AMS-I.A., AMS-I.C., AMS-I.D.
Wind	264,420	ACM2, AMS-I.D., AMS-I.F.

Energy Consumption

Greater efficiency in the consumption of energy is commonly an attractive option for emissions reduction, due to its dual benefit of reducing both emissions and the size of the energy bill. However, despite many years of promotion, it is also the most overlooked option. In the CDM, for instance, demand-side energy efficiency projects only make up 1% of the CER generation. There are many reasons for this, including the fact that most developing countries focus on energy access rather than energy savings.

Lighting

As part of the *Programme Prioritaire d'Electrification Rurale,* a CFL distribution CDM Programme of Activity (pCDM) project has been initiated; the so-called "*Promotion of Energy-Efficient lighting using Compact Fluorescent Light Bulbs in rural areas in Senegal*". This pCDM project aims to distribute energy efficient CFL bulbs to as many newly electrified rural households as possible. The first part of the Programme will distribute 150,000 CFLs to about 30,000 households in the Saint-Louis region. This will potentially generate 3,835 CERs/year, and if all of the 365,000 households were included, the potential would be approximately 463,000 tCO_2e/year[26]. To reach the remaining 50% of the rural population, a PV solar program could be initiated (see section for household solar PV potential in Senegal).

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
CFL distribution	463,000	AMS-II.E. AMS-II.J.

Efficient Cook Stoves

As the majority of rural households still rely on traditional biomass such as charcoal and firewood, there could be a potential for introducing energy efficient technologies to those who are not a part of the electrification program. Improved cook stoves can, in most cases, reduce the biomass used per household for cooking by 50%. In CDM terms, methodology AMS-II.G provides the opportunity to choose a baseline that represents the emission factor of the substitution fuels likely to be used by similar users. As kerosene is widely used in sub-Saharan Africa, it is also the fuel that is likely to be used by similar users. If the remaining 365,000 rural households that are not grid connected under the above-mentioned electrification programme are instead covered by an improved cook stoves programme, they would equally help to reduce emissions. Assuming that they use about 30 GJ/year per household for cooking, and that the improved stoves reduce the energy consumption by 50% (and the emission factor of kerosene is used as baseline), the potential emissions reduction would be 365,000 * 0.03 TJ/year * 71.5 tCO_2/TJ (kerosene) = 782,900 tCO_2/year, which corresponds to a 25% penetration rate for the entire population.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Improved stoves	782,900	AMS-I.E., AMS-II.G., AMS-I.C.

[26] *Senegalese Rural Electrification Agency, 2011.*

Industrial Production Processes

Industrial activities cover several industry sectors and reduction options related to energy efficiency, as well as change of processes and substitution of materials. In developing countries there are many cottage industries, such as small-scale brick production, or even household-based production, like textiles, which in most cases are not represented and do not constitute noteworthy emissions reduction options. In many countries, brick kilns are the exception, and may even represent considerable reduction potentials. Brick production in Senegal, however, is believed to be primarily mud bricks. Neighbouring Mali is home to the world's largest mud brick structure (the Djenné mosque), and in Niger mud bricks are also dominant. No information has been retrievable on Senegal's brick production.

Instead, there are reduction options in the cement industry. In Senegal, the CDM project "Partial Substitution of Coal by Jatropha Fruits and Biomass Residues in the Production of Portland Cement" has already been registered. It is implemented at Sococim Industries cement plant in Rufisque, 30 Km west of Dakar. The project encompasses a partial fuel-switch from coal to biomass in the cement plant producing 1,234,000 tons of clinker per year. The project will eventually be utilizing 96,277 tons of biomass, reducing the emissions from the use of fossil fuels by 153,648 tCO_2/year. The plant at Rufisque (the biggest in West Africa[27]) is not the only cement plant in Senegal. The total clinker production in 2008 was 3,200,000 tons[28]. If the same project type were to be implemented in the rest of the Senegalese cement industry, with the same production/reduction ratio, the potential emissions reduction would be almost 400,000 tCO_2/year.
Senegal is predominantly rural and with limited natural resources, earning most of its foreign exchange from fish, phosphates, groundnuts, tourism, and services.[29] While the fertilizer industry contributes directly and indirectly to emissions of greenhouse gases (GHGs), particularly carbon dioxide (CO_2) and nitrous oxide (N_2O), through the production, distribution, and use of fertilizers, the mining of phosphates contribute only slightly. The major emission sources for phosphate rock processing are dryers, calciners, and grinders[30] through electricity consumption. Power supplies are mainly diesel generators, therefore improving the energy efficiency in phosphate processing could have significant emissions reduction impact, however, no data has been retrievable for the current energy consumption. A high proportion of the concentrate is used for the industrial processing and production of soluble P-fertilizers for export, for instance SSP, TSP, DAP and NPKs[31]. P-fertilizers are not a significant source of emissions, as N-fertilizers are, hence this is not an object for emissions reduction.
Generally, Senegal is using mining as a platform for economic development. The Mining Code of 2003 welcomed private players, and private investments in the sector are expected to reach €4bn by 2013. ArcelorMittal and the government are involved in a joint venture, estimated at €1.7bn-€1.9bn, to develop major iron ore deposits at Falémé. Mineral Deposits Limited (MDL) has made a huge investment in zircon mining in Grande Côte, which could result in the project contributing 7% of global zircon output.
Emission reductions through energy efficiency could hold significant potential in the development of these mining activities.

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[27] *www.polysius.com, 2009.*

[28] *indexmundi.com, 2008.*

[29] *http://en.wikipedia.org/wiki/Economy_of_Senegal*

[30] *http://www.epa.gov/ttnchie1/ap42/ch11/bgdocs/b11s21.pdf*

[31] *http://www.uoguelph.ca/~geology/rocks_for_crops/45senegal.PDF*

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Cement industry	553,700	AMS-II.D., AMS-III.B., AMS-III.Q., AMS-III.AS. ACM12, AM24

Transportation

The emissions from liquid fuels in Senegal in 2008 were 2.7 million tCO_2e.[32] A sizeable share of this was for power generation, where 295 MW of the country's 700 MW generation capacity was based on oil/diesel -- consuming about 300,000 tons of oil[33].

Dakar has one of the largest deep-water seaports along the West African coast, with total freight traffic averaging 10 million metric tons. This makes Dakar, and Senegal, a major transport hub for West Africa. On the approximately 900 km of Senegalese railways, the domestic rail freight carried in the year 2000 was 50.6 millions of ton-km (source DTTSNCS), or about 3.0% of the estimate for road freight.[34] Dakar is the endpoint of three routes in the Trans-African Highway network: the Cairo-Dakar Highway, the Dakar-Ndjamena Highway, also called the Trans-Sahelian Highway, and the Dakar-Lagos Highway. Consequently, 1.7 billion ton-km of road transport, by modern trucks, would correspond to about 100-250,000 tCO_2e[35]. Vehicles, vehicle size, and road conditions in Senegal would easily double these figures, thus assuming that 500,000 tCO_2e emissions would stem from the land transport sector, corresponding to a little less than 200 million litres of diesel.

Senegal embarks decisively on biofuels promoted by the Ministry of Biofuel and Aquaculture. Since 2006, the country has launched a National Program for Biofuel Production, with the aim of contributing to national energy self-sufficiency in the production of bio energy alternatives. By 2012, this program aims to cover 321,000 ha of Jatropha plantation in the 321 rural communities that form the country, with a production goal of 1190.000.000 litres of refined oil from seeds.[36] This roughly corresponds to the country's entire liquid fuels consumption, and thus holds the potential to reduce emissions by the aforementioned 2.7 million tCO_2e. However, it is uncertain whether the entire production can be consumed domestically, as a full conversion of the entire fleet of vehicles is doubtful. A 50% conversion of goods transport overland would yield about 250,000 tCO_2e, which is the figure that is used for illustrative purposes as a probably realistic estimate for the results of Senegal's biofuels programme. It may, though, be composed of a number of other sources as well. There may be emissions reduction options in the Dakar Port as well as. The comparably sized Tema port of Accra in Ghana revealed a reduction potential of about 4,000 tCO_2e in a biofuels conversion of internal transport equipment, based on 1.5 million litres of diesel consumption per year. A similar reduction potential might exist in Senegal.

The only large city in Senegal is Dakar, with about 2.5 million inhabitants currently being serviced by a public/private transport company, Dakar Dem Dik (DDD), established in 2001. DDD began with 60 buses, but by 2004 the number had fallen to fewer than 40. Since then, 409 additional buses have been procured with bilateral assistance, though less than 300 are operational. The buses may well constitute a sufficiently large captive fleet for a CDM project to be viable. A full conversion to biofuels would potentially yield about 55,000 tCO_2e, while a 50% conversion should reduce half as much (based on 300 km/day/bus and 1.5 km/litre of diesel).

[32] *http://data.worldbank.org/indicator/EN.ATM.CO2E.LF.KT*

[33] *http://www.globalbioenergy.org/uploads/media/1005_Imperial_College_-_Mapping_food_and_bioenergy_in_Africa.pdf*

[34] *http://www.worldbank.org/transport/transportresults/regions/africa/senegal-output-eng.pdf*

[35] *http://timeforchange.org/co2-emissions-shipping-goods*

[36] *http://www.globalbioenergy.org/uploads/media/1005_Imperial_College_-_Mapping_food_and_bioenergy_in_Africa.pdf*

Minibus services ("cars rapides") are provided by a large number of small-scale private operators, with a current fleet estimated at about 2,500 vehicles (less than 50 passengers). These provide about 80% of the public transport supply. Furthermore, there is a large fleet of legally registered taxis.[37] These would be covered by a more general blending programme for biofuels. The suburban rail services provided by the Petit Train de Banlieue (PTB), with a capacity that is still limited by unfinished works on a second track, is too small for consideration in a CDM context, but could be captured by more general biofuels policies, either for power generation, or for transport.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Biodiesel for transport	250,000	ACM17, AMS-III.C., AMS-III.T.

Summary

Senegal has an overall abatement potential of 74,453,068 tCO_2e. The total investments needed to achieve these reductions can only be roughly assessed, as a sizeable share of the reductions relate to technologies for which no data currently exists -- in terms of their investment to CER-revenue ratio.

Technology type	Emission Reduction Potential per year (tCO_2e)
REDD+ / Avoided deforestation	6,904,188
Afforestation/ Reforestation	69,041,875
Charcoal production	233,100
Biodiesel	1,707,300
Ethanol	29,600
Sugar bagasse	37,386
Maize residues	270,000
Domestic biogas	159,700
Wastewater	33,500
Landfill gas electricity	35,995
Single cycle to combined cycle	109,901
Hydro	369,090
Solar PV	83,300
Wind	264,420
CFL distribution	463,000
Improved stoves	782,900
Cement industry	553,000
Biodiesel for transport	250,000

These estimates should not be regarded as being precise. Rather, they represent a form of calculation that allows comparison among economies, and their relative attractiveness as destinations for carbon finance.

[37] *http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2010/05/13/000020953_20100513152007/Rendered/PDF/537740PAD0P1011y100IDA1R20101014511.pdf*

It should be emphasized that while attempting to be exhaustive, the estimates here do not claim to be all-inclusive. There may be unidentified sources of reductions not included in the technology overview, and not represented by existing methodologies, but in all likelihood these would be minor compared to the potentials identified.

UNEP RISØ CENTRE
FREDERIKSBORGVEJ 399,
BUILDING 110, P.O. BOX 49,
4000 ROSKILDE,
DENMARK

UNEP@DTU.DK
TEL +45 46 77 51 29