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Baseline Report for the ECOWAS Renewable Energy Policy (EREP)

Final draft, 23 October 2012

ECREEE
www.ecreee.org

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Definitions

Coverage rate: % of the population living in areas where the service is available

Access rate: % of the considered population which is effectively connected to the considered service

Dispersion rate: N° of electrified localities / total localities

Woodfuel: Fire-wood and charcoal

List of Abbreviations

AECID	Agencia Española de Coopéracion Internacional para el Desarrollo (Spanish International Cooperation Agency for Development)
AfDB	African Development bank
AfD	French Development Agency
ADC	Austrian Development Cooperation
CEB	Benin Electric Community
CILSS	Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel
CLSG	Cote d'Ivoire, Liberia, Sierra Leone, Guinea
CLUB-ER	Network of African Agencies and Structures in charge of Rural - Electrification
CSP	Concentrated Solar Power
DDO	Distillate Diesel Oil
DSO	Distribution system operator
ECOWAS	Economic Community of West African States
EDG	Electricity of Guinea
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
ERERA	ECOWAS Regional Electricity Regulatory Authority
FIT	Feed in Tariff
GEF	Global Environmental Facility
GW	Giga Watt
GWh	Giga Watt hour
IPP	Independent Power Producer
IRED	Regional Initiative for Sustainable Energy
MS	Member States (ECOWAS)
MW	Mega Watt
MWh	Mega Watt hour
NREP	National Renewable Energy Policy
ODA	Official Development Assistance
OMVG	Organisation de mise en valeur du fleuve Gambie
OMVS	Organisation de mise en valeur du fleuve Senegal
RE	Renewable Energy
RET	Renewable Energy Technologies
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PRBE	Regional Programme for Biomass Energy
PREDAS	Regional Programme for the Promotion of Domestic and alternative energies in the Sahelian region
PV	Photovoltaic
RREP	Regional Renewable Energy Policy
REEP	Regional Energy Efficiency Policy
RMO	Regional Market Operator
RTSO	Regional Transmission System Operator
TSO	Transmission System Operator
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
WA	West Africa
UEMOA	West African Economic and Monetary Union
WAPP	West African Power Pool
WB	World Bank

1 Summary of report

The Economic Community of West African States (ECOWAS) is a regional group of fifteen countries, founded in 1975. Due to growing energy deficit in the ECOWAS region, many member states have expressed the necessity to mainstream renewable energy into their national policies. However, these efforts can be more successful if developed under a regional framework. The scope of the policy document will be on the following renewable energies:

- Small-scale hydropower (SSHP) up to a maximum capacity of 30 MW and partially also medium-scale hydropower (MSHP) up to a maximum of 100 MW
- Bio-energy covering woodfuel (fire wood and charcoal), by-products from crops production (stalks, straw, husks, shells, kernels etc.), urban wastes and finally energy crops for power generation or sustainable biofuels
- Wind (on-grid, off-grid, on-shore, off-shore)
- Solar: PV and CSP, as well as solar thermal water heating and cooling

1.1 Context

The Energy context of the 15 ECOWAS Member States evolve in a complex framework of regional and sub-regional coexisting policies:

- The ECOWAS/UEMOA white paper on energy access to energy services in peri-urban and rural areas has set three targets to be achieved by 2015 for (i) access to improved cooking fuels and stoves (ii) access to individual electricity supply, (100% for the urban areas and 36% for the rural areas); (iii) 60% of the population living in rural areas should have access to motive power for productive uses.
- The revised WAPP Master Plan of 2011 foresees that around 36% of the total installed capacity in ECOWAS will originate from renewable energy sources by 2025. The contribution of large hydro would be around 28% and "new renewables" would have a share of 8%.
- In parallel to the regional renewable energy policy, ECOWAS is currently developing an energy efficiency policy. Both policies are complementary. The RE scenario considers possible energy savings.
- The Regional Initiative for Sustainable Energy (IRED) within the UEMOA proposes 78% RE penetration by 2030 in the UEMOA electricity system, whereas 62% will be provided by wind, solar and biomass.
- The CILSS initiative covers 7 of the ECOWAS countries (Niger, Burkina Faso, Mali, Senegal, Cape Verde, Guinea Bissau and the Gambia) and focuses on woody biomass, sustainable management of forest and wooded lands and sustainable use of wood-fuel, including substitution strategies (LPG and kerosene).

1.2 Institutional framework

The regional Institutional framework of ECOWAS consists of 4 main institutions:

- The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), promotes the establishment of a regional market for renewable energy and energy efficiency
- The West African Power Pool (WAPP), in charge of developing an integrated bulk power supply market for 14 ECOWAS countries (Cape Verde is not connected to the continent)
- The ECOWAS Regional Electricity Regulatory Authority (ERERA), the regional regulatory authority for cross-border electricity interconnections in West Africa.

- WAPCo, a limited liability company that owns and operates the West African Gas Pipeline, connecting the Nigerian gas resources to Benin, Togo and Ghana.

1.3 Energy access situation

Of the 300.7 million ECOWAS citizens, only 126.2 million inhabitants have access to electricity services today, 75% of them live in towns. 174.5 million inhabitants have no access to electricity and 77% of them live in the country side. Some countries are more advanced than others in providing electricity access to their citizens. It is the case of Cape Verde, Ghana, Nigeria, Côte d'Ivoire, Senegal and Mali where about half of the population has theoretically access to electricity. For the remaining countries the opportunity of electricity access is more limited, in average 16%, among which 90% are urban population.

1.4 Financial framework, tax and tariff issues

Institutional frameworks and incentives need to be developed to attract private investors. The investments in West African power sector remains quite conventional with a predominant share of ODA funding. However in 2011, the share of non-OECD investors (China and India) and private investors has grown significantly. The investments in smaller RE represent a small share of the overall RE investments in Africa (only 2% in 2009 and 5% in 2011).

Subsidies create distortions among supply options encouraging investments in cheaper conventional technology and discouraging investments with high upfront capital cost (typically RETs), especially when planning never consider in real economic terms these least cost options.

According to the World Bank's estimates, technically, sub-Saharan Africa could accommodate more than 3200 CDM projects, enabling an additional power generation of 170 GW. Although the ECOWAS's CDM project potential is huge, the region benefits less from the carbon market.

The development of RE is part of a progressive approach based on sequenced series of setting financing systems. Before reaching a RE environment supported by the involvement of a strong private sector and banking system, it is necessary as part of an emerging market to support the development of RE by mixing subsidies, tax incentives and by the establishment of a favourable regulatory framework for RET IPP, and the feed in tariff approach.

1.5 Renewable energy resource and technology assessment

The following renewable energy resources were identified:

- SSHP opportunities particularly for the southern ECOWAS member states as complementary bulk production for national grids or local grids to the large hydro options already included in the WAPP programme balance
- Biomass uses particularly in the South with industrial waste products (shells, husks, stalks, fruit stones, cake, old rubber trees or palm oil trees). As 75% of the population rely on fuel wood this resource is not really available for other purposes than domestic energy and deserves to be saved and protected.
- Solar energy for bulk power production in northern ECOWAS countries, saving hydro production and thermal power/systems losses during the day (constraints: up-front cost and reliable and stable transmission grid at disposal with a suitable voltage).
- Wind power: Erratic production located on the coastal zones and in northern Nigeria and Mali presenting the advantage of low investments costs, mostly similar to large thermal power capacity. Unlike other RE, the wind energy requires a more stable and reliable grid with some

regulating capacities like hydro and thermal capacity to absorb in real time the fluctuation of a wind based power production.

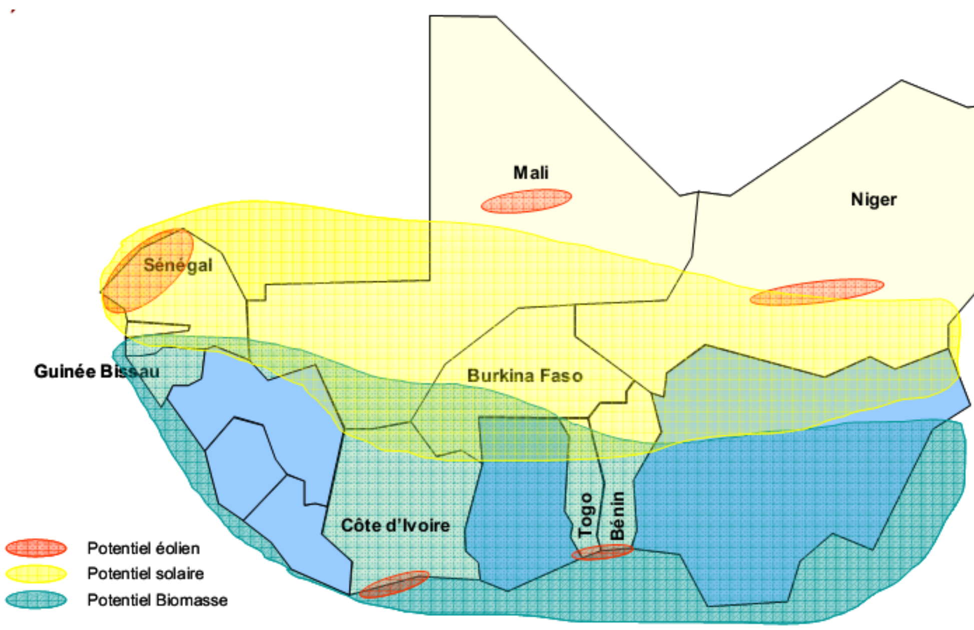


Figure 1: Map of Renewable Energy Potentials in the EOWAS region

Some of the renewable energy technologies are already competitive with other alternatives today while others will become competitive by 2020/2030. For countries having sufficient resources, biomass and SSHP are the best options, providing electricity at a cost that is compatible with the regional projects' price options. All the production costs for various technologies are summarized in the following figure for commercial and ODA financial conditions.

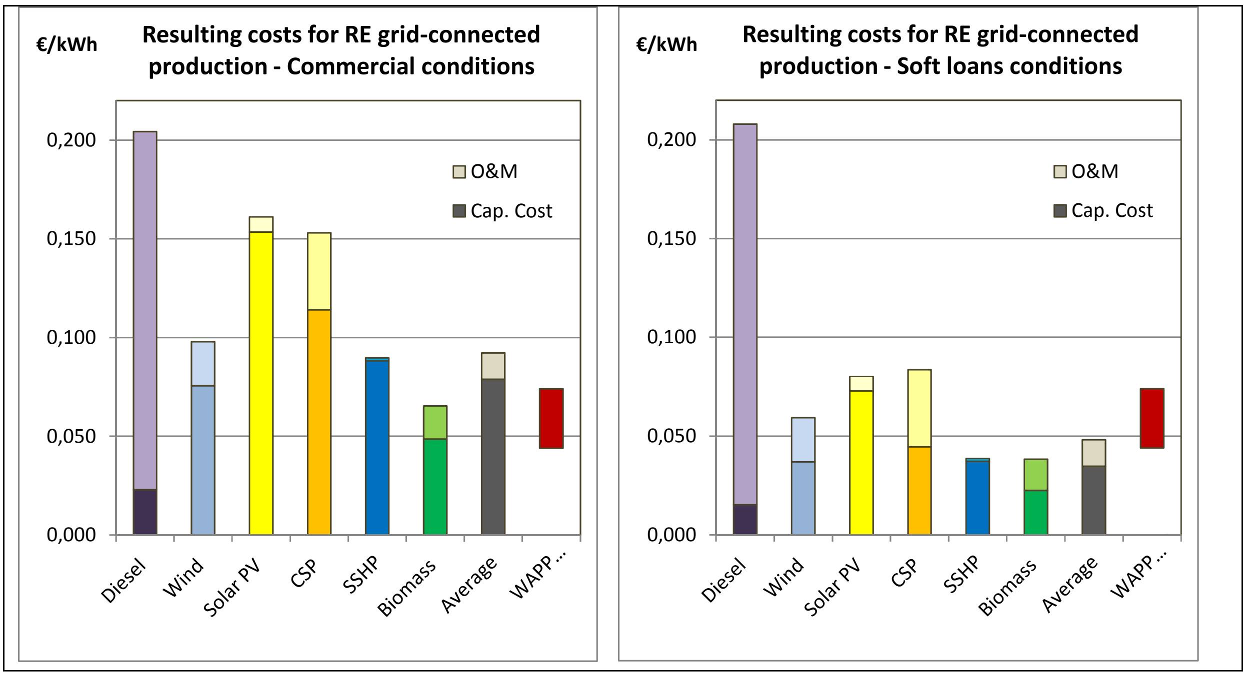


Figure 2: Technology various costs (commercial and soft loan conditions)

Small-scale hydro power and biomass options are the champions among the RE technologies. They are fully competitive with the assessed regional grid parity (black column labelled 'average') for both financial assumptions. Wind energy is becoming the second cheaper RE technology, however a few cents of Euros is more expensive than the 'grid parity'. At the present time, solar energy remains expensive. It can only effectively compete with high diesel thermal production costs when the resource is at its best. In the light of this analysis the priority must be given to biomass and small-scale hydro power. Wind energy is interesting as a cheaper energy source but requires reserved capacity to be regulated. Solar remains the most expensive RE sources. Taking into consideration the expected evolution of price falls for RE technologies, incentives should be provided to initiate a learning process of integrating these resources and technologies in the panel of candidates for the future power supply.

1.6 **The ECOWAS Renewable Energy Policy (EREP)**

1.6.1 Rationale

Renewable energy sources are available in large extent and some of the technology options are approaching the grid parity as it is the case of Small-scale hydro -plants, biomass, and wind energy. Therefore, it is the appropriate time to develop a Regional Renewable Energy Policy securing on short and medium term, least cost renewable energy options for bulk energy production on the national grid instead of diesel generation and for boosting off-grid rural electrification. The EREP creates synergies and complements the ECOWAS Energy Efficiency Policy (EEEP) which is under development. The envisaged 30% electricity savings were considered in the load forecast.

1.6.2 Objectives

At Regional level, the main objectives of the ECOWAS Renewable Energy Policy, EREP, will be**:**

- To mobilize additional medium and medium large sized renewable energy options that could on the long term reduce the need for environmental adverse energy sources like coal and uranium. These options could bring rapid supply solutions for countries having capacities shortfall while waiting for the WAPP options

At national level, the objectives for the EREP can be formulated as following:

- to assist and secure the mobilization of medium sized RE least cost options reducing durably the use of fossil fuel in power generation or/and enabling an increase of the overall power capacity alleviating the possible up-coming supply shortages due to the delays in the major regional strategies. The EREP harnesses the mutual benefits of energy efficiency improvements.
- To promote a conducive regulatory and financial framework enabling the private sector to invest in the energy sector.

At off-grid level, the objectives should be:

- to create the conditions for a real market for robust decentralized solutions that are affordable for the local rural population with a low purchase power.

At household level, the objectives are:

- to support national sustainable management of forests and savannah woodlands, promote an efficient use of domestic energy (fuel wood as well as gas and kerosene) through the regional policy for energy efficiency. It is also to promote productive or energy savings solar applications such as solar drier and solar water heater through information and sensitization activities. And finally, to promote the emergence of a market for solar lamps to create opportunities for regional mass production.

1.6.3 Potential markets for RE applications

■ Grid-based supply

The modelling of the overall power supply market assumes that the regional market for grid-based supply will grow from a value of 45 TWh/9 GW servicing 135 million inhabitants:

- To 150 TWh/25 GW by 2020, enabling a doubling (factor 2) of the 2010 grid-supplied population (access rate 64%; outreaching 24% of the localities);
- To 245 TWh/39 GW by 2030, enabling a tripling (factor 3.3) of the same segment of population (access rate 74.8%; outreaching 42% of the localities).

These forecasts are perfectly in line with the WAPP energy and capacity forecast, foreseeing the needs to increase the installed capacity (MW) and the supply (GWh) with a factor 2.3 in 2020 and 3.7 in 2030 compared to the reference 2010.

■ Market segment for RE powered mini-grids

The market for mini-grid systems has to address the needs of 58% of the localities having an average size of 1,200 inhabitants that will not be grid-connected. An overall potential market of 156,000 RE powered mini-grids with an average capacity of 50 kW has been identified for the next 20 years covering the needs of 103.2 million inhabitants of the ECOWAS region living in localities comprised between 200 and 2,200 inhabitants. To cover the totality of these needs it will be necessary to build 23 mini-grid/year/1million inhabitants (2010) during the period 2012-2030.

■ Stand-alone equipment

To cover the residual demand coming from the isolated population, a need of 4.7 million stand-alone RE equipment has been identified; 2.1 million up to 2020 covering the half of the demand and 4.7 million enabling the universal access by 2030. In terms of market, the maximal contribution for stand-alone equipment will be of 875 equipment/year/1 million inhabitants (2010) from 2012 to 2030, corresponding to a total of 128,000 mini grids on the period.

1.6.4 Targets for EREP

Three groups of targets are set for the ECOWAS Regional Renewable Energy Policy: for "**on-grid connected renewable energy applications**"; for "**off-grid and stand-alone applications**"; and for "**domestic renewable energy applications**" ranging from cooking related applications (cook stoves, household biogas, briquettes and LPG strategy) to energy efficient measures such as solar water heater and distributed power generation (PV roof top and small wind turbines).

Targets for grid connected renewable energy

in MW installed capacity	**2010**	**2020**	**2030**
EREP renewable energy options in MW	**0**	**2,425**	**7,606**
EREP renewable energy options in % of peak load	**0%**	**10%**	**19%**
Total renewable energy penetration (incl. medium and large hydro)	32%	35%	48%
in GWh	**2010**	**2020**	**2030**
EREP renewable energy options – production in GWh	**0**	**8,350**	**29,229**
EREP renewable energy options - % of energy demand	**0%**	**5%**	**12%**
Total renewable energy production (incl. medium and large hydro)	26%	23%	31%

Targets for off-Grid applications

Least-cost option	2010	2020	2030
Off-grid (mini-grids and stand-alone) share of rural population served from renewable energy in %		22%	25%

Target for Domestic applications and biofuels

Least-cost option	2010	2020	2030
Biofuels (1st generation)			
Ethanol as share of Gasoline consumption		5%	15%
Biodiesel as share of Diesel and Fuel-Oil consumption		5%	10%
Improved cook-stoves - % of population	11%	**100%**	**100%**
Efficient charcoal production share-%		**60%**	**100%**
Use of modern fuel alternatives for cooking (e.g. LPG) - % of population	17%	**36%**	**41%**
Solar water heater technologies for sanitary hot water and preheating of industrial process hot water:			
▪ Residential sector (new detached house price higher than €75,000)		At least 1 system installed	At least 1 system installed
▪ District health centres, maternities, school kitchen and boarding schools		25%	50%
▪ Agro-food industries (preheating of process water)		10%	25%
▪ Hotels for hot sanitary water		10%	25%

1.6.5 Financial robustness

The EREP options selected to fulfil the proposed targets suggest interesting financial prospects. As many countries will depend up to 2018/21 on an energy mix including a remaining large share of diesel generation, the renewable energy options will not constitute a financial burden for the future and some of those could be implemented on fully commercial conditions.

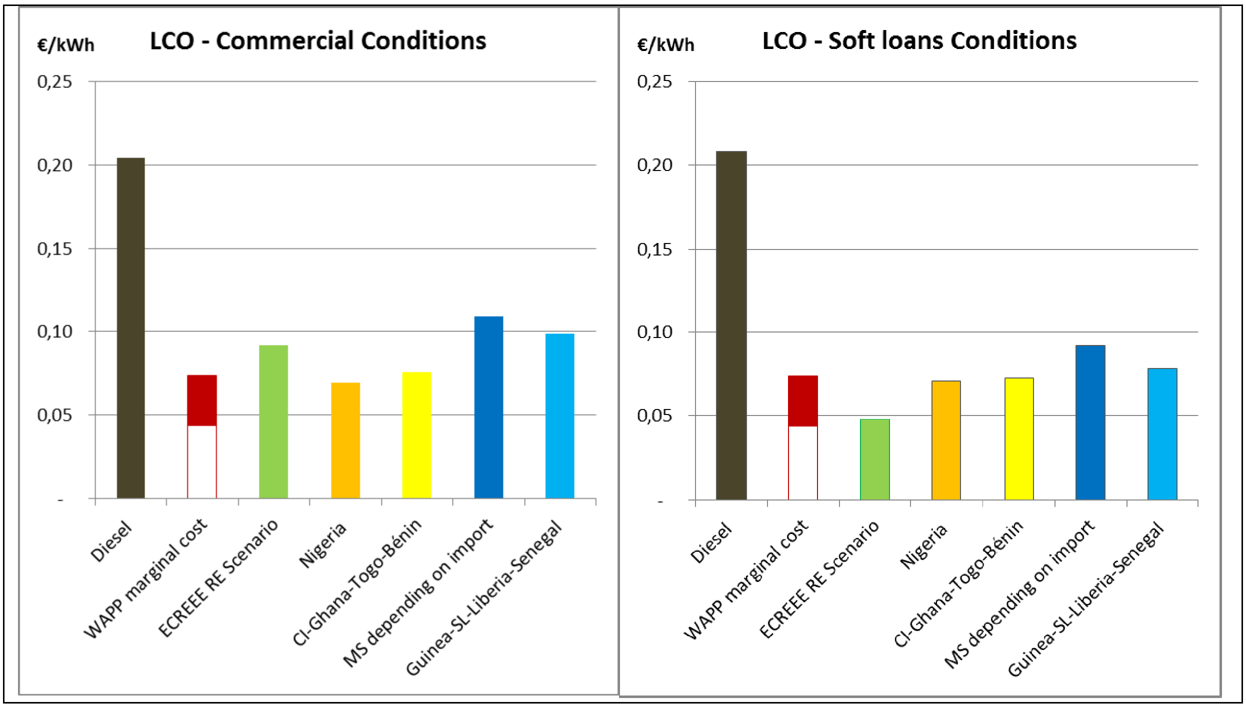


Figure 3: LCOE for various parts of the ECOWAS compared to diesel production and WAPP tariffs. (Commercial and soft loan condition)

As shown in the figures the levelised cost for the EREP proposed options (green column) are lower than the grid parity for countries relying on a large share of diesel-based production until they can access the WAPP supply and price options (blue columns). For the other countries the more competitive options need to be selected.

However, EREP options will need some financial support during the early years of the learning process to initiate the development of a regional market for renewable energy which actual weakness is one of the major barriers to cost reduction.

2 Introduction

The Economic Community of West African States (ECOWAS) is a regional group of fifteen countries, founded in 1975.[1] Its mission is to promote integration in "all fields of economic activity, particularly industry, transport, telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions, social and cultural matters (...)".

As policy response to the challenges of energy security, energy poverty and climate change, the ECOWAS member states have expressed the necessity to mainstream renewable energy and energy efficiency (RE&EE) into their national policies. However, these efforts can be more successful if developed under a regional framework. The experiences in other regions, such as for example in the European Union, have shown that regional integration can be useful in finding optimal renewable energy solutions and that regional agreements on policy can catalyse the necessary actions at national level.

Having the mandate to create favourable framework conditions for RE&EE markets by supporting activities to mitigate existing technical, legal, institutional, economic, financial, policy and capacity related barriers, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) has launched the development of the ECOWAS Renewable Energy Policy (EREP). In parallel, the Centre is developing the complementary ECOWAS Energy Efficiency Policy (EEEP). Both policies are to be adopted at the ECOWAS High Level Energy Forum in Accra, in October 2012.

This Baseline report was developed as a basis for the EREP by ECREEE with support of the Africa-EU Renewable Energy Cooperation Programme (RECP) funded through the European Union and advisory services of Innovation, Energy and Development (IED). It was also supported by the Austrian Development Cooperation, Spanish Agency of International Development Cooperation (AECID) and the United Nations Industrial Development Organization (UNIDO). From October 2011 to March 2012 several country missions were undertaken.

2.1 Technology scope of the Baseline report

Renewable energy resources include solar energy, wind, hydro, the heat of the earth (geothermal), plant materials and organic wastes (bioenergy), waves, ocean currents, temperature differences in the oceans and the energy of the tides. Renewable energy technologies produce power, heat or mechanical energy by converting those resources either to electricity or to motive power. The focus of the document, however, will be on the following commercially viable and mature renewable energy technologies which have a significant feasible potential in the ECOWAS region:

- **Bio-energy** is covering three different fields:
    - Woodfuel (fire-wood and charcoal) used for domestic cooking purposes and commercial applications (restaurants, breweries, potteries, black smith, etc.). Woodfuel excess resources could be used to power generation with other biomass (residues from charcoal production for instance)
    - By-products from crops production (stalks, straw, husks, shells, kernels etc.). These can be a fuel for power generation when gathered together on an agro-industry site. The same remark is valid for manure and dung for biogas production (resource concentration at dairies or slaughter houses or cattle markets) and Urban Waste
    - Finally, energy crops for power generation or energy plantations or possibly sustainable biofuels (e.g. jatropha) offers some interesting possibilities.
- **Small-Scale hydropower (Small-hydro or SSHP)** up to a maximum capacity of 30 MW (partially includes also Medium-scale hydropower projects (MSHP) from 30 to 100 MW).

[1] Benin, Burkina Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo

Large-scale hydro power (LSHP is starting from 100 MW) is already covered by the WAPP Master Plan. The different sizes of hydro power in the ECOWAS region are defined as follows:

Table 1: ECOWAS Hydro Power Definitions

Terms		Power output
Pico hydropower	**"Small-scale" Hydro-power "SSHP"**	*< 5 kW*
Micro hydropower		*5 - 100 kW*
Mini hydropower (MHP)		*100 – 1 000 kW (=1 MW)*
Small hydropower (normally "SHP")		*1 MW - 30 MW (!)*
Medium hydropower		*30 MW - 100 MW*
Large hydropower "LHP"		*> 100 MW*

- **Wind power** (on-grid, off-grid, on-shore, off-shore)
- **Solar energy:** PV and CSP, as well as solar thermal water heating and cooling

The use of renewable energy technologies in the ECOWAS region can contribute to the following:

- Provide bulk power generation connected to the HV transmission grid: The main targets will be both regional power supply, when national production exceeds domestic needs, and also national supply itself in order to diversify the national electricity mix (larger hydro plants, solar plants (PV and CSP), Wind farms, Biomass thermal plants)
- Provide bulk power generation connected to the MV or LV power grid: Here the RE production is targeting the national /local supply level with various purposes (contribution to the power generation option, voltage support on long MV lines, and peak shaving in urban areas). The following technologies can be relevant: Small-scale hydro plants, smaller solar plants, PV roof top, wind turbines, smaller Biomass/biogas power plants, excess energy from self-producers, or use of raw vegetal oil in conventional thermal plants to reduce fuel consumption)
- Power mini-grid systems: enabling access to modern, reliable and affordable energy services in rural areas. The relevant technologies are: hybrids with or without storage capacity, solar and wind plants, Small-scale hydropower installations, use of raw vegetal oil in diesel generators, biomass based gasifier plants, biogas plants.
- Power stand-alone systems: domestic and community solar home systems with storage
- Other applications: domestic and industrial hot water production with solar heaters, solar driers for food processing, Biomass cogeneration for food processing and associated power generation, solar cookers, solar cooling (box and parabolic concentration), solar PV systems for industry and institutions to mitigate use of diesel.

3 Overall context

Summary:

Energy challenges and regional policy objectives:

The ECOWAS region is facing a severe energy crisis and the challenges of energy security, energy poverty and climate change mitigation simultaneously. The ECOWAS region is evolving a complex framework of co-existing regional, sub-regional and national coexisting energy policies and objectives:

- *The ECOWAS/UEMOA white paper on energy access to energy services in peri-urban and rural areas has set three targets to be achieved by 2015 for (i)* access to improved cooking fuels and stoves (ii) access to individual electricity supply, (100% for the urban areas and 36% for the rural areas); (iii) 60% of the population living in rural areas should have access to motive power for productive uses. *It foresaw that at least 20% of new investment in electricity generation should be driven by local renewable resources.*
- *The revised WAPP Master Plan of 2011 foresees that around 35% of the total installed capacity in ECOWAS will originate from renewable energy sources by 2025. According to this scenario the contribution of large and medium hydro would be around 31% and "new renewables" a share of 4%.*
- *The Regional Initiative for Sustainable Energy within the UEMOA (IRED) proposes 78% RE penetration by 2030 in the UEMOA electricity system. It is expected that the major contribution to RE power production will come from new renewables and large hydro.*
- *The CILSS initiative covers 7 of the ECOWAS countries (Niger, Burkina Faso, Mali, Senegal, Cape Verde, Guinea Bissau and the Gambia) and focuses on woody biomass, sustainable management of forest and wooded lands and sustainable use of wood-fuel, including substitution strategies (LPG and kerosene).*

Energy access situation:

Of the 301 million ECOWAS citizens in 2010, only 126 million inhabitants have access to electricity services. 75% of them live in towns. 174.5 million inhabitants do not have access to electricity and most of them (77%) live in the country side. Some countries are more advanced than others in providing electricity access to their citizens. In the case of Cape Verde, Ghana, Nigeria, Côte d'Ivoire, Senegal and Mali about half of the population has access to electricity. For the remaining countries the opportunity of electricity access is more limited, in average 16%, of which 90% is urban population.

Electricity supply situation and trends:

The WAPP Master Plan classifies the ECOWAS countries into three categories:

- ***Countries with potential for a self-sustained supply****: These are Senegal, Côte d'Ivoire, Ghana, Nigeria, Togo/Benin and Niger after 2020 (when a large coal based thermal production plant is expected).*
- ***Countries with continued dependence on power imports****: These are the Gambia, Guinea Bissau, Mali, Burkina Faso and Niger before 2020.*
- ***Countries with the potential to become power exporters*** *(usually by developing their hydropower potential): such as Côte d'Ivoire (during a period) Guinea, Sierra Leone and Liberia after 2018. For all these countries the excess of hydro power will depend on the implementation of the WAPP investment programme in respect to the schedule agreed.*

ECOWAS renewable energy market segments:

The following RE market segments were identified:

- ***Large applications for regional power trade*** *(e.g. to complement the WAPP/IRED projects)*
- ***Medium sized applications*** *contributing to national supply security and dependence on imports (oil products but also electricity so long the regional market is not fully implemented)*
- ***Medium to small-scale applications*** *to power off-grid areas through mini-grid systems*
- ***Stand-alone applications*** *for isolated population living in scattered settlements (fewer than 200 inhabitants)*

3.1 Energy challenges in the ECOWAS region

The endeavour to develop a renewable energy policy responds to the severe energy crisis in the ECOWAS which hampers the social, economic and industrial development of the region. The countries face the interrelated **challenges of energy access, energy security and climate change mitigation** simultaneously. The lack of access to modern, affordable and reliable energy services is interrelated with a variety of economic, social, environmental and political problems:

- In "business as usual" scenarios – without considerable additional investments – **energy poverty** and its consequences for economy and society will continue to be a predominant challenge in the ECOWAS region in 2030. West Africa, with around 300 million inhabitants equivalent to roughly one third of Africa's total population, has one of the lowest modern energy consumption rates in the world. Household access to electricity across the region is about 20% but wide gaps exist between the access rates in urban areas and in rural areas. The electricity networks serve mainly urban centres and suburbs. The urban and rural poor in West Africa spend more of their income for poor quality energy services than the better-off for better quality services.

- The electricity systems in West Africa are facing challenges due to the **growing gap between predicted demand, existing supply capacities and limited capital to invest**. Despite the growing gap and lack of investment capital the energy intensity in the countries remain high and energy is used in an inefficient way throughout all sectors. The estimated technical and commercial electricity losses in the electricity systems lie up to 40% throughout the West African region. Increasing fossil fuel import dependency, shortages and fluctuating fossil fuel prices are major concerns of West African countries and require a diversification of sources. In some countries even more than 90% of the electricity generation is satisfied by expensive diesel or heavy fuel. As a result, the steadily increasing and fluctuating oil prices have had a devastating effect on the economies in the region.

- With climate change, another concern was added to the heavy energy agenda of the ECOWAS region. West Africa is so far only responsible for a fraction of global energy related GHG emissions. However, the **energy sector will be highly impacted by mitigation and adaptation costs of climate change** in the forthcoming decades. Climate change risks and the need for reliable and affordable energy supply to ensure energy security and energy access create a dilemma. On the one hand, urgent investments are required. On the other hand, the expansion of energy supply based on inefficient low-cost fossil fuel combustion technologies will increase GHG emissions and interrelated negative climate change impacts which harm Sub Sahara Africa at most. New energy infrastructure investments have a long life-time and determine the GHG emissions for the next 20 to 30 years. Climate change impacts (temperature rise, extreme weather events, droughts, etc.) will challenge the energy security of ECOWAS countries and have to be mainstreamed into energy policy planning. This is particularly important with regard to hydro power due to the possible changes in the rain patterns and river flows.

3.2 Regional energy policies and objectives

As far as energy issues are concerned, the 15 ECOWAS member states evolve in a complex framework where regional, sub-regional policies and national policies coexist at the same time:

- The ECOWAS White Paper for increasing access to energy services for rural and peri-urban populations by 2015.
- The 2011 Master Plan of the West African Power Pool (WAPP)
- The UEMOA context with its energy policy and programmes as the former PRBE for the biomass and the present Regional Initiative for Sustainable Energy (IRED).
- The Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), which is covering six of the ECOWAS countries (Niger, Burkina Faso, Mali, Senegal, Cape Verde and Guinea Bissau), and is focusing on woody biomass, sustainable management of forest and wooded lands and sustainable use of wood-fuel, inclusive substitution strategies (LPG and kerosene).
- Each country's energy policy and strategies

3.3 The ECOWAS/UEMOA White Paper as benchmark for energy access

In January 2006, the Heads of States and Governments of the 15 ECOWAS member states adopted the ECOWAS/UEMOA regional policy on considerably increasing access to energy services for populations in rural and peri-urban areas for poverty reduction hoping that its implementation would lead to an acceleration of development process towards achievement of the MDGs. Three targets were proposed to be achieved by 2015:

I. 100% of the total population, or 325 million people, will have access to improved cooking fuels and stoves, whereas 9.2% with access to LPG cooking devices
II. At least 60% of people living in rural areas will have access to productive energy services in villages, in particular motive power to boost the productivity of economic activities;
III. 66% of the population, or 214 million people, will have access to an individual electricity supply. This would be
    a. 100% of urban and peri-urban areas;
    b. 36% of rural population
    c. Moreover, 60% of the rural population will live in localities with
        (i) Modernized basic social services – healthcare, drinking water, communication, lighting, etc.
        (ii) Access to lighting, audiovisual and telecommunication services, etc. and
        (iii) The coverage of isolated populations with decentralized approaches

10 indicators were listed in order to measure the impact of the implemented policy. Indicator 10 stated that "*at least 20% of the new investment in electricity generation will be driven by local and renewable resources, including hydro-electricity, in order to achieve energy self-efficiency, reduced vulnerability and sustainable environmental development in keeping the regional plan*". Moreover, Action line 2 of the White Paper foresees the establishment of an RE&EE investment and innovation fund which raises funding for at least 200 demonstration projects and supports local manufacturing and service companies. The level of the implementation of the regional white paper in the 15 countries is very different and only five countries clearly mention renewable energy in their national white book while 6 of them have not yet adopted it.

White Paper implementation progress

Most ECOWAS countries have set a target with regard to access to electricity over a time horizon. However, almost all ECOWAS member states have not yet set specific targets for access to modern cooking fuels, improved cooking stoves and mechanical power. In addition, no country has set a specific target for reducing the share of the population relying on traditional biomass. Aid agencies such as the Austrian Development Agency (ADA), AECID, UNDP, UNIDO and multilateral financing institutions (IFIs) are assisting the countries to implement the white paper at national level. They also assist in mainstreaming sustainable energy technologies and services into the markets.

In this context, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) has recently launched the ECOWAS Renewable Energy Facility for peri-urban and rural areas (EREF) which responds to action line 2 of the white paper. Despite efforts of national governments and international agencies, the progress in access to modern energy services has been slow, as indicated in table below, because of constraints such as inappropriate or poor implementation of policies, targets and regulations. It is clear that the envisaged objectives cannot be attained by 2015. Moreover, the objectives of the White Paper would now have to be adapted to the new objective framework of the United Nations which aims at Sustainable Energy for All (SE4ALL) by 2030.

Table 2 : Stocktaking of the Achievements of the ECOWAS/UEMOA White Paper on Energy Access

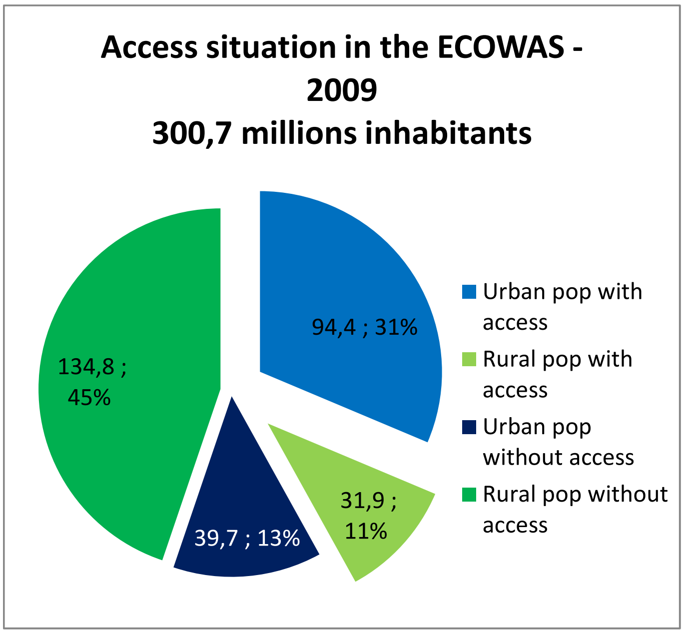
Type of White Paper Goals	Goals of the White Paper by 2015	Energy access achievements by 2011
Access to modern cooking fuel	100% of the population	17% of the populations (30% urban, 7% rural)
Individual electricity access	66% of the population	42%
In urban and peri-urban areas	100%	70%
Rural populations	36%	11%

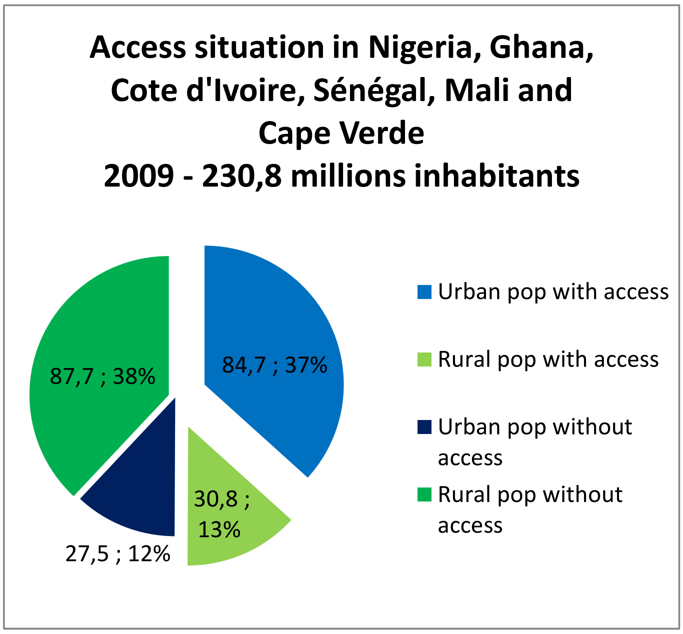
3.3.1 The contribution of RE to increase energy access

In 2009, 42% of the total population had access to electricity. About 75% of this population live in towns and only 25% live in the countryside. 58% of the total population live without access to electricity services, among them 25% is urban and 75% is rural[2].

[2] Main source UNPD report on General Energy Access in ECOWAS Region: UNDP Dakar – Regional Energy Poverty Project – 2011, corrected for some factual and compilation errors as for example Mali's national access rate: 28% instead of 17% and the regional electricity access rate 42% instead of 27%; the so-called electrification rate in the table is equivalent to the penetration rate: percentage of households having actual access to electricity in electricity-supplied areas.

Figure 4: Electricity access situation in the ECOWAS region





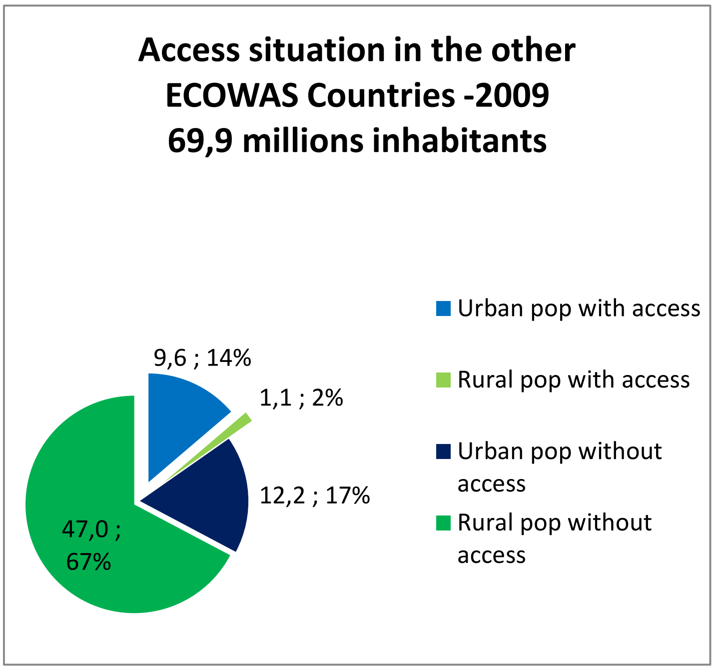


Table 3: Electricity Access Situation in the ECOWAS region

	Population 2010	Urban Population in %	Rural pop in %	Urban population in 10^6	Rural population in 10^6	Total elect. rate in %	electr. rate rural pop in %	electr. rate urban pop in %	Tot population with access	Urban pop with access	Rural pop with access	Urban pop without access	Rural pop without access
Benin	8,8	42%	58%	3,7	5,1	24,8%	2,4%	56%	2,2	2,1	0,1	1,6	5,0
Burkina	16,5	20%	80%	3,3	13,2	14,6%	2,0%	65%	2,4	2,1	0,3	1,2	12,9
Cap Verde	0,5	61%	39%	0,3	0,2	87,0%	70,0%	98%	0,4	0,3	0,1	0,0	0,1
Côte d'Ivoire	19,7	50%	50%	9,9	9,9	47,3%	18,0%	77%	9,3	7,5	1,8	2,3	8,1
The Gambia	1,7	58%	42%	1,0	0,7	19,0%	3,0%	31%	0,3	0,3	0,0	0,7	0,7
Ghana	24,4	51%	49%	12,4	12,0	66,7%	47,0%	86%	16,3	10,7	5,6	1,8	6,3
Guinea	10,0	35%	65%	3,5	6,5	15,0%	3,0%	37%	1,5	1,3	0,2	2,2	6,3
Guinea-Bissau	1,5	30%	70%	0,5	1,1	15,0%	2,0%	45%	0,2	0,2	0,0	0,2	1,0
Liberia	4,0	61%	39%	2,4	1,6	15,0%	2,0%	23%	0,6	0,6	0,0	1,9	1,5
Mali	15,4	33%	67%	5,1	10,3	27,1%	14,0%	54%	4,2	2,7	1,4	2,4	8,9
Niger	15,5	17%	83%	2,6	12,9	8,0%	1,5%	40%	1,2	1,0	0,2	1,6	12,7
Nigeria	158,4	50%	50%	79,2	79,2	50,6%	26,0%	75%	80,2	59,6	20,6	19,6	58,6
Senegal	12,4	43%	57%	5,3	7,1	42,0%	18,0%	74%	5,2	3,9	1,3	1,4	5,8
Sierra Leone	5,9	38%	62%	2,2	3,7	15,0%	1,0%	38%	0,9	0,8	0,0	1,4	3,6
Togo	6,0	43%	57%	2,6	3,4	22,0%	5,0%	45%	1,3	1,1	0,2	1,4	3,2
ECOWAS	300,7	45%	55%	134,0	166,7	42%	19,1%	70%	126,2	94,4	31,9	39,7	134,8

Six countries already have a significant national electricity access rate. These are Cape Verde (87%), Ghana (66.7%), Nigeria (50%), Côte d'Ivoire (47.3%), Senegal (42%) and Mali (27%). For these countries 27.5 million urban people and 87.7 million rural populations had no access to electricity in 2009. For the remaining nine countries, only 16% of the population on average had access to electricity most of which lives in towns (90%). 84% of the total population live without access - among this 80% is rural.

Cape Verde can be considered as completely electrified. Most of the islands except Santiago already have universal access to electricity and it is expected that the whole country will have it within a few years.

Countries like Ghana, Nigeria, and Cote d'Ivoire have by now well-developed national grids that will be used to further provide access to the rural areas. They are also developing a self-sufficient power supply strategy based on their own resources (gas and large hydro). However, mini-grid solutions and stand-alone solutions will be relevant for some remote areas and for the small rural scattered settlements (200-1000 inhabitants).

For some countries like Senegal and Mali, even though grid-based rural electrification will be the trend, some specific areas such as the forest areas in Senegal or the northern part of Mali are not appropriate to grid-based access. For example, 3.2 million Senegalese are distributed on 13,216 settlements which maximal size is 1,000 inhabitants.

For these groups of countries, implementation of grid connected medium to large sized RE power production will also constitute a CO_2 neutral contribution to the national/regional supply saving in first position thermal power production based on gas and coal.

In the nine remaining countries (Niger, Burkina Faso, Benin, Togo, Liberia, Sierra Leone, Guinea Bissau, Guinea, and the Gambia), electricity access to rural areas is poor, around 2%. Furthermore, only less than half of the urban areas have electricity access. It is obvious that these countries have to develop their national grids. Some countries like Burkina Faso and Benin are extending theirs. These countries are depending greatly on the timely implementation of the regional projects with new large hydropower, CC gas plants and/or power line projects.

Therefore, grid connected RE can provide a reliable and sustainable contribution to the national power while waiting for the regional supply. Further, RE powered mini-grid options for rural electrification would have to be considered and developed as the economic burden to develop the national grid will be very high and not necessarily a least cost option.

3.4 The WAPP Master Plan as benchmark for power generation costs

The vision of the WAPP is to "integrate the national power system operation into a unified regional electricity market with the view to provide, in the medium and long term, the citizens of ECOWAS Member States with stable and reliable electricity supply at affordable cost. Therefore, the vision of the WAPP secretariat is to develop and put in place a cooperative power pooling mechanism for integrating national power system operations into a unified regional electricity market." The main objective for the WAPP is to find a technical and economic optimum between:

- the development of large regional power generation projects and
- the development of regional power interconnections among the ECOWAS countries, so that power from the proposed projects could flow to the deficit countries.

3.4.1 The WAPP Master Plan Scenario

The WAPP Master Plan Scenario from 2004 aims at tripling the demand for power generation from around 10,659 MW in 2011 to more than 30,731 MW by 2025. In 2011, the Master Plan adopted in 2004 was revised. The revised version aims at the following general objectives:

- To elaborate an optimal development plan for regional generation and transmission of electrical energy, as many previous options have been challenged by the member states, due to the global energy and financial crisis and the high volatility of oil prices.
- To propose a list of regional priority projects that will ensure energy supply security and the completion of an interconnected HV regional network enabling power exchanges through all West African countries by 2018.
- The fulfilment of these objectives should be facilitated by the elaboration of a strategy for implementing the regional priority projects.

The 2011 WAPP Master Plan project pipeline was adopted by ECOWAS in November 2011. The execution of the planned projects would increase the share of RE in the overall electricity capacity mix of the ECOWAS region from a level of 27% in 2011 (100% large hydro) to 36% by 2025. The major share of 28% would still be provided by large hydro. The "new renewables" would account for about 8%. The share of coal-based power generation would be 4%.

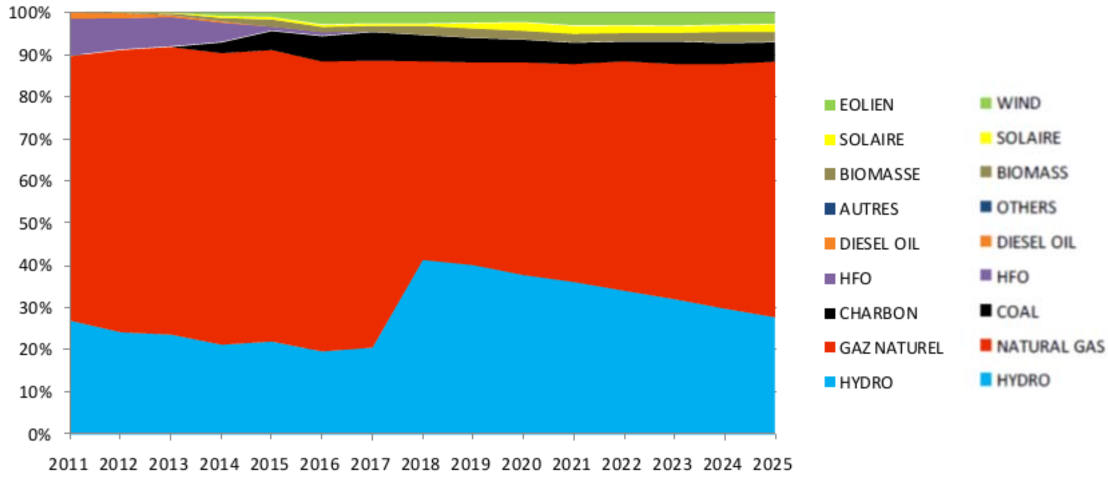


Figure **5** : Electricity mix in the WAPP voluntary RE Scenario in terms of installed capacity

The WAPP scenario aims at decreasing the marginal power generation costs in the ECOWAS region from a range between 4.4 c€/kWh and 22.2 c€/kWh in 2010 to a range between 4.1 EUR/cents to 7.4 EUR/cents per kWh in the period 2017-2025.

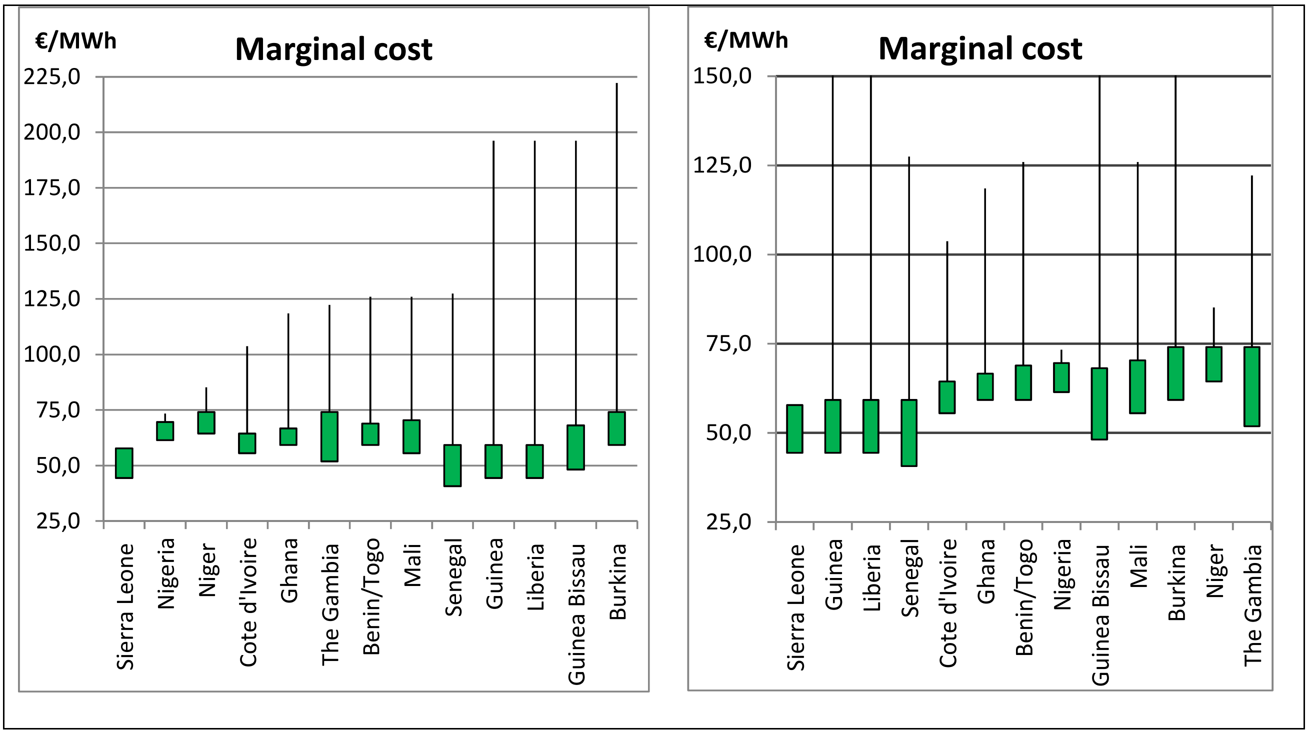


Figure 6 : Development of the marginal generation costs in WAPP Master Plan

The fine lines in the figure above indicate the actual level of generation costs in the respective countries. The green bars show the envisaged range of generation costs after implementation of the WAPP project pipeline in 2025. The cost range constitutes also a reference point for determining the competitiveness of the different available RE generation technologies in different countries. The second reference point is to compare the cost-effectiveness of RE production with oil-based thermal power production (e.g. diesel or heavy fuel) until the WAPP project pipeline is fully implemented. This reference point is also valid for the off-grid rural areas.

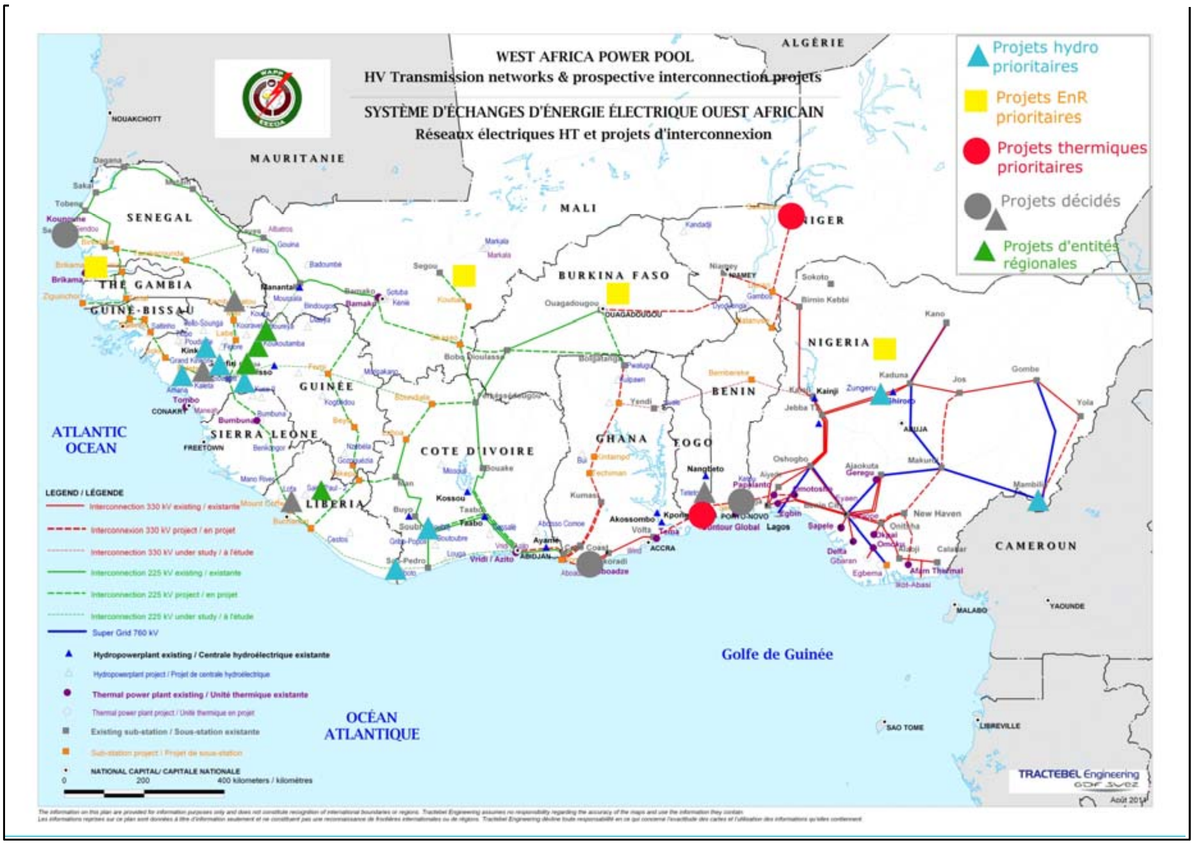
It is to be noted that the revised master plan volume 2 includes also an alternative "new renewable energy" scenario (around 3,650 MW of additional RE capacity to be installed - 20% from biomass, 40% from solar and 40% from wind). The conclusions indicate that a renewable energy scenario, with 10% of the total installed capacity could be covered by RE (excluding large hydro) by 2020. The scenario is economically robust for countries without hydro resources or access to natural gas. It is expected that the alternative scenario would incorporate very limited additional costs (around 2% increase on the kWh costs).

3.4.2 The project pipeline of the 2011 WAPP Master Plan

The project pipeline of the WAPP Master Plan is based on three types of regional projects:

- The national or regional projects having a regional mission and which are already approved
- The major approved projects supported by regional power entities like OMVS and OMVG
- and the Regional Priority Projects selected by the WAPP consisting of:
  - power generation projects based on large hydroelectricity potentials (21), on natural gas (3) on coal (2) and on new renewables (4)
  - power transmission HV lines, enabling power transfer alongside the costs and the power injection and loop-backing to the landlocked countries (Niger, Mali and Burkina Faso, Northern Nigeria)

Figure 7: WAPP Master Plan Grid Extension Map



The 2011 WAPP project pipeline has a strong focus on the expansion of RE power generation capacities by 2025. In sum, the implementation of the project pipeline will lead to:

- the construction of 10,268 MW additional generation capacity (of which 7,093 MW are large hydro power plants and 800 MW will be solar and wind). The scenario foresees a doubling of the current installed capacity in the ECOWAS region (around 9 to 10 GW in 2010 of which 3.45 GW is large hydro)[3].
- and 16,000 km of transmission HV lines (26 transmission line projects)

The overall investment costs for the project pipeline are estimated at US$ 24.5 billion (18.0 Billion EUR): US$ 18 billion (14 Billion EUR) for generation projects and US$6.5 billion (4.9 Billion EUR) for transmission projects. The details of investments are given in the table below:

[3] No specific indication of the total installed capacity has been found in the revised master plan report. 3,445 MW hydro from IRENA LCOE approach 2012.

Table 4: Approved WAPP Master Plan projects by energy sources

	No of project	MW	M EUR
Hydro	21	7,093	8,925
Solar	2	300	830
Wind	2	500	601
NG CC plant	3	1,300	875
Coal	2	1,075	2,347
Total	30	10,268	13,578

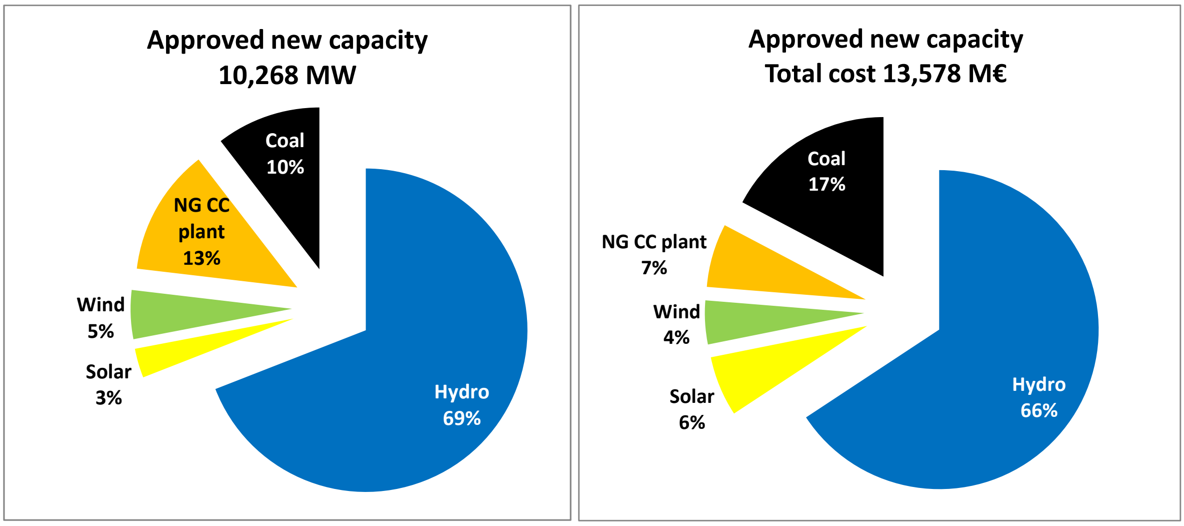


Figure 8: WAPP Master Plan: Approved new capacities and investments

3.4.3 Master Plan implementation schedule

The revised schedule for the WAPP implementation is given by the diagram attached in the annex.

The implementation strategy builds on 4 specific axes:

- to unify and synchronise the WAPP Zone A, by establishing the Coastal Backbone and the North Core system (Nigeria, Niger, Burkina, Benin)
- to create the inter-zonal transmission hub, by integrating the Mali-Senegal system to the WAPP Zone A (Ivory Coast-Mali, Ghana-Mali; Ghana-Burkina, Guinea-Mali)
- and to connect the remaining countries for Zone B to the WAPP, through the OMVG-OMVS system (The Gambia, Guinea, Guinea-Bissau) and through the CLSG system (Ivory Coast, Liberia, Sierra Leone and Guinea)

From this status the following conclusions can be highlighted:

1) The coastal link (Ivory Coast →Benin) as well as the interconnectors to the Mali-Senegal system are progressing and will be implemented as per the schedule, although some minor delays can be expected on the 330 kV line from Abodze-Bolgatanga and the 225 kV line from Bolgatanga to Bamako.
2) The commissioning of the two large CC power plants of Aboadze (CI) and Maria Gleta planned in 2014(B) will possibly be delayed by a couple of years, as the technical design is yet to be started.
3) As far as hydro capacity is concerned, it seems that only the Mount Coffee hydro plant is on track. All other projects are at a pre-financing stage while their commissioning are still expected in 2016/17/18. Major delays can be expected.

4) The OMVS-OMVG system, which will supply Gambia, Guinea Bissau and Guinea as well as the CLSG system (Liberia, Sierra Leone and Guinea) rely both on the construction in time of HV lines and larger dam to become the future hydro power reservoir of the whole region. There is a definite risk that these systems will not be fully operational in 2017-18, as expected by the plan, and significant delays can be expected.

3.5 The UEMOA Regional Initiative for Sustainable Energy (IRED)

The development objective for the IRED was formulated as follows: In 2030, all UEMOA citizens will have access to a cheap energy supply, from a West Africa comprehensive and integrated and harmonized power market delivering clean energy based on a dynamic public private partnership. This vision is built on three specific objectives:

1. To develop production and supply systems for all securing a low electricity tariff for business competitiveness and development. A target of 30 FCFA/kWh or 4.6 c€/kW is set for 2030. The 2007 access rate of 17% for electricity services should reach 80% in 2020 and the universal access goal should be achieved in 2030. Both price and penetration targets are set very high and are deemed very ambitious.
2. To develop an integrated market for power exchange in order to get benefits in sharing complementary power capacities. This assumption relies on the development of the regional HV interconnection system, managed by the WAPP.
3. To supply the citizens with clean energy, that means based on an extended use of RE (hydro, solar energy, and biomass). This strategy would be made possible via a larger mobilisation of CDM and other carbon funding mechanisms. As indicated in table 6, the RE scenario contributes to 40% of the installed capacity in 2007 and is expected to reach 61% in 2020 and 78% in 2030. Around 2% comes from new renewables (solar, wind and biomass) in 2007, roughly 27% by 2020 and 62% by 2030. Around 38% is provided by large hydro power in 2007, 34% in 2020 and 16% in 2030. The WAEMU scenario foresees the installation of additional 15,146 MW of new renewables and 2,981 MW by 2030.

Table 9 Breakdown of planned capacity development in the UEMOA[4] (in %)

	OFFRE 2007	OFFRE 2012	OFFRE 2020	OFFRE 2030
Energies fossiles (pétrole)	38%	30%	13%	5%
Energies fossiles (gaz, charbon)	22%	40%	27%	12%
Hydroélectricité	38%	25%	34%	16%
Energies renouvelables (solaire, biomasse, éolien)	2%	4%	27%	62%
Energie nucléaire	0%	0%	0%	4%

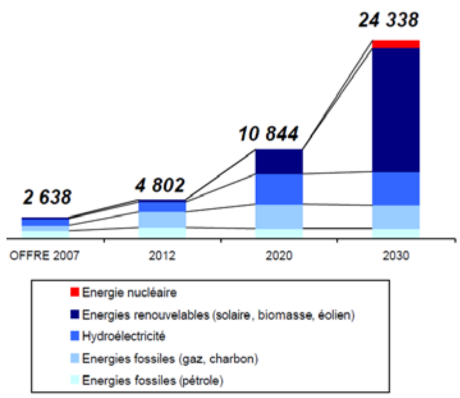


Figure 10 Breakdown of planned capacity development in the UEMOA[5] (in MW)

[4] UEMOA: IRED, Annexe, September 2009, p.13
[5] UEMOA: IRED, Annexe, September 2009, p.13

The vision will be implemented via the significant mobilization of the private sector through dynamic PPPs arrangements. This strategy is based on 3 main pillars:

- Rehabilitation and development of large hydro-production
- Conversion from oil to gas of existing thermal production and rehabilitation and development of large gas fired CC plants (450 MW)
- Sharing the regional capacity through the regional integration (interconnections)

In addition, some renewable energy sources are identified to play a growing role in the future supply (after 2020). Among those:

- Solar energy in countries as Mali, Burkina and Niger, with the Concentrating Solar Plants (CSP) as basic technology, although this technology is presently quite expensive and more complicated. The UEMOA energy specialists have agreed with the consultant[6] that PV plants will constitute in the next coming years a more appropriate technology for the Sahelian countries, as it is a static, low maintenance technology which price is presently diminishing. The CSP will not follow the same pattern as it requires much more heavy equipment and its operation and maintenance is much more manpower demanding. The WAPP RE scenario has not kept the CSP option as an economic valid option.
- Furthermore SSHP opportunities which are not included as core activities will be supported by the UEMOA to strengthen the reliability of national power production and to contribute to access to modern energy in the rural areas.

Compared to the expected demand forecasts ranging for year 2030 from 11 to 32 GW with a mean value of 25.5 MW (reference scenario), there is a tremendous gap that will be filled by energy import from the WAPP countries and by additional RE option if the objectives of clean energy supply are achieved. Hereafter, the IRED supply scenario meant to meet the increased demand in the short, medium and long terms. However, it is to be noted that in the IRED there are no details on the breakdown of this supply capacity except for the indication that this increase will be based on an extended use of RE (hydro, solar energy, and biomass).

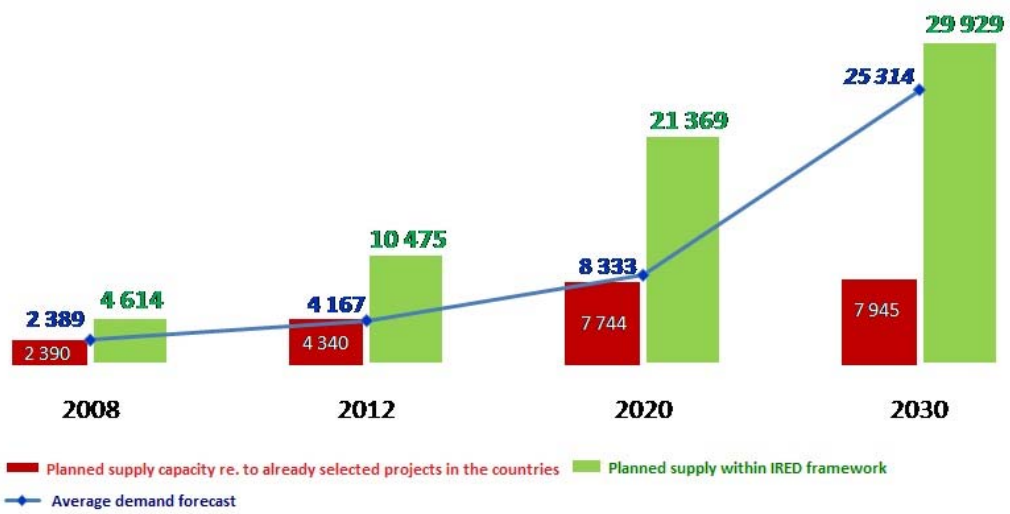


Figure 11: Planned supply capacity regarding the already selected projects in UEMOA countries compared to the planned supply capacity within IRED framework (MW)

[6] Meeting of February 29, 2012 with Alassane Ouattara Energy Adviser (UEMOA)

3.6 Permanent Inter-State Committee for Drought Control in the Sahel (CILSS)

The CILSS initiative covers 7 of the ECOWAS countries (Niger, Burkina Faso, Mali, Senegal, Cape Verde, Guinea Bissau and the Gambia) and focuses on woody biomass, sustainable management of forest and wooded lands and sustainable use of wood-fuel, including substitution strategies (LPG and kerosene). According to the PREDAS evaluation report (2010), a domestic energy programme for the CILSS countries, Guinea Bissau, Senegal and Gambia, have sufficient resources in regard to their present and future demand provided that the use of efficient stoves becomes the normal practice.

For the three most densely populated Sahelean countries that are Burkina Faso, Mali and Niger, wood resources are becoming scarce in view of the growing demand. Special efforts are required for sustainable forestry management on the supply side, and energy conservation measures on the demand side. Cook-stoves diffusion is successful in Bamako and in the large Malian cities and is increasing in Burkina Faso (200.000 items for an improved cook-stoves FA FASO project financed by the Netherlands cooperation DGIS). The national LPG production estimated to 30.000 tonnes on the new refinery of Agadez will provide a relief for the overexploited wood resources in Niger. The nearly 20 years old rural market model for wood fuel developed in Mali and in Niger, trying to rationalise and make sustainable the management of the forest through market mechanisms and differential taxes, seems to be failing. However, it is encouraging to see the development of a new trend of trees disseminated in the field that are the property of the individuals and not of the community (Maharadi region)

For the other ECOWAS countries that are not CILSS, Cote d'Ivoire is the only one that is developing its forest areas. Programmes for sustainable wood and charcoal production are also being implemented. Countries like Benin, Togo, Liberia and Sierra Leone should not have a major problem with their wood-fuel supply but effort to disseminate efficient cook stoves will always be relevant. In Nigeria, the forest and savannah woodland areas regress year after year as indicated in the FAO global forest assessment.

Efforts are being made in the CILSSS countries to build commitment around a national domestic fuel policy having sustainable forest management, efficient uses of the resources (cook stoves and charcoal production) and fuel substitution as main pillars.

3.7 Benefits of RE in the context of the regional power market

The expansion of power generation from "new renewables" offers the opportunity to complement the regional power trade scenario of the WAPP. The ECOWAS countries can take advantage of their local renewable energy sources depending on their individual situation and the competitiveness of the available renewable technologies. The Master Plan divides the ECOWAS region into three country groups and assigns different roles to them.

a. **Countries with potential for a self-sustained supply:** It is the case of Senegal, Côte d'Ivoire, Ghana, Nigeria, Togo/Benin and Niger after 2020 (a larger coal based thermal production is expected at that year). It is also the case of Cape Verde.

b. **Countries with continued dependence on power imports**: The Gambia, Guinea Bissau, Mali and Burkina Faso. Niger will request about 1/3 of its electricity needs as imported energy up to 2021, after it would be a surplus that could be exported.

c. **Countries with the potential to become power exporters after 2018**: That is the case of Guinea, Sierra Leone, Liberia, and to a less extent Cote d'Ivoire and Niger after 2021. The hydro production will lead to a low marginal electricity cost that can be a barrier for other RE options like for instance biomass or mini hydro.

3.7.1 RE benefits for countries with self-sustained supply

For this group of countries (Ghana, Nigeria, Togo/Benin, Senegal, Cote d'Ivoire), additional power generation from "new renewables" is expected to impact positively as it would replace part of the planned conventional capacity development. However, it could require complementary ancillary power capacity to ensure grid stability (e.g. integration of wind and solar). Only some of the renewable energy technologies will be competetive with conventional sources used in these countries:

a. For Senegal, additional RE could reduce thermal power production based on coal during the whole period and could contribute to improve the supply security by 2012-13, as Senegal's supply includes a share of energy importation. As the thermal production will be based on coal[7], additional RE production will have a positive effect on CO_2 emission.
b. For Ghana, additional RE production could substitute a part of the energy importation enhancing the supply security from 2018 and a share of the gas based thermal production (2014-17) that is expected to be exported towards Burkina Faso.
c. For Côte d'Ivoire, the erection of a new dam in 2018 will secure the domestic supply and a certain amount of energy to export. There is no additional RE production on top for the hydro production, programmed by the WAPP and Cote d'Ivoire is very reluctant to consider RE options in their power supply.
d. For Nigeria, the additional RE production would replace the thermal production based on gas or just filled the capacity gap.
e. For Togo-Benin, as well as for Nigeria, additional RE production would substitute a share of gas based thermal production (Maria Gleta gas power plant 450 MW from 2014) or fill the gap in case of delays.

In all the cases, the magnitude of thermal or hydro production (base load) is sufficient to balance possible variation through RE production (e.g. wind, solar). The countries can rely on different RE resources:

a. Senegal**:** Wind and biomass are obvious candidates. Solar option has to be confirmed in relation to an adequate access to the grid (suitable voltage and distance).
b. Ghana: Biomass and wind... the solar option is possibly less cost efficient than biomass, but can be used for smaller application. Mini hydro schemes could contribute for both grid energy and to power isolated schemes.
c. Nigeria: SSHP, solar and wind in the North (to be verified) and potentially biomass and agro-industrial wastes.
d. Togo/Benin: Biomass and SSHP connected to the grid.
e. Niger after 2020: Solar but it will require a sufficient transfer capacity on the HV grid depending on where the solar farms will be erected.

[7] Sendou coal power plant 875 MW new capacity planned in 2016

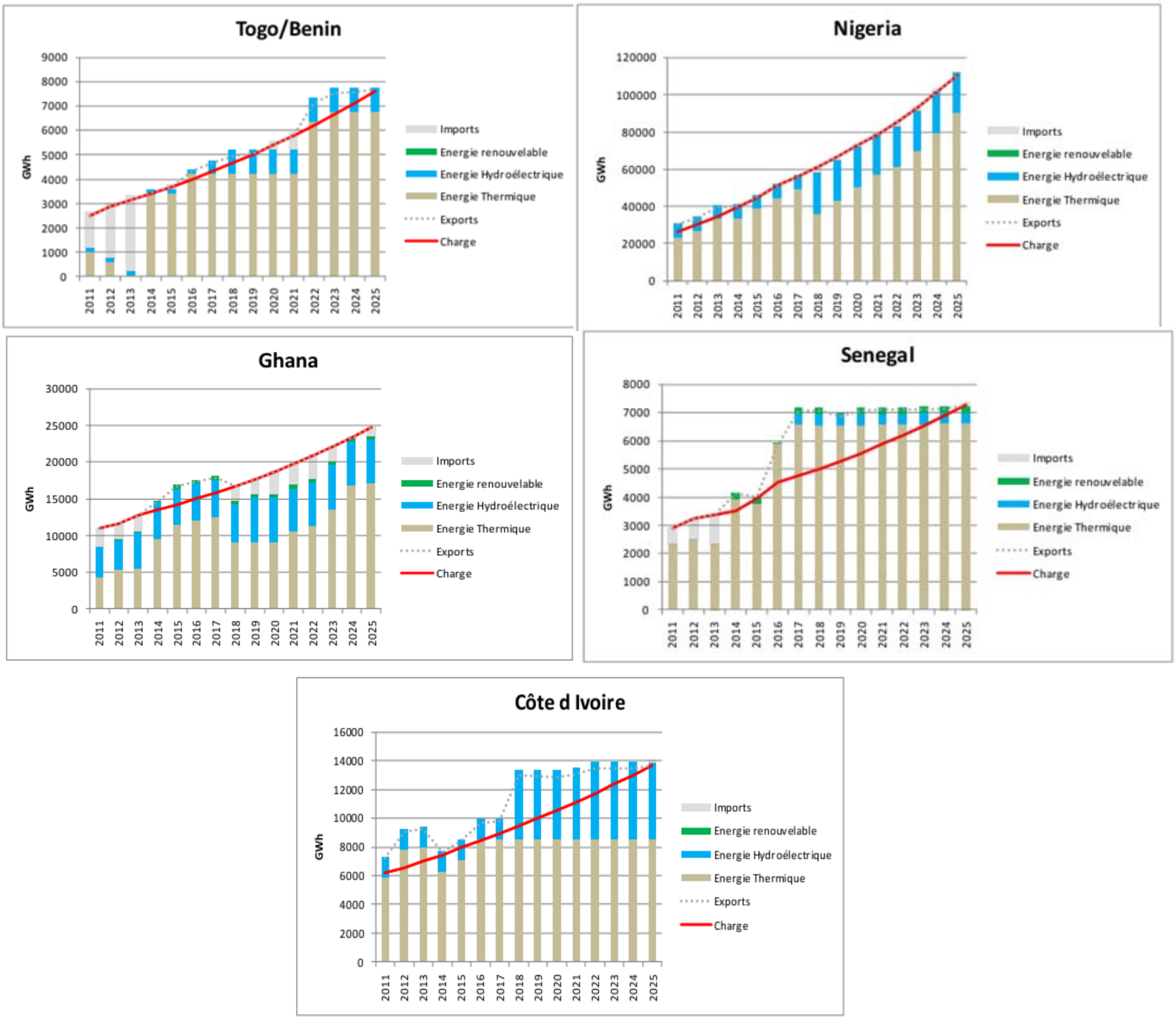


Figure 12 : Countries with self-sustained supply

3.7.2 RE benefits for Countries with import dependence

For Burkina Faso, the Gambia, Guinea Bissau, Mali and Niger (prior to 2020) additional RE production could increase their supply security and would probably reduce significantly the risks and the costs of a necessary expansion of diesel/heave fuel production due to delays of the WAPP Master Plan. In the non-renewable scenario, the countries will rely heavily on power imports and are very vulnerable to delays of the WAPP Master Plan implementation. This could lead to the restart of their diesel/heavy fuel based thermal plants (available cold reserves) and possibly massive load shedding programmes. It would also lead most probably to new investments in conventional production. The renting of emergency diesel generators would be the worst case scenario.

A country like Burkina Faso has already anticipated its planned investments in diesel reserve capacities when implementing 80 MW in 2009-2012, and are requesting additional diesel power capacity for their regional centres. For example the Ouaga - Bolgatanga 162 kV line is already postponed for a few years.

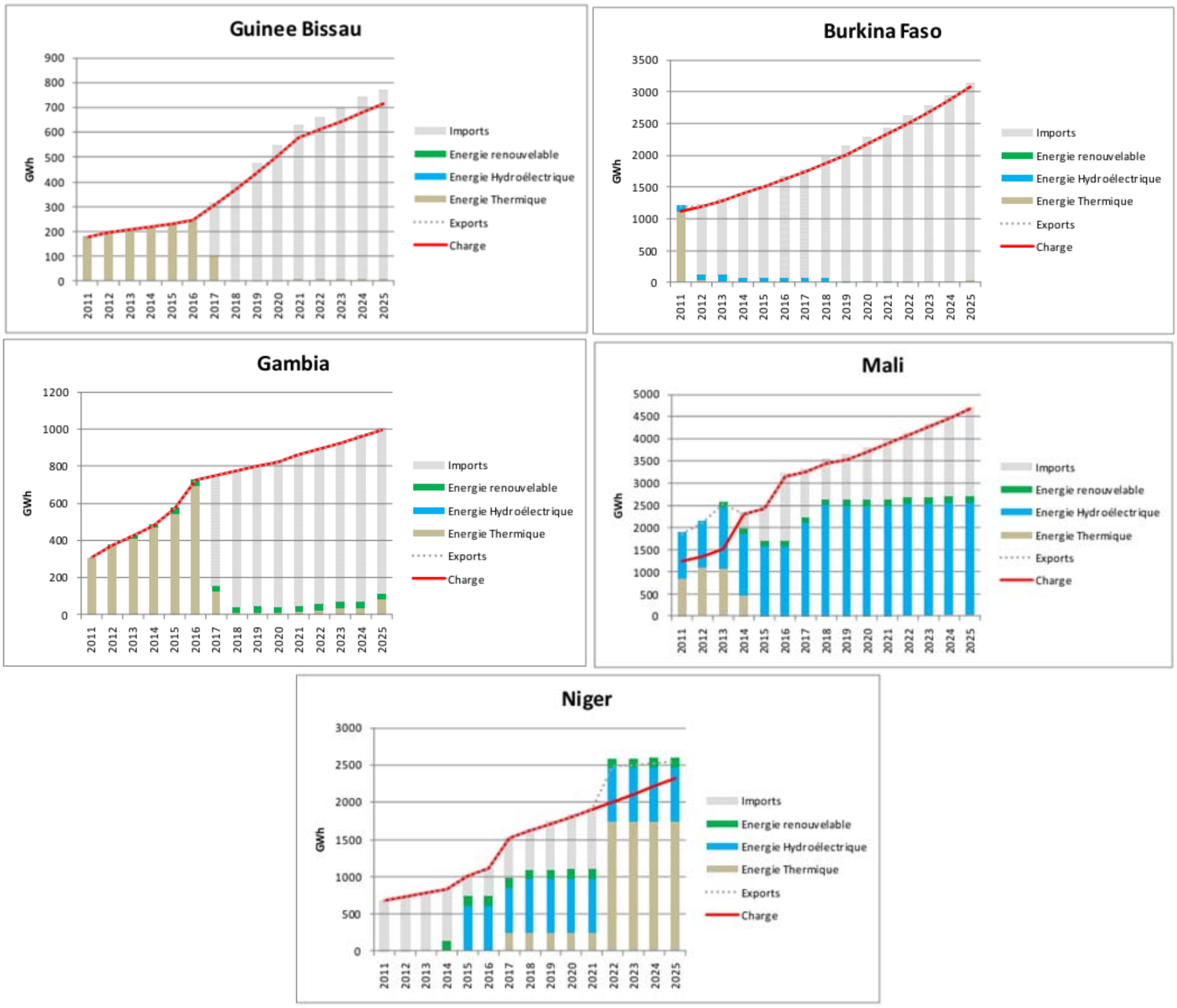


Figure 13: Countries with import dependence

The expansion of local generation from "new renewables" is an interesting option for these countries. Some of the technologies are very competetive in relation to conventional options such as diesel and heave fuel oil based generation. In the case of Niger, the additional RE production would contribute to a better supply security during the whole period up to 2020 and then will substitute part of the coalfired power production, having an adverse impact in terms of CO_2 production (200MW Salkadamma plant). The options for additional RE production for these countries are summarised in the table below:

Table 5: RE options for Countries with import dependence

Options	Burkina	Mali	Niger	Guinea Bissau	The Gambia
Solar PV	Relevant	Relevant	relevant	?	?
Wind	Nil	North for Tumbuktu. The potential is at the margin to be economically viable for larger production	Possible potential in the Northern part of the country, but connection to a suitable grid	On the Coast? But there is a lot of tropical vegetation	On the Coast

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Biomass	Cotton staks, bagasse	Cotton staks, cotton seed shell and rice husks (office du Niger)	Nil	Relevant Timber industry residues Anacardiers shells	Groundnuts shells for cogeneration at Banjul oil mill
Biogas	Agro-industries, dairies	Slauter-houses			
Biofuel	7000 ha jatropha, several stakeholders	2000 to 4000 ha Mali biocarburants	Nil	Nil	Nil
SSHP	around 138 MW potential estimated	Around 70 MW potential	About 30 MW potential	About 48 MW potential	No resources

Apart from small-scale hydro power, solar and wind resources that can contribute to larger power generation (MW size), the biomass requires a certain amount of resources gathered together in one place in order to be economically viable as grid energy option. Otherwise, the transport costs hamper the viability of the power production. Biomass can also in small scale provides energy to rural areas (gasifier, biogas plants).

Uses of biomass will mainly depend on the political willingness to promote it. In general, the use of biomass residues supposes a certain concentration at agro-industrial processing location in order to assure a minimum economy in the waste to energy process. Picking cotton staks in the field is a costly business as the energy density per ha is very low and the transport costs are high due to the low density of the product.

Besides dairies and slaughters wastes and manures which are in sufficient quantities to enable economic biogas production, most of the WA 'potential resources' are not economically available for energy production and their collection should be concentrated on their fertiliser value in order to produce a better compost.

Biofuel production has become a controversial issue, as the 2008/09 food crisis has been connected to biofuel production in USA and Germany. However, countries like Mali and Burkina continue to develop some jatropha based bio-fuel production focusing on a local production for local needs (raw filtered oil to be used in local stationary diesel motor for electricity or for mechanical drive)..

3.7.3 RE benefits for potential power exporting countries

In the WAPP Master Plan scenario, the supplies of countries such as Guinea, Sierra Leone and Liberia will rely entirely on new large hydro capacities and transmission lines. Unfortunately, delays in decision making regarding the CLSG line routing are already occurring. Moreover, Guinea has decided to consider the Kaleta dam (240 MW) as national project which creates serious concerns among the neighbouring countries.

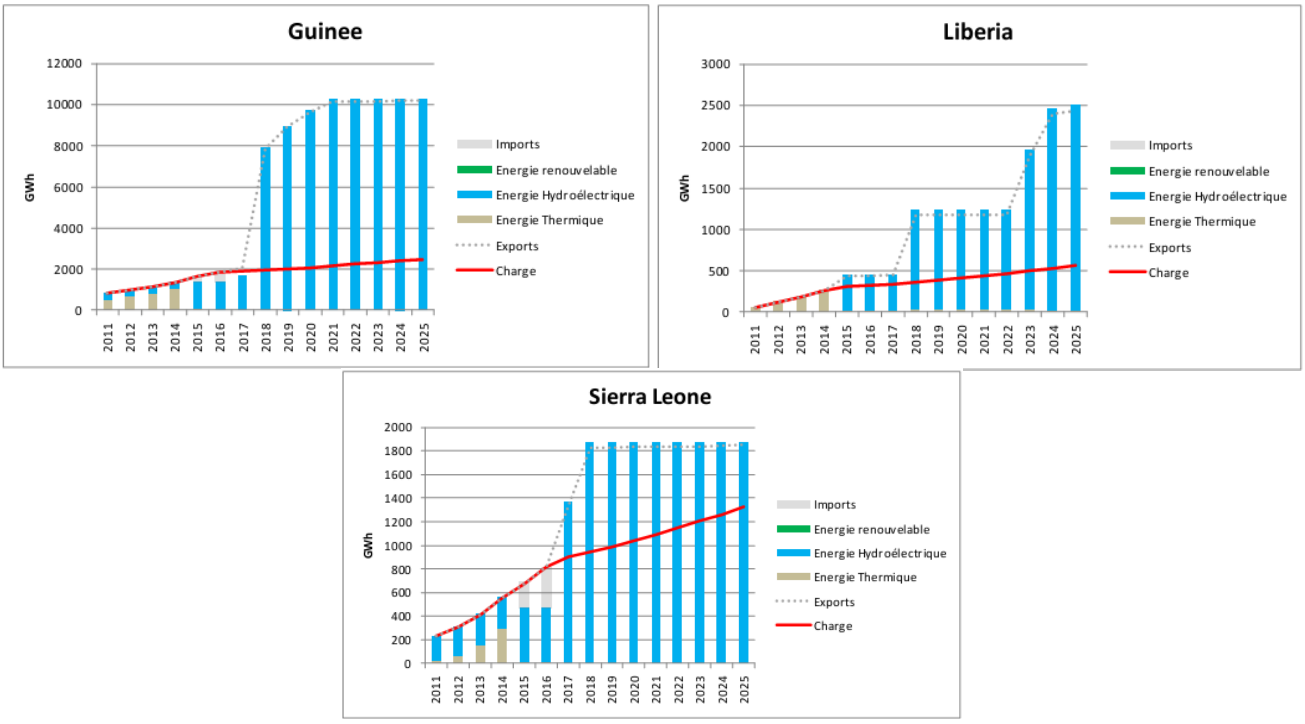


Figure 14: Countries with potential power export

From 2018-19 onwards, it will be difficult for other renewable energy options to compete with the cheap large hydro power supply. The RE WAPP scenario has demonstrated that wind, SSHP and large biomass plants can be competitive to the resulting WAPP energy delivery, in particular when the level reach the 41 to 74 €/MWh. Other resources are available, such as waste rubber trees in Liberia, and a substantial potential of agro-industrial potentials in Côte d'Ivoire, that could be mobilized for economical energy production. Biomass power can also be promoted.

A biomass power plant with a capacity of 36 MW to supply the capital of Liberia is near to financial close. In Sierra Leone, a factory capable of producing 90,000m3 of ethanol per annum and 32MW of nominal electrical power capacity, of which 15MW will be available for sale to the national grid, is under construction, funded by the AfDB.

3.8 Different Assumptions and uncertainties of WAPP/IRED scenarios

3.8.1 Electricity load forecast for ECOWAS

The two first phases for IRED are thoroughly planned and almost financed through the UEMOA Energy Fund. However, the plan does not cover the capacity expansion after 2020. For the WAPP, a selection of priority generation and transmission projects has been developed and approved in the 2011 Master Plan. All financing means are not completely secured but most of the projects have received financing pledges by a consortium of multilateral and bilateral donor organizations.

An implementation schedule is established for both initiatives, but it can be subjected to modifications due to unforeseen or inherent delays tied to the project implementation cycle and/or fund mobilization. Regional projects, involving large company consortia and joint agreements of a large number of governmental and financing partners, are of high risk and a very time consuming effort. For instance, the IRED has planned an ambitious capacity development of around 2,224 MW for the period 2008-2012. Also, some of the intended projects of the WAPP seem to be delayed or the results are uncertain (e.g. large hydro development in Guinea).

Power demand forecasting is a difficult exercise in West Africa since a part of the demand is presently suppressed or not accounted due to the lack of infrastructure to access the service in the sub-urban and rural areas or due to the lack of supply (e.g. load shedding). Furthermore, part of the demand is not expressed due to economic reasons (too expensive connection fees or too high tariffs for the poor).

Thus there is a large discrepancy between the two sets of forecasts as the ’low demand’ forecast carried out by the IRED study is at the same level as the ‘high demand’ forecast for the WAPP master plan. The growth rates used in the WAPP forecasts are respectively 6% and 7% for "low demand and baseline demand". The IRED document proposes quite higher growth rates: 7% for the suppressed demand forecast, 10.9% for the baseline and 11.9% for the no constrained access to electricity forecast. The current growth in consumption in the electrified network takes account of rural electrification. For the future, the growth rate of rural electrification is assumed to be identical to that of today, which may not happen.

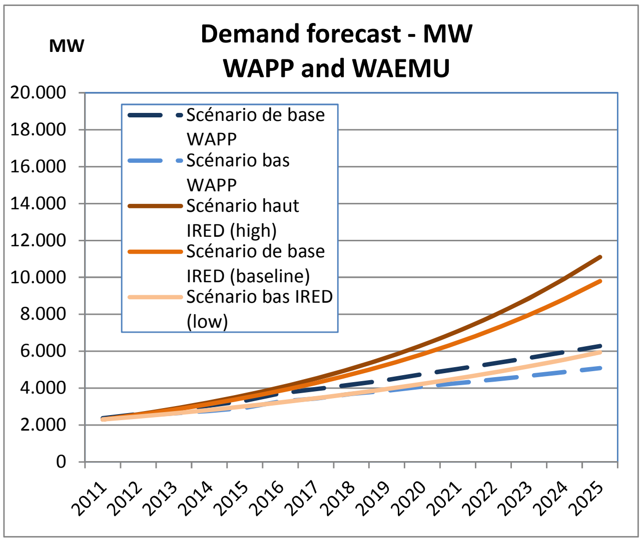


Figure 15 Comparison between IRED and WAPP forecasts

It’s interesting to visualize the respective sizes of the countries and their projected energy demands. In 2025 Nigeria will continue to be the major economic actor by contributing with around 61% to the overall ECOWAS power demand, followed by the Ghana with 12.2% and the Ivory Coast with 6.5%. The other 11 countries will constitute only about 20% of the total demand in 2025.

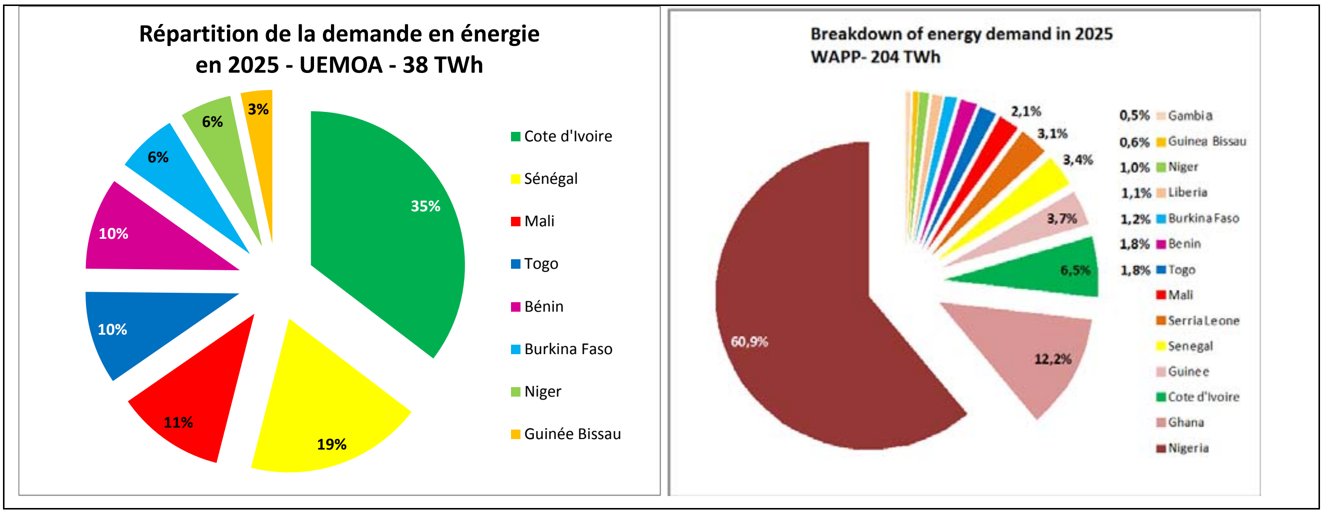


Figure 16: Breakdown of energy demands for respectively UEMOA and ECOWAS countries in 2025.

3.8.2 The WAPP load forecast as basis for the EREP

For the present study the WAPP basic forecast will be used as baseline for the development of the RE scenarios as it covers the entire ECOWAS region. It must be noticed that this forecast does not take into account the off-grid demand that can be covered by mini-grids systems and stand-alone equipment. Furthermore, the forecast includes a large share of Nigeria's suppressed demand that was not covered due to important delays in investments. Since 2009/10, efforts have been made to catch up these production deficits.

Table 6: WAPP basic demand forecast

Country	Consumption in GWh			Capacity in MW		
	2011	**2020**	**2030**	**2011**	**2020**	**2030**
BENIN	1,341	2,576	4,275	219	420	697
BURKINA FASO	873	1,694	2,840	178	345	579
CAPE VERDE	360	540	740	112	169	231
COTE D'IVOIRE	6,005	10,244	15,580	968	1,652	2,512
GAMBIE	239	847	1,351	50	135	212
GHANA	11,107	18,828	28,758	1,629	2,775	4,198
GUINEE	608	1,937	3,072	139	340	519
GUINEE BISSAU	141	385	705	29	83	152
LIBERIA	47	355	633	9	68	121
MALI	1,136	3,398	5,621	199	550	900
NIGER	849	1,609	2,469	149	287	449
NIGERIA	39,102	91,873	148,049	6,376	14,983	23,778
SENEGAL	2,654	5,306	8,441	456	891	1,412
SIERRA LEONE	202	907	1,561	38	170	292
TOGO	1,042	2,609	4,482	170	426	731
Mines	350	12,733	15,325	50	1,834	2,348
ECOWAS - mines	**65,706**	**143,108**	**228,576**	**10,721**	**23,294**	**36,783**
ECOWAS + mines	**66,056**	**155,841**	**243,901**	**10,771**	**25,128**	**39,131**

The WAPP basic forecast plans a doubling of energy and capacity demand in 2020 (increase factor of 2.18 and 2.17 respectively for GWh and MW) and a comfortable tripling for 2030 (x factor 3.48 and 3.43).

3.8.3 Conformity of RE Targets of WAPP/UEMOA Policies

The scenarios of WAPP and UEMOA head to a similar direction. Both WAPP and IRED (UEMOA) scenarios propose ambitious targets for the integration of renewable energy into their regional electricity systems (the targets are exceeding the targets of the EU or SADC by 2020). However, it should be noted that the very pro-active IRED scenario seems to be more an idealistic vision rather than as scenario based on a sound economic cost-benefit analysis. The WAPP scenario was modelled on the basis of already identified projects and by considering the competitiveness of the different technology options:

1. In the UEMOA scenario RE contributes to 40% of the installed capacity in 2007 and is expected to reach 61% by 2020 and 78% by 2030. The size of the UEMOA system is about 23% of the ECOWAS energy system. In the UEMOA scenario, around 2% of the installed capacity would be derived from new renewables (solar, wind and biomass) in 2007; around 27% by 2020 and 62% by 2030. Approximately 38% is provided by large hydro power in 2007,

34% in 2020 and 16% in 2030. How these very high shares should be achieved is not explained further. With more than 33.5 billion EUR, the investment plan exceeds the estimations of the WAPP Master Plan for the whole ECOWAS region nearly two times. How this investment will come is also not discussed.

- The WAPP scenario foresees a RE penetration rate of 35% of installed capacity by 2020 throughout 2025 in the basic scenario and a share of 41% in the more ambitious alternative RE scenario. Around 4% of installed capacity would be provided by new RE in the basic scenario and 10% in the alternative scenario. The rest would derive from large hydro sources.

Both scenarios require essential investment in RE infrastructure in the forthcoming years:

2. In the WAPP base scenario, around 69% of the additional capacity would be derived from large hydro and around 8% from new renewables by 2025.
3. The IRED scenario foresees the installation of additional 15,146 MW of new renewables by 2020 and 2,981 MW by 2030.

3.8.4 Implementation Risks

Both regional programmes develop a perfect picture of the future development of the WA power supply based on well-known centralized options from the modern capital intensive power sector, based on a dense and efficient transmission system distributing centralized produced electricity to domestic and industrial consumers with high purchase power. These programmes need to be challenged on following fronts:

- anticipation of some risks that could occur during the implementation phase as for example a mismatch between the planned power availability in the south (hydro and gas) and the transmission capacity to the deficit areas. Power lines are completed but there is not enough energy to transport. Worst will be the case with available capacity and no line to share it to neighbouring areas.
- the grid-based distribution to rural areas cannot be financed as its impact on the average tariff is too high (high capital cost, high energy losses) and/or some rural areas remain un-served.

Risk of delay due to mobilisation of financing: WAPP and IRED scenarios focusing essentially on large projects following the logic of economic viability are exposed to a high risk of delay in the implementation due to the difficulties in securing the financing. And this in particular in the current new international context characterized by a deep financial crisis might make the financing more uncertain. A differentiation on the investment segment and the attention to smaller projects (i.e. Small-scale hydropower) could help to minimize this risk.

3.9 Limitations of the WAPP/IRED scenarios

3.9.1 Exclusive focus on electricity

Since the WAPP/UEMOA reports are more focused on electricity they blend out other renewable energy solutions (such as solar thermal systems, biogas) for cooking, heating or cooling. However, some of these solutions can be of high value for some of the ECOWAS countries. Moreover, the WAPP Master Plan does not consider SSHP as a renewable energy option which leaves one of the most competitive technologies out of the scenario projections.

3.9.2 The rural off-grid areas

Another issue that both scenarios do not very well address are the needs of rural areas. Both initiatives are more focused on regional power trade which will mainly satisfy the needs of urban areas and to some extent also peri-urban areas (e.g. grid extension). The provision of large amounts of cheaper electricity at national level will not necessarily mean increased access for the rural areas, as its distribution to the less and dispersed populated rural areas can be a costly affair. The regional approach introduces a technological bias for rural electrification. Supposedly cheap and abundant electricity leads to assumptions in favour of grid-based rural electrification which are not questioned, as grid-based electricity is deemed to be the real quality product that administrative centres or influential politicians' villages deserve. This often results in construction of non-economic MW distribution networks that preclude on short and medium terms, a least cost RE approach. When looking at the technology catalogue developed in both studies, only large sized technologies are considered as for example fluid-bed furnace/boiler for biomass uses, or larger hydro plants or 1MW wind turbine. The approach thus strengthens the traditional bias for grid based electricity.

3.9.3 The issue of biomass

Despite the fact that a high level of uncertainties are tied to the financing and the implementation schedule of these plans, the 'big picture' for regional power supply as it is elaborated by the WAPP and IRED projects makes sense in an economic view. Since electricity needs and power supply are the main concerns of these major programmes, little attention is also paid to the biomass resources that constitute about 75% of the overall energy balance for both ECOWAS and WAEMU countries. These resources are often over-exploited or exploited in an unsustainable manner, particularly for cooking. However, if the end-uses can be managed in a sustainable way, and measures for sustainable forest management and regeneration taken, substantial amounts of woody biomass could be released which could be used for power generation together with residual agricultural by-products, as is presently the case in many developing countries. But this will require a mind-set change for many policy makers, as wood to power generation is a taboo issue for many of them. This will remain an important issue.

3.9.4 Grid-stability and smart-grids

Although WAPP and IRED scenarios consider wind and solar as renewable energy technologies contributing to the energy mix, no mention of control and monitoring technique of intermittent loads is made in order to assure high-performance and reliable operation of the RE technologies. The promotion of smart-grids could help address the problems associated with the efficient and reliable delivery and use of electricity and with the integration of renewable sources. In most countries the issue of grid-stability will not be relevant as the contribution of intermittent renewable energies will stay small. However, in the case of some island grids in Cape Verde, the issue of grid stability is becoming a limiting factor to inject further wind power (e.g. Praia, São Vicente, St. Antão).

4 Regional institutional framework for energy

At the beginning of the 80ies, ECOWAS Heads of State identified the need for a more pragmatic approach to the fight against energy poverty by taking the major decisions on the regional energy programme. These include the adoption of the ECOWAS Energy Policy in December 1982, the December 1999 decision to establish a regional electricity market (WAPP), the January 2003 adoption of the ECOWAS Energy Protocol, the January 2006 adoption of the ECOWAS Generation and Transmission Master Plan, as well as the adoption in January 2008 of a Supplementary Act establishing a regional regulator to ensure open and transparent energy trade in West Africa.

In 2006, ECOWAS/UEMOA adopted the White Paper on access to modern energy services for populations in rural and peri-urban areas. These initiatives reflect an increasing drive for integrated energy markets in the region and hence justify a regional approach in developing the renewable energy and energy efficiency sectors. For example, the ECOWAS/UEMOA White Paper foresaw that at least 20% of new investments in electricity generation in the region will be driven by renewable resources. It was against this background that the ECOWAS Council of Ministers at its 61st Session in Ouagadougou, Burkina Faso, requested the Commission to re-focus its energy access agenda towards promoting the use of alternative energy sources, including solar, wind and other Renewables and set the base for the establishment of the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) on November 23, 2008.

Key legal texts include:

- The ECOWAS Treaty and the ECOWAS Energy Protocol which are giving the legal context to the WAPP
- Articles of Agreement of the West African Power Pool Organization and Functions (October 2005) defining the compulsory character of regional power projects. The WAPP has been created in 2006 and is based in Cotonou – Benin.
- Regulation C/REG.27/12/07 on the Composition, Organization, Functions and Operation of the ECOWAS Regional Electricity Regulatory Authority.
- Supplementary Act A/SA.2/1/08 establishing the ECOWAS Regional Electricity Regulatory Authority ERERA, which is constituted and based in Accra – Ghana since 2007.
- Regulation C/REG.23/11/08 establishing the ECREEE, the Regional Centre for Renewable Energy and Energy Efficiency based in Praia, Cape Verde.

Four fundamental institutions have been created and are fully operational.

4.1 The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)

ECREEE is a specialized agency of ECOWAS with a public mandate to promote regional renewable energy (RE) and energy efficiency (EE) markets. It acts as an independent body but within the legal, administrative and financial framework of ECOWAS. The Centre was established in 2010 with support of ECOWAS, the Governments of Austria and Spain and key technical assistance of the United Nations Industrial Development Organization (UNIDO). ECREEE aims at the following objectives:

- to promote sustainable development in West Africa by improving access to modern energy services, energy security and climate change mitigation through the use of RE&EE.
- to create an enabling environment for regional RE&EE markets by mitigating various barriers for the dissemination of green energy technologies and services.

With its activities ECREEE contributes to:

- the UN Goals on Sustainable Energy For ALL (SE4ALL) which aim at achieving three interlinked targets by 2030: universal access to modern, affordable and reliable energy services; doubling the rate of improvement in energy efficiency; doubling the share of renewable energy in the global energy mix.

- the WAPP Master Plan Scenario which aims at doubling the regional electric generation capacity by 2025.
- the ECOWAS White Paper on energy access which foresees that at least 20% of new investments in rural electrification should originate from locally available renewable resources.

The geographic scope of ECREEE is defined as follows. The Centre:

- supports and executes RE&EE activities and projects which cover one or more ECOWAS countries: Benin, Burkina Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Côte d'Ivoire, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.
- focuses primarily on activities and projects with regional impact or national projects which demonstrate high potential for scaling-up or regional replication.
- works in urban as well as peri-urban and rural areas. Due to the high relevance of decentralized RE&EE technologies and services for rural areas the Centre will run a special rural energy program.

The Centre promotes the following energy technologies/solutions:

- All appropriate renewable energy and energy efficiency technologies and solutions, including partly renewable energy based hybrid systems and mini-grids.
- Small-scale hydro-power projects usually with a maximum capacity of 30 MW.
- Biofuel projects which prove to be sustainable.
- Liquid Petroleum Gas (LPG) cooking projects are eligible due to their high relevance for low-income population groups.

The Centre implements activities, programs and projects in the scope of the four result areas:

- Tailored policy, legal and regulatory frameworks
- Capacity development and training
- Knowledge management, awareness raising, advocacy and networks
- Business and Investment Promotion

ECREEE provides the following services to different clients and target groups:

- develop and implement a coherent regional RE&EE policy framework of ECOWAS and facilitate its implementation on national levels;
- Develop and execute regional programs and projects with other partners and mobilize funding;
- Operate as key entry point for the implementation of international funding to mitigate climate change in the energy sector (e.g. UN, GEF, IBRD);
- Provide co-funding for demand-driven programs and projects executed by the private and public sector or civil society in the region (e.g. call for proposals and tenders);
- provide a framework for capacity building activities and strengthens networks between research and training institutions as well as organize train-the-trainers workshops;
- Update and provide RE&EE information and data for investors;
- Think tank, lobbying agent and advisory platform for RE&EE in West Africa;
- Networking and co-organization of conferences, forums and workshops;
- Facilitate north-south and south-south cooperation for knowledge and technology transfer;

The institutional structure of the Centre includes:

- the Secretariat based in Praia, Cape Verde
- the Executive Board (EB)
- the Technical Committee (TC)
- the National Focal Institutions (NFIs) in the 15 ECOWAS countries

The **ECREEE Secretariat** is based in the capital of Praia, Cape Verde, and operates in all three ECOWAS languages (English, French, and Portuguese). It operates with a small multinational team of West African and international full-time staff.

ECREEE has established a **network of National Focal Institutions (NFIs)** which interlinks the Secretariat with all ECOWAS Member States. The activities of the Centre are executed in cooperation with the NFIs or other entities of the public and private sectors. The Secretariat implements the activities and elaborates the annual work plans and status reports and presents the documents for review and approval to the Technical Committee and Executive Board.

The Centre is governed by an **Executive Board (EB) and a Technical Committee (TC)** which meets usually twice a year. The EB is the highest decision making body which provides strategic guidance and approves the annual work plans, progress reports and financial statements of the Centre. The technical guidance is provided by the Technical Committee (TC). The TC has the role of reviewing major technical documents and reports for submission to the EB. If necessary the TC reviews projects to be funded by ECREEE resources and recommends their approval by the EB.

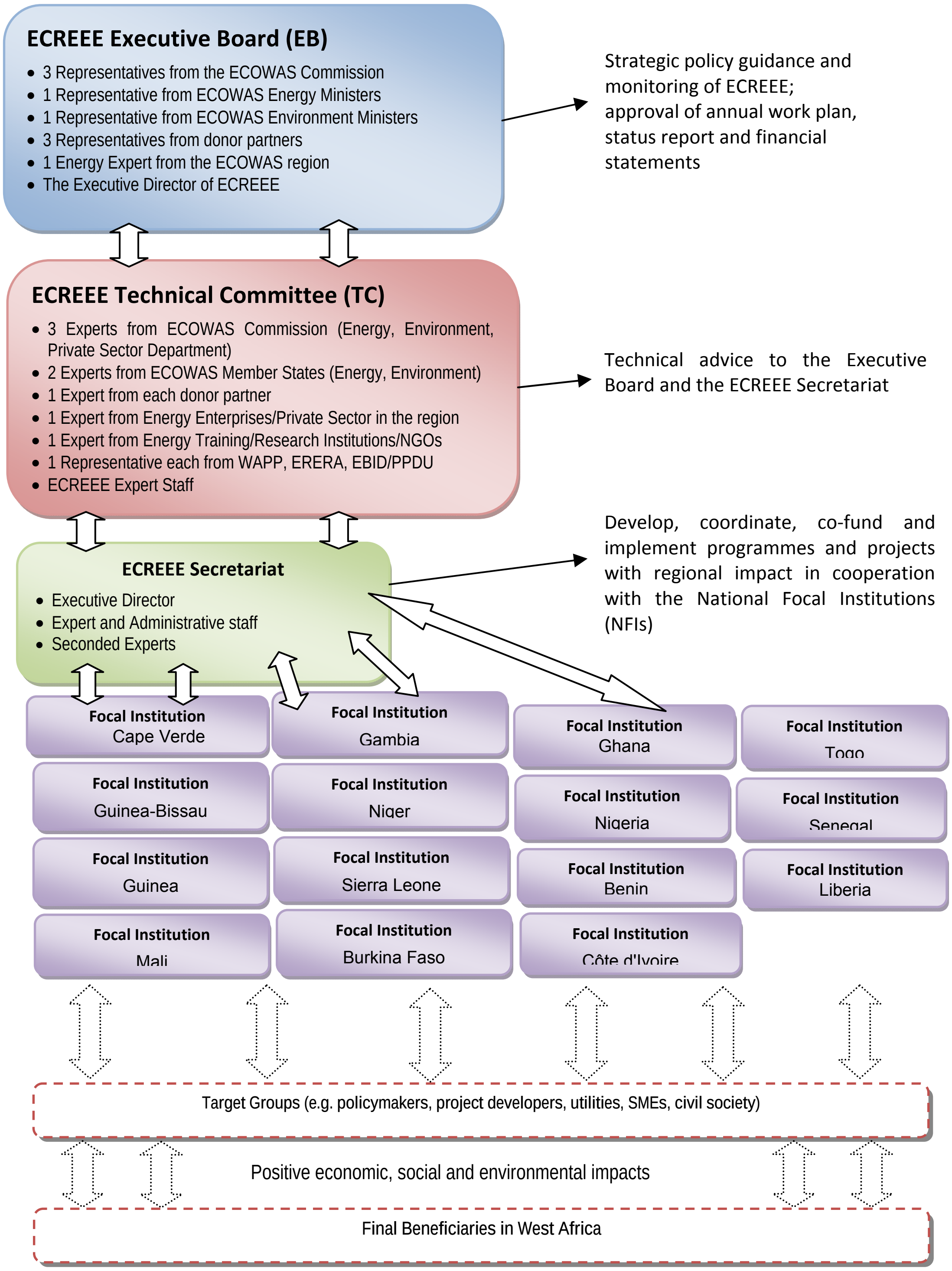


Figure 17: Institutional Structure of ECREEE

4.2 The West African Power Pool (WAPP)

The WAPP is organised with its General Assembly, Executive Board, Organizational Committees, WAPP General Secretariat and WAPP Information and Coordination Centre. The West African Power Pool brings together the utilities of 14 of the 15 ECOWAS member states, except Cape Verde which is an archipelago, without electrical connection with the African continent. The vision of this Organization is 'To develop and put in place a cooperative power pooling mechanism for integrating national power system operations into a unified regional electricity market."

At the present time, the WAPP is promoting the development of infrastructures (high voltage transmission network connecting the different power systems, and large power capacities to solve the recurrent energy crisis) and the elaboration of common electrical standards to promote and achieve a complete synchronization of the WAPP area.

As previously said, the WAPP is an association of all private and public utilities which are operating within the boundaries of the continental ECOWAS region (the Cape Verde utilities are not affiliated to the WAPP). Some countries like Ghana, Mali have several utilities represented (for example the 3 Ghanaian utilities: GRIDCO, VRA, and ECG). The WAPP represents the corporate interests of the regional power sector and is not per se a political decision institution as ECOWAS is.

The WAPP's decisional organs are the General Assembly and its Executive Board which is in charge of implementing the decisions made in the General Assembly. Three committees help the Executive Board in its duties and tasks:

- the Engineering and Operation Committee dealing with the standards
- the Strategic Planning Committee dealing with the overall coordination of planning activities (transmissions networks and new capacity production).
- the Finance and HR Committee, which will be split in two separate committees to cope with the development of the WAPP activities.

The daily activities of the WAPP are coordinated by the WAPP general secretariat based in Cotonou. The secretariat is organized in three divisions:

- Operations Division (Information and Coordination Centre)
- Finance, Procurement & Human Resources Division
- Planning, Investment Programming & Environmental Safeguards Division

4.2.1 WAPP's priorities

The present priorities of WAPP are to develop and build the necessary conditions of the emergence of a single power market within the WAPP boundaries, by:

- Developing and coordinating the WAPP Master Plan which should provide at the horizon 2020/25 a sufficient transmission and power capacity at the regional level; In 2011 the revised Master Plan was adopted.
- Elaborating the WAPP operation manual which gives rules, technical standards and specifications, rights and duties for systems operators and power producers operating on the regional grid, and ensure the approval of this manual by all utilities that are WAPP members. This manual is completed but not yet approved by the national authorities. However, the manual doesn't take into account the specific technical character of RE power production (e.g. variations in the supply). As larger RE productions are planned after 2017, the manual will be revised at that time.
- Accelerating the synchronization of the different power systems. Presently there are only

three electrical blocs that are synchronized (operating at the same synchronous frequency): two blocs in the WAPP Zone A (east part of the WAPP) - Côte d'Ivoire-Burkina-Togo-Benin and Niger-Nigeria-Benin, and the bloc Mali-Senegal in WAPP zone B. The two blocs from Zone A cannot be presently synchronized due to the high frequency fluctuations occurring in Nigeria. All remaining countries are operating as separate national networks and belong to WAPP Zone B (The Gambia, Guinea Bissau, Guinea, Sierra Leone and Liberia)

- The creation of a power market needs a unified synchronized regional network. It needs also the creation of two new regional functions: a regional system operator monitoring and controlling in real time the energy flows on the grid in close cooperation with the national system operators and a market operator who has to programme the load planning and to follow the power exchange and trade in commercial terms. Presently, **these functions do not exist.** The WAPP plans to build the technical coordination centre in the vicinity of Cotonou, in the near future, which will monitor the power exchange between Cote d'Ivoire, Ghana, Burkina and Togo and Benin, when Benin is not supplied from Nigeria.

4.3 ERERA – The ECOWAS Regional Electricity Regulatory Authority (ERERA)

The ERERA is the regional regulator for cross-border electricity interconnections in West Africa. The mission and objectives of ERERA include the following:

- Regulation of cross-border electricity connections and trading among ECOWAS member states
- Establishment of clear and transparent tariff setting methodology for regional power pooling
- Facilitating the setting up of regulatory and economic environment for the development of the regional market
- Technical regulation of the regional power pooling and monitoring of regional market operations
- Assisting the ECOWAS Commission in defining the strategy for the regional energy policy
- Establishing effective dispute resolution methods among regional market participants
- Assisting national regulatory bodies in ECOWAS on capacity building and technical issues upon request

ERERA is governed by a decision-making and managerial body called the Regulatory Council. The Regulatory Council currently consists of three members, headed by the Chairman with two other members (to be enlarged to 5 members later). Council Members appointed are for a fixed non-renewable term of 5 years. The Council is supported by a pool of experts who are responsible for the day to day operations of ERERA.

4.4 The West African Gas Pipeline Company limited (WAPCo) -

The WAPCo is a limited liability company that owns and operates the West African Gas Pipeline (WAGP) under the auspices of ECOWAS. The company has its headquarters in Accra, Ghana, with an office in Badagry, Nigeria, and field offices in Cotonou - Benin, Lome - Togo, Tema and Takoradi, both in Ghana. WAPCo is a joint venture between public and private sector companies from Nigeria, Benin, Togo and Ghana. The company's main mandate is to transport natural gas from Nigeria to customers in Benin, Togo and Ghana in a safe, responsible and reliable manner, at prices competitive with other fuel alternatives. WAPCo is owned by Chevron West African Gas Pipeline Ltd (36.7%); Nigerian National Petroleum Corporation (25%); Shell Overseas Holdings Limited (18%); Takoradi Power Company Limited (16.3%), Societe Togolaise de Gaz (2%) and Societe BenGaz S.A. (2%).The West African Gas Pipeline Authority based in Abuja is the regulatory body for WAPCo.

4.5 Major issues for the establishment of an integrated power market

A major institutional issue of the WAPP is to prepare the member states to modify their electricity acts, in order to open access to spare transmission capacity on the national HV lines qualified as part of the regional transmission system. A qualification of all elements constituting this regional transmission grid has to be carried out in order to assess what kind of investment will in the future rely on the national or the regional level. At the present time, Nigeria and Ghana are the two countries having open access on their transmission grid. The remaining utilities (vertically integrated or deregulated) keep in force their monopoly as single buyer on the national transmission grid without third party access.

Another major issue is to take a decision for assigning the market operation functions to an institution. However, the decision whether to assign the market operation functions to an existing institution or to a new one has not yet been taken. Regarding the supervision and the monitoring of the power exchanges, a Technical Coordination Centre has to be established. A plot of land is already allocated to the erection of the Coordination Centre in Cotonou. However, the Cote d'Ivoire dispatching centre has some ambitions to play this role.

An Operation Manual has been developed by the WAPP secretariat recommending technical standards for operating the regional networks safely and efficiently. This manual has not yet been appropriated and approved by the national utilities members of the WAPP, as only few of those are interconnected. The WAPP secretariat monitors the implementation of adjustments of national standards with respect to the regional Operation Manual. This manual will need to be revised to take into account the intermittency of RE power production availability (solar and mainly wind).

Presently, all power exchange and trade agreements are bilateral between the national utilities involved. Since open access is not the rule, power exchanges over a third country are not possible, as it is the case for the exchange between Cote d'Ivoire and Benin-Togo (CEB). Ghana is purchasing power from Cote d'Ivoire to sell it to CEB. WAPP is codifying bilateral trading and developing standard contracts for trading. A definition and a qualification of the market participants is also on going and the role and duties/obligations of the domestic technical system operators (TOS) with regard to the regional coordination centre are under elaboration.

The regional regulation authority, ERERA, is in place and operational. But all ECOWAS member states do not have an operational regulator as yet as for example Benin and Burkina Faso. In terms of regulation, the next major step will be to define the mandates, obligations and duties for the regional market operator, enabling a 'day ahead market' and following all bilateral trading with transit through third countries. Contract templates shall be developed by the WAPP general secretariat during the present preparation phase. Procedures regarding these contracts should be later developed by the Market Operator as part of its initial activities.

In conclusion, the physical integration of the WAPP's power systems is a prerequisite to an extended power exchange between the separate blocs or national systems. According to the master plan, this integration should be achieved at the horizon 2017-18, corresponding to the completion of the major regional infrastructure programmes (large hydro dams, interconnections, and gas operated large CC plants).

As long as the open access to the regional transmission system is not granted by all relevant authorities of ECOWAS' member states, the creation of the regional power market will stay at its present preparation phase. It will be important that the coordination centre controlling the power exchanges across the borders on the regional grid is established and starts to operate on a trial basis to get experiences and to guide national system operators (TOS) with their new duties and responsibilities. The countries need to achieve a certain minimum in adoption and implementation of regional standards which are a prerequisite for safely operating the regional network.

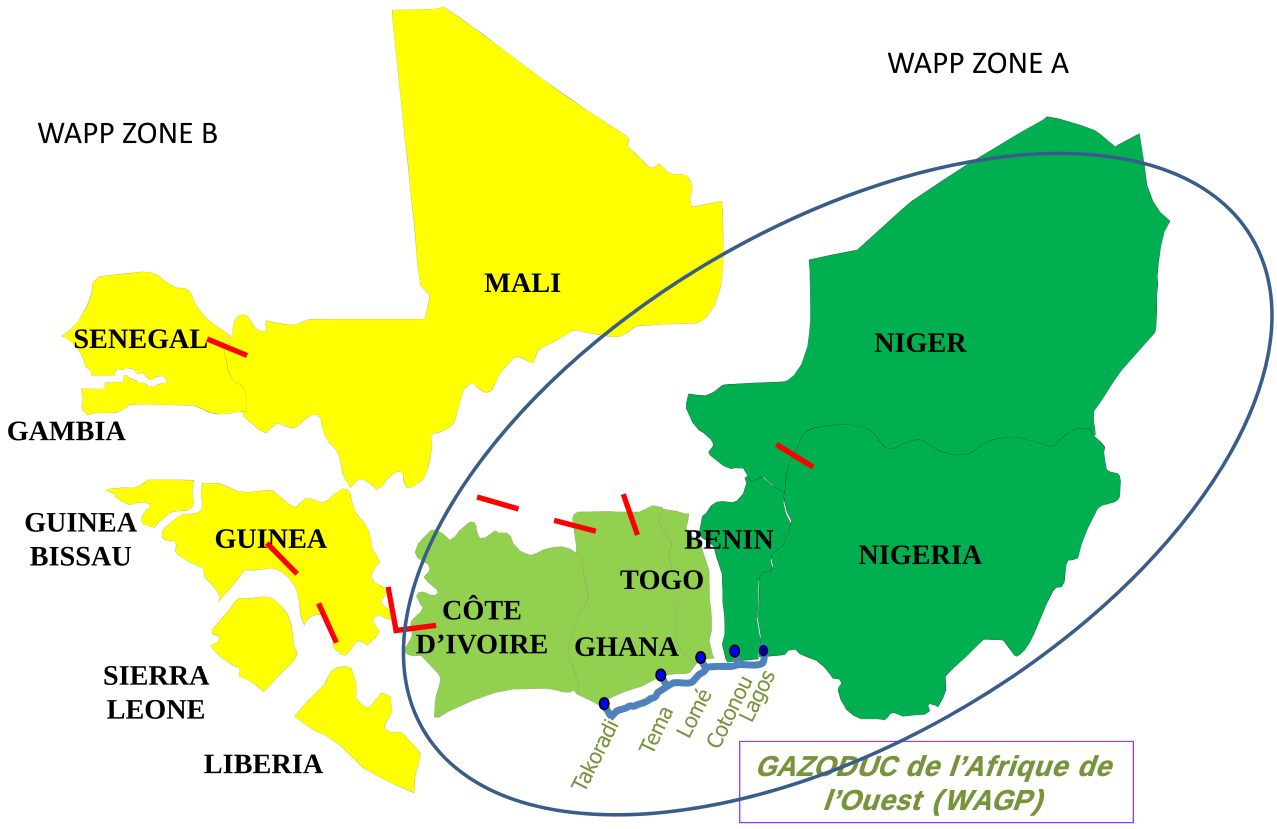


Figure 18: WAPP's present situation regarding network synchronization

5 National institutional and regulatory Frameworks

Summary:

The status of implementation of the ECOWAS/UEMOA White Paper and the mainstreaming of renewable energy into the Poverty Reduction Strategy Papers vary among the ECOWAS countries:

- *Burkina Faso, Ghana, Guinea, Liberia and Niger have developed a strategic White Paper for access to modern energy services, following the regional guidelines*
- *Mali and Senegal, have developed adequate tools and policies with the aim of mainstreaming energy access and uses of renewable energy into the main policy documents, becoming part of the presidential programme*
- *Nigeria has developed its Renewable Energy Master Plan and created an Agency for rural electrification (2006). In Benin, a study on 'Renewable Energy for Sustainable Development' financed by the UNDP has been elaborated in 2010*
- *Some countries have not yet started (Guinea-Bissau and Togo) or are about to start (Sierra Leone and The Gambia) this policy exercise*

RE mainstreaming into national Policy and Regulatory Frameworks

The focus of national policy has consistently been on centralized conventional sources of electric power. However, 3 different groups can be differentiated within the ECOWAS countries:

- *A **pioneering ECOWAS group** (Cape Verde) has succeeded in adopting a policy and is already advanced in implementing it.*
- *A **second ECOWAS group** is composed of the countries that are currently making an effort to develop, adopt or implement a RE policy: Senegal, Ghana, Mali, Liberia, Guinea, and Nigeria have a detailed RE policy at national/Presidential level.*
- *A **third ECOWAS group** is composed of countries where RE is not the focus, but is mentioned as tool for the diversification of the energy mix in order to reduce fuel dependency or increase access to modern energy services in rural areas.*

National RE Targets

In general, we can observe that there are five countries that have no defined RE targets so far: Guinea Bissau, Burkina Faso, Sierra Leone, Togo and The Gambia. However, these countries are actively developing RE projects, like in Burkina Faso (PV and biofuels), Togo (wind) and Sierra Leone (Small-scale hydropower) and the Gambia (wind and biofuels). For the others, the targets are set though sometimes figures are confusing as often it is not clear whether the RE target refers to the overall installed capacity or the electricity generated or, in other cases whether the countries count large hydro into the statistics or only new RE. Only few countries differentiate between electricity and energy for heating and cooling. However, in most countries there is a lack of implementation of these policies and targets through laws, regulations, budget allocations and financial incentives.

Other issues hindering the development of RE:

- *Presence of incentives established to promote investments in conventional power generation (e.g. fossil fuel subsidies).*
- *Subsidizing grid power has so far penalized investments in alternative energy solutions.*
- *lack of clear responsibility of the renewable energy policy implementation in many countries, and only few countries have dedicated agencies for renewable energy.*
- *Lack of coordination with other Ministries in charge of RE sources*
- *Monopoly position of the national utilities which prevents the development of private sector*

- *non-discriminatory open access to the national electricity grid for renewable power is not assured*
- *Rural Electrification Agencies created to take charge of decentralized rural electrification and its financing have not succeeded and most of* them are focused on grid-extension projects and only a few of them integrate renewable energy solutions into their scope of activities (e.g. mini-grids, stand-alone systems)
- *Except for Cape Verde, Nigeria and Ghana, there is no regulatory authority in many ECOWAS countries which has a specific mandate for renewable energy.*
- *In most of the countries the legal and regulatory framework for IPPs and PPPs in the energy sector are inexistent or weakly implemented*
- *As far as standard and labelling is concerned there are efforts by some countries, in particular, for cook stoves (Burkina, Mali, Benin, Togo)*
- *Banks and investors continue to be focused on large-scale projects in the conventional sector and ignore smaller RE investments*

5.1 Renewable energy in the PRSPs and the ECOWAS/UEMOA White Paper

One of the main conclusions of the Earth Summit, held in Johannesburg in 2003, was that energy was the forgotten MDG. Many initiatives have been launched in order to mainstream energy in the national development agenda. At the same period, the different poverty reduction strategy documents became a reference for the multi and, in particular, bilateral donors. To facilitate this process ECOWAS/UEMOA adopted the White Paper on Energy Access to Modern Energy Services in Peri-Urban and Rural Areas (see further explanation in the previous chapters). The regional policy and its foreseen activities aimed at promoting the development of national policies and investment programs on energy access to be included in the national PRSP documents in order to secure adequate financial resources. The table below shows the status and level of implementation of the ECOWAS/UEMOA White Paper in the individual countries and to which extent renewable energy is included in the respective Poverty Reduction Strategy Papers (PRSP).

Table 7 Renewable Energy position in the PRSP documents

Access to modern enery	Benin	Burkina Faso	Cape Verde	Ghana	Guinea	Guinea-Bissau	Ivory Coast	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone	The Gambia	Togo
Mention in PRSP		To some extent	Yes	Yes	Yes		To some extent	Yes	Yes	To some extent	Yes	Yes		Yes	
Nat. white book	To some extent	Yes	na	Yes	Yes	nil	na	Yes	To some extent	Yes	To some extent	To some extent	2012	2011	nil

- Yes
- To some extent
- No or not available

As shown in the table above, five countries have developed a strategic White Paper for access to modern energy services, following the regional guidelines (Burkina Faso, Ghana, Guinea, Liberia and Niger). This exercise can be deemed as positive as many countries have been in position to interact positively with the national reference policy (PRSP) to modify significantly their energy institutional and regulatory framework and to mobilize financial means to implement their strategy.

Other countries, such as Mali and Senegal, have developed adequate tools and policies with similar results, i.e. mainstreaming of energy access and uses of renewable energy into the main policy documents, becoming part of the presidential programme (Senegal).

At the same time Nigeria has developed its Renewable Energy Master Plan and created an Agency for rural electrification (2006). In Benin, a study on 'Renewable Energy for Sustainable Development' financed by the UNDP has been elaborated in 2010.

Some countries have not started yet (Guinea-Bissau and Togo) or are about to start (Sierra Leone and The Gambia) this policy exercise: Generally, there is a good correlation between the readiness to develop a new policy, the willingness that is adopted by central decision makers and to implement it. Countries like Sierra Leone, Togo, Guinea-Bissau, and to some extent Benin are lagging behind the countries which have been more proactive in policy development for rural and renewable energy.

5.2 RE policies, targets and laws

5.2.1 National Policy Documents

In general, the focus of national policies of ECOWAS countries remains on conventional sources for power generation. At the background of the increasing fossil fuel prices (oil price peak in 2008) and international climate change concerns, some of the ECOWAS countries have started to develop national energy policies with increased emphasis on renewable energy and energy efficiency. However, in most countries the policies and targets are not translated into concrete actions in the form of laws, regulations, budget allocations or incentives. Moreover, in most cases, there is no clear policy and/or strategy for RE mainstreaming into rural areas. Some of the policies are weakly developed and lack technical foundation. The ECOWAS countries can be divided in three policy groups:

- The **pioneering ECOWAS group** has succeeded in adopting a policy and is already progressed in implementing it. This group currently consists of Cape Verde only. The Government has set an ambitious target of 50% RE penetration in the overall electricity mix by 2020. To achieve the targets, the Government adopted also the investment plan "Cabo Verde 50% Renovavel em 2020" which includes a pipeline of priority projects (mainly wind and PV). In addition, the Government adopted a renewable energy law in 2011 which makes it compulsory for the national utility to allow Independent Power Producers (IPPs) to use the grid and to buy the injected electricity. So far, there is no feed-in-tariff in place and the selling prices are negotiated by a PPA. Private households which are feeding into the grid have the possibility to get the injected electricity deducted from the next electricity bill (net-metering).

- A **second ECOWAS group** is composed of the countries that are currently making an effort to develop, adopt or implement a RE policy: Senegal, Ghana, Mali, Liberia, Guinea, and Nigeria have a detailed RE policy at national/Presidential level. However, from the adoption to the implementation of the policy, is very often a long way. So far, only Ghana and Senegal have passed a renewable energy law. The policy of Ghana foresees also the establishment of a feed-in-tariff system. The tariffs for the different technologies are currently under negotiations. Nigeria's regulator (NERC) is developing a regulatory framework for promoting renewable energy based power in Nigeria too.

- A **third ECOWAS group** is composed of countries where renewable energy is not the focus, but is mentioned as tool for the diversification of the energy mix in order to reduce fuel dependency or increase access to modern energy services in rural areas. These countries are generally struggling with a recurrent lack of power capacity and are unfortunately quite focused on the development of their conventional power system (which is in some cases more expensive than the option of renewable energy).

In this context, it should be mentioned that in countries where a renewable energy policy was adopted, very often the provided financial resources or the implementation on practical levels are lacking and are not adequate to reach the targets set. For these reasons some countries do not take advantage of their renewable energy sources although some of them would be more competitive than fossil fuel based options (diesel, heavy fuel). Also, in many of the countries the development of renewable energies is hindered by lack of global planning that include them in a comprehensive strategy and allocation of financial means to implement them. The proper technical capacity is often lacking. Rural electrification is too often conceived as a natural grid based extension of the national electrification plan, giving little room for least cost mini-grid and stand-alone solutions powered by renewable energy. Subsidies to conventional fuel hinder the development of RE, as they constitute hidden costs into the electricity tariffs structure. Currently, country like Ghana has cut subsidies.

Table 8 Level of renewable energy integration into policy documents in 2011

RE and Policy Documents	Benin	Burkina Faso	Cape Verde	Ghana	Guinea	Guinea-Bissau	Ivory Coast	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone	The Gambia	Togo
RE /Energy Policy	To some extent	To some extent	Yes	Yes	Yes	To some extent		na	Yes	To some extent	Yes		Yes	Yes	
RE / Electricity bill				Yes					Yes			Yes	na	Yes	
Specific RE Policy			Yes	Yes				Yes			Yes	Yes			
Specific RE law			Yes									Yes			

Yes

To some extent

No or not available

5.2.2 *National renewable energy targets*

There are around eight ECOWAS countries which have at least included short-term and/or long-term renewable energy targets in their energy/electricity sector policies.

- The RE champion is obviously Cape Verde seeking a RE penetration of 50% in the overall electricity mix by 2020. The target of 25% RE penetration was achieved in 2012 as planned. Cape Verde has therefore the highest RE penetration per capita in the ECOWAS region. Other countries have also adopted targets: Senegal with 15% of RE penetration by 2020, followed by Ghana and Mali with10% of RE penetration respectively by 2020 and 2022 and Nigeria (10% of the installed electric capacity by 2020, and Cote d'Ivoire with 5% of RE penetration by 2015). In some cases, very ambitious targets have been set as for example Liberia with 30% of RE penetration by 2015.
- There are five countries that have no defined RE electricity targets so far: Guinea Bissau, Burkina Faso, Sierra Leone, Togo and The Gambia. However, these countries are actively developing RE projects, like in Burkina Faso (PV and biofuels), Togo (wind) and Sierra Leone (Small-scale hydro) and the Gambia (wind and biofuels).

It should be noted, that only in a few cases technical analysis has led to the definition of the targets. In some cases the cost-effectiveness and feasibility is questionable. There is confusion on the targets set by most of the countries and, depending on the documents, the figures might be different. The question is also whether the countries count large hydro into the statistics or only new RE. Often it is not clear whether the RE target refers to the overall installed capacity or the electricity generated (which makes a major difference). Only few countries differentiate between electricity and energy for heating and cooling (Guinea, Liberia, Mali and Nigeria). Guinea has set very differentiated targets according to the topology of their eco-zones and the RE opportunities (biomass, Small-scale hydro, PV solar water heater and biogas). In most cases there is no unified strategy to mainstream renewable energy into rural sector policies (e.g. agriculture, education, health).

Only some ECOWAS countries have adopted RE targets. A summary of "new renewable" targets is provided below:

Table 9 Targets for Renewable Energy penetration

County\Target	Grid connected Electricity		Energy (heating, cooling)		Specific sector Target (off-grid/rural areas/non-electricity/for health or agriculture etc.)
	Short Term	Long term	Short Term	Long term	
BENIN	36% (945 GWh* 2015)	37% penetration (1700 GWh* en 2025)	NA	NA	NA (Rural elec, 170 localities by solar PV)
BURKINA	NA	NA	NA	NA	NA
CAPE VERDE		50% Penetration			
COTE D'IVOIRE	5% 2015	NA	NA	NA	
GAMBIA	NA	NA	NA	NA	
GHANA		10% RE penetration 2020			
Guinea			By 2013: 5% coverage of solar thermic for hot water and cooking	20% by 2025	Rural elec through solar energy by 2013 (2% Moyenne Guinée; 4% Guinée maritime; 6% Haute Guinée; 1%Guinée forestière) Rural elec through solar enrg by 2025: (6% Moyenne G; 12% G. Maritime; 19% Haute G; 3% G. Forestiere) 1% of coverage for rural elec by wind energy. (by 2025: 2% Moyenne G.; 3% G. Maritime; 3% haute G; 1% G forestiere) 5% of the demand in rural area covered by Biogaz digester in Short term (2013), 30% by 2025. Biofuels production 2% of the demand by 2015
LIBERIA	30% RE penetration 2015	NA	10% of RE consumption 2015	NA	NA
Mali (1)		10% penetration by 2022		15% pen by 2022	plus 10%/per year of GWh generated from RE and per household from 2014 onwards
NIGER (3)		10% RE in energy mix 2020			Reduction of wood-fuel use from 88% to 20% (2015) as share of wood-fuel and agricultural wastes in the overall energy balance
NIGERIA (2)	5% 2015 (746 MW installed)	10% 2025 (2945 MW installed)	16% 2015	9% 2025	
SENEGAL		15% RE penetration in 2020 (Biocarburant, Hydro, RE)			
SIERRA LEONE	NA	NA	NA	NA	NA
TOGO	NA	NA	NA	NA	NA

* Ces valeurs sont la part d'EnR dans l'offre totale d'énergie électrique

(1) SREP Mali Vol 1

(2) RE Master Plan Nov 2005 page 19 and RE Policy Guidelines

(3) Stratégie Nationale et Plan d'Action sur les Energies Renouvelables 2003

5.2.3 RE in electricity laws and regulations

Only a small part of the countries have adopted RE laws and regulations:

- In **Mali** the electricity act (2000) incorporates the option to introduce feed-in tariffs.
- **Senegal** has a very good regulatory framework which aims at mainstreaming RE into the energy sector, rural development and poverty reduction. A law which sets the conditions for purchasing electricity from renewable energy sources has been adopted in December 2011. Currently, the Government defines the feed-in-tariff levels for the different RE technologies with the technical assistance of GIZ.
- **Ghana** has passed its renewable energy law in 2012 which includes also the introduction of a feed-in -tariff system. Currently, the Government defines the tariff levels for the different RE technologies.
- **Cape Verde** has developed a comprehensive and detailed law for RE in order to attract private investors as well as IPPs. Moreover, the Government undertook a comprehensive RE potential assessment and adopted an investment plan for various solar and wind sites.

5.2.4 Lack of Coordination and clear mandates

The bottleneck in most countries is the lack of implementation of the RE policy objectives. When it comes to concrete implementation, policy makers face various barriers. Generally, there is a lack of clear institutional mandates and responsibilities when it comes to RE implementation. Only few countries have dedicated agencies for renewable energy. In general the responsibility of renewable energy is within the Ministry of Energy and only in few cases there is a specific Directorate:

- In Nigeria, the Act establishing the Energy Commission of Nigeria (ECN) was submitted to the Nigerian Law Makers for amendment. It aims at giving the ECN the mandate to promote the use of RE and EE on national level. Currently, several Ministries have overlapping mandates.
- Guinea has a Renewable Energy Division within the National Division of Energy
- The Gambia Renewable Energy Centre (GREC) is the technical supporter of the DoSPEMR responsible for RE research activities as well as the development and promotion of RE. However, the current state of the GREC is poor, with a very limited number of qualified staff, and deteriorated and obsolete offices, office equipment and technical installations. A similar situation can be met in Guinea-Bissau.
- A specific Directorate for renewable energy has been recently created in Cote d'Ivoire. A general reform of the energy structure in the country is in progress.
- In Burkina Faso, a specific Directorate for renewable and domestic energy exists and develops some activities on PV, cook stoves and biofuels, without having a corporate RE policy.
- In Benin, in 2011, a specific agency for renewable and domestic energy was created in order to focus more on RE.
- Liberia: The Rural and Renewable Energy Agency has been created. Liberia, along with with Mali, belongs to the countries which cover power and non-power generating RE technologies under the same agency.

5.2.5 Lack of coordination with other ministries in charge of RE sources

Biomass and Domestic fuel wood are in general under the Ministry of Forestry and/or Agriculture; fiscal related issues (tax and incentives, etc.) are often coordinated by Ministries of Trade and Industry and the Ministry of Finance and Energy. The lack of coordination among the different Ministries hinders development in the renewable energy sector.

In many countries, research activities related to RE are coordinated by the Ministry of Higher Education and Research (for example in Cote d'Ivoire, Burkina Faso, and Benin).

Furthermore, budget allocations of the Government, utilities and rural electrification agencies, very often do not reflect the RE policy focus. RE remains the inefficient playground for the civil servants from the Ministry of Energy. Other problems are the lack of human resources and lack of skills of the ministerial staff to implement RE programmes and policies. Very often, there is a lack of awareness of the generation costs of different RE technologies in comparison to conventional sources. Cost-benefit analyses which requires a financial life-time analysis of projects is often not done adequately.

5.2.6 National Utilities are still in position of Monopoly:

Efforts to liberalize the electricity sector have been started in all ECOWAS countries. The production sector is theoretically liberalized in most of the ECOWAS countries. In many cases the national utility has been going through restructuring due to their difficult financial situation at the end of the nineties. In some cases, as in Cote d'Ivoire, in Nigeria, in Ghana, and in Mali, the utility has been unbundled while in other countries the utility remains de facto in a monopoly position in particular for distribution and transmission. Some of the National Electric Utilities have tentatively been privatized or plans for privatization are in progress. Failures with privatization of utilities have occurred in Cape Verde, Senegal, Guinea, Mali, and The Gambia. In Burkina Faso, the privatization has been taken out of the agenda after nearly 10 years procedure.

Insert 1 - The case of Nigeria:

In Nigeria the Power Holding Company of Nigeria (PHCN) (Formerly National Electricity Power Authority (NEPA) is being unbundled into generation, transmission and distribution companies. In the process of privatization, the distribution side will be split into 11 companies. The generation side will be broken down into 6 companies. Only one company, responsible for transmission, will remain under government ownership to ensure some control over the power system. As the sole agency responsible for generating and distributing electricity, the PHCN will use their technical capacity and experience to give guidance in the current project. As result of the process Nigeria is one of the ECOWAS countries together with Ghana to open access to the HV network.

Insert 2 - The case of Cote d'Ivoire:

The electricity law n°85-583 of July 1985 enabled at that time the deregulation of all activities within the power sector, inclusive of importation. In1990 as the former national utility EECI was close to bankruptcy, the sector has been reorganized into an asset company, a transmission and distribution utility, several IPP and a service utility dealing with planning and rural electrification.

SOGEPE, the former EECI, has been transformed in 1998 into a national asset company managing the asset base and the financial flow of the power sector.

Since 1990, the Ivorian Electricity Company (Compagnie Ivoirienne d'Électricité – CIE) has been granted a public service concession as power utility and exploits electricity generation, transmission and distribution facilities. SAUR a filial of Bouygues is the concessionaire.

The Cote d'Ivoire case story can be considered as a successful privatization. Some conditions were favourable for the installation of large foreign investors in Cote d'Ivoire: the presence of natural gas reserves in the Gulf of Guinea enabling the implementation of cheaper power generating technologies and the fact that one of the major actors (Bouygues) was present throughout the production chain (gas production, IPP and in charge of the energy transport and distribution)

5.2.7 Rural electrification

The private sector has not been attracted to invest in energy in rural areas due to the lack of legal and regulatory framework as well as the low consumption of electricity and limited ability and willingness to pay that characterize these areas. To respond to these challenges, some ECOWAS Governments have created Rural Electrification Agencies to take charge of decentralized rural electrification and its financing. In many cases, next to the Rural Electrification agencies (REAs), rural electrification funds (REFs) have also been established to mobilize the financing.

Table 10 : List of existing Agencies and/or Funds in ECOWAS region

Country	Rural Electrification Agency
Benin	Agence Béninoise d'Electrification Rurale et de Maîtrise de l'Energie (Beninese rural electrification and energy conservation)
Burkina Faso	Fonds de Développement de l'électrification (Electrification Fund) (FDE)
Cape Verde	Coordinated by the Ministry of Energy
Cote d'Ivoire	/
The Gambia	/
Ghana	Rural Electrification Fund
Guinea	Bureau de l'Electrification Rurale Décentralisée (Bureau of decentralized rural electrification) (BERD)
Guinea Bissau	/
Liberia	Rural and Renewable Energy Agency (RREA)
Mali	Agence Malienne pour le Développement de l'Energie Domestique et l'Electrification Rurale (Malian agency for the Development of Household Energy and Rural Electrification (AMADER))
Niger	Cellule d'Electrification Rurale (Rural electrification agency)
Nigeria	Rural Electrification Agency
Senegal	Agence Sénégalaise d'Electrification Rurale (Senegalese rural electrification agency) (ASER)
Sierra Leone	/
Togo	An Exploratory mission is underway to create a Rural Electrification Agency

FDE in Burkina, BERD in Guinea, and ABERME in Benin are examples of agencies that are active in the promotion of RE projects in rural areas. However, very often, innovative solutions which are even more cost-effective are left out due to lack of knowledge or technical capacities.

Cape Verde has established a Fund in 2011 to promote decentralized rural electrification based on RE; a Ghana Renewable Energy Fund will be created under the RE Law to support decentralized renewable energy projects in remote areas; **Liberia** has created a Rural and Renewable Energy Agency, a semi-autonomous institution with the mandate to integrate energy into rural development planning, to promote renewable energy technologies, to facilitate the delivery of energy products and services through rural energy service companies and community initiatives, facilitate the funding of rural energy projects including managing a Rural Energy Fund that will provide loans, loan guarantees and grants as targeted subsidies to ensure access by the poor.

Insert 3 - the case of Mali

AMADER promotes RE through a rural electrification fund and PPP arrangement with national promoters financing up to 20% of the initial investment on own equity. Renewable energy projects are eligible to receive financing. In recent years some PV-diesel hybrids were co-financed. REs are also available for local communities to boost social services and productive uses (lighting of schools, maternity and health centres, water pumping and irrigation in the agricultural sector). The SREP fund (Scaling-Up Renewables Energy Programmes) financed by the AfDB, the World Bank, etc. was established and focuses mainly on three types of projects:

- 20 MW solar power plant as IPP
- Solar rural electrification programme (PV-Diesel hybrids systems and SHS)
- Development of mini and micro hydro capacity to feed on the grid or to provide local rural electrification

A first summary of the achievements[8] of the REAs/REFs since their creation in the early 2000 shows that in many cases these funds were not designed to function as financial or lending institutions. They also did not have sufficient financial expertise to mobilize additional resources from large financial institutions or leverage refinancing. Most of them have been focused on grid-extension projects and only a few of them have integrated renewable energy solutions into their scope of activities (e.g. mini-grids, stand-alone systems). It is important that their tasks and orientation be re-examined, and with provision of proper staff and expertise, their prime area of focus becomes rural electrification using renewable energy resources.

5.2.8 Regulators and Renewable Energy

Except for Cape Verde, Nigeria and Ghana, there is no regulatory authority in many ECOWAS countries which has a specific mandate for renewable energy. In Ghana the regulation is split between two bodies, the Energy Commission (dealing with the technical regulation as concession, authorization and planning) and the PURC regulating the tariff. The EC in Ghana has some competence within RE. There are countries that do not have a national independent regulator: Benin, Liberia, and Guinea Bissau. Others like Burkina Faso and Guinea each has a regulator but it is not operational or lacks a clear mission. As for Mali, Togo, and Senegal, each has a regulator independent of both operators and the Government, and has legal personality and financial autonomy, but no specific competence for RE.

Insert 4 – The case of Nigeria

Mandated by the government to regulate activities connected to the electricity sector, *Nigerian Electricity Regulatory Commission* (NERC) is organized into 7 divisions. The 7th division is 'The Renewable Energy, Research and Development Division', which has the task of providing the Commission with the required database and policy instruments to carry out its various activities. In addition, the Division is responsible for helping the Commission drive its renewable energy programme. NERC developed a policy document containing regulations on Meter Reading, Billing, Cash Collections and Credit Management for Electricity Supplies. Similar scheme can be extended to the current project.

In most of ECOWAS countries, the presence of private operators is still limited to large production units connected to the conventional power sector. Cote d'Ivoire accounts for 2 major IPPs, CIPREL and AZITO ENERGY, and there are at least two new up-coming ones. In Cape Verde several private IPPs are providing electricity services based on diesel generation or wind power. In 2011, a 25.5 MW grid connected bundled wind project, based on a Public Private Partnership (PPPs) model was launched. Another IPP in the area of wind power was established in 2011 on the island of Santo Antão.

[8] CLUB-ER Publications: Financing Rural Electrification Programmes in Africa, 2010 www.club-er.org

In Ghana there are two major independent power producers (IPPs):

i) CMS of Michigan, USA which bought 51% in a joint venture with VRA to set up the 220 MW Aboadze thermal power plant;
ii) Asogli Power Plant (560 MW)

Senegal is totally open to IPPs and currently two large production sites have been established as IPP: GTI Dakar and Manantali Eskom. In Togo there are currently 3 IPPs but for self-consumption only. There are very few experiences with IPP producing on RE equipment. There are few RESCOs (Renewable Energy Service Companies) in Senegal, Mali and Burkina Faso dealing with decentralized energy services based on PV technology.

5.2.9 IPPs, PPPs and FiT

In most of the countries the legal and regulatory framework for IPPs and PPPs in the energy sector are non-existent or weakly implemented. The effective implementation of these laws is an enormous challenge in most of the countries. Examples in the areas of new RE can be hardly found. Only some countries such as Cape Verde, Mali, Ghana and Senegal have laws enabling PPPs, standard PPAs and/or FITs. Nigeria is preparing a law in this regard. PPPs in the form of concessions are applied in some of the ECOWAS countries (e.g. Senegal, Cape Verde, Mali and Guinea).

In 2010 a medium scale wind farm, operated by an IPP (partnership between a Cape Verdean company and a Dutch company) was connected to the grid of the island Santo Antão. After that, a Public-Private-Partnership was inaugurated in Cape Verde in 2011. The 25.5 MW bundled Wind Project "Cabeolica", was financed by a consortia of ADB, EIB in cooperation with the Finfund and the African Financial Corporation.

Feed-in-tariffs or other forms of incentive schemes (e.g. investment subsidies) are very few. Incentives for the development of RE have recently been introduced in **Cape Verde** and in **Senegal** where laws have passed on the condition to sale and purchase of electricity coming from RE sources and on the surplus of electricity from RE (FiT). In **Ghana** the Renewable Energy Bill was passed in Parliament in 2012. It (...)

i) introduces a feed-in tariff mechanism to encourage the adoption and use of renewable energy;
ii) creates a platform for the trading of renewable energy and foresees the introduction of a renewable energy purchase obligation for the utilities;
iii) foresees targets for blending petroleum with biofuels.

Tax exemptions are introduced for the import of PV Panels or RE equipment in general (Cape Verde, Benin, Burkina Faso, Gambia, Mali, Niger, Senegal, and Togo). Often the exemptions do not cover wiring and batteries. The Cape Verde RE law is also open to income tax holidays for companies investing and operating RE plants in Cape Verde. Equal measures are presently considered in the Nigerian institutional RE framework.

5.3 Standards and labelling

As far as standard and labelling is concerned there are efforts by some countries in particular for cook stoves (Burkina, Mali, Benin, and Togo). In Mali, a series of norms for biofuels have been developed by the newly created ANADEB. The only exception is Ghana where RE producers are obliged to comply with technical standards and guidelines established by the Energy Commission. There are a number of private companies dealing with the supply, installation and maintenance of RE equipment. This number varies from 8 to 15 in certain countries. Besides, many informal and unqualified PV dealers are active on the market selling low-quality equipment.

5.4 Capacity building needs

University training in RE is organized in Benin, Burkina Faso (Solar Energy and biomass at 2ie), in Ghana (KITE, KNUST), Cape Verde (UNICV) and possibly in other capital cities (Dakar and Bamako). In Nigeria, the Energy Commission and other private companies including NGOs are involved in the training in RE installation and maintenance. The Energy Commission of Nigeria has established centers in different parts of Nigeria to train and conduct research in the different energy sources including RE and EE.

- National Centre for Energy Research and Development at University of Nigeria, Nsukka and
- Sokoto Energy Research Centre at Usmanu Danfodiyo University, Sokoto.

Both centers focus on R&D in solar energy and other renewable energy sources. Other research centres such as CNESOLER in Mali, and IRSAT in Burkina, CERESCOR in Guinea, LERT in Togo also offer some training activities related to RE.

However, these efforts are not coordinated or supported by a global strategy for the development of renewable energy. To highlight the example of Ghana: under the Renewable Energy Law, the Energy Commission as technical regulatory authority will play a role in:

i) the preparation of the educational curriculum on efficient use of renewable energy sources;
ii) the promotion of local manufacture of components to facilitate rapid growth of renewable energy sources; and
iii) the promotion of training and support of local experts in the field of renewable energy

At the regional level Agrhymet in Niamey (Niger) is the CILLSS centre of excellence for sustainable management of natural resources and forestry.

ECREEE in cooperation with 2iE, KNUST and UNICV is presently carrying out a capacity needs assessment in all 15 ECOWAS countries. The result of the assessment will be used to design a regional capacity development program.

6 Investment frameworks, tax and tariff issues

Summary:

- *Institutional frameworks and incentives are not appropriate to attract private investors in the ECOWAS region.*
- *The investments in West African power sector remain quite conventional with a predominant share of development aid (ODA) funding. The same pattern is valid for RE with 82% ODA funding and practically non private interest involved. The success stories (e.g. IPPs, PPPs) are in most cases limited to the conventional sector (e.g. natural gas, large hydro). IPPs or PPPs in the new RE sector can be hardly found.*
- *The investments in smaller RE represent in 2009 only 2% of the overall RE investments in Africa*
- *Current subsidies in the area create distortions among supply options encouraging investments in cheaper conventional technology and discouraging investments where high upfront capital cost (typically RETs) is involved. This is especially so when, for various reasons, power planning has not considered the least cost options in real terms. Thus there has been a bias towards grid extension which forecloses decentralised options*
- *According to the World Bank's estimates, technically, the sub-Saharan Africa could accommodate more than 3200 CDM projects, enabling an additional power generation of 170 GW. Although the ECOWAS' CDM project potential is huge, the region has hardly benefitted from the carbon market.*
- *The development of RE is part of a progressive approach which includes establishment for facilitating and supporting financing systems and structures. Before reaching a RE environment supported by strong private sector and bank system involvement, it is necessary as part of an emerging market to support the development of RE by mixing subsidies, tax incentives and by the establishment of a favourable regulatory framework for RET IPP, and the feed in tariff approach.*

6.1 Power sector investments in general

Investments in the power sector of ECOWAS (only for capital cost) amounted to about Euro 1.5 billion in 2007 and 2009 and 1.9 in 2011. The distribution between the different partners funding these capital investments is given below:

Table 11 Financing flows to the power sector in ECOWAS (incl. large hydro)

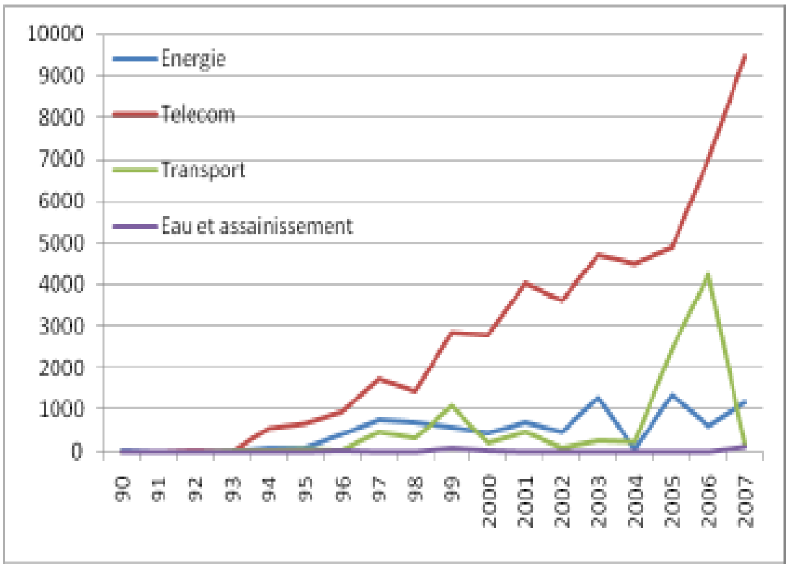
	in billion Euro (2007)	overall %	in billion Euro (2009)	overall %	in billion Euro (2011)	overall %
Public sector	0.61	41%	0.72	47%	0.69	36%
ODA	0.61	41%	0.45	29%	0.55	29%
Non OCDE financiers (China, India,..)	0.15	10%	0.27	17%	0.6	31%
PPI	0.12	8%	0.11	7%	0.08	4%
Total	**1.49**		**1.55**		**1.92**	

Source: Briceño-Garmendia 2009 and other

The share of private investors remains abysmally low with 7%. The main burden (76% of the investments) is supported by the national budget of the member states, with help from the ODA. New non-OECD countries are positioning themselves in this market segment like India and China with a 17% contribution to the sector investments.

The amount of these investments represents only 1% of ECOWAS zone's GDP, while according to the 2008 Regional Economic Outlook of the IMF, all sub-Saharan African countries have spent on average 2.7% of GDP in the electricity sector (including investments in operation and maintenance segment which represents 0.7% of GDP). It should be noted that the persistence of this low level of investment would not allow the implementation of the WAPP Master Plan. Public finance remains the dominant source of finance and public investments are largely tax-financed and executed through central government budgets, while operation and maintenance expenditure is largely financed from user charges and executed via state-owned utilities. This naturally limits the possible investments. And if user charges are not adequate, utilities also become financially constrained. In fact, they become a further strain on the national budgets, along with the subsidies given to this sector.

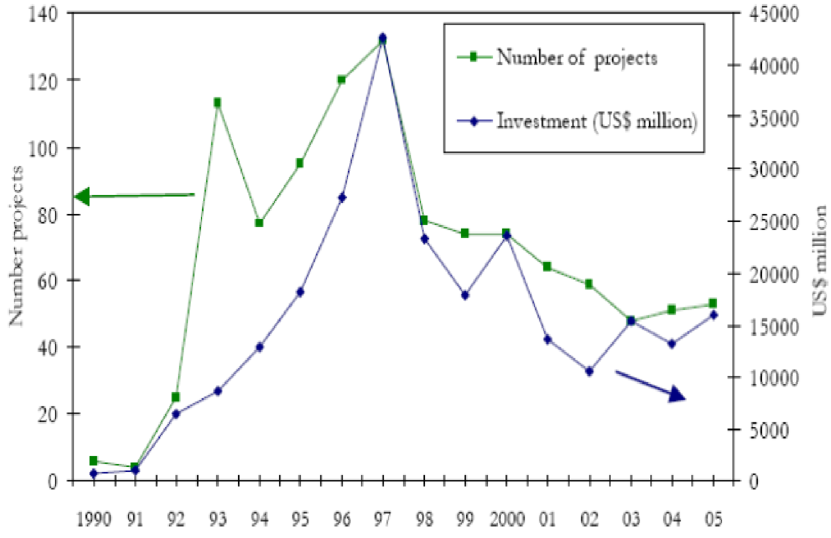
As shown below, the contribution of the private sector in financing the electricity sector is actually much lower as compared to telecom.



Source : Base de données du PPI de la Banque mondiale pour 2008

Figure 19: Private sector financing different sectors

It is, therefore, no wonder that the power sector in Sub-Saharan Africa has been characterized by insufficient investment for electricity generation and grid extension, low electrification rates, inadequate maintenance, low capacity utilization and, transmission and distribution losses up to 40% in some countries. As an example for the insufficient capital for electricity, the International Finance Corporation estimated that between 1990 and 1998, direct foreign investment in the power sector in Sub-Saharan Africa accounted for only 6% of all infrastructures'. The figure below shows the decrease of private investment in electricity infrastructure from 1997 to 2005 in emerging markets, including both investments in public power infrastructures and in industrial and commercial power infrastructures dedicated to their own needs.



Source: Data from the World Bank Private Participation in Infrastructure (PPI) Project Database http://ppi.worldbank.org

Figure 20 Evolution of the Private Investment in Electricity Infrastructure for low and middle income countries.

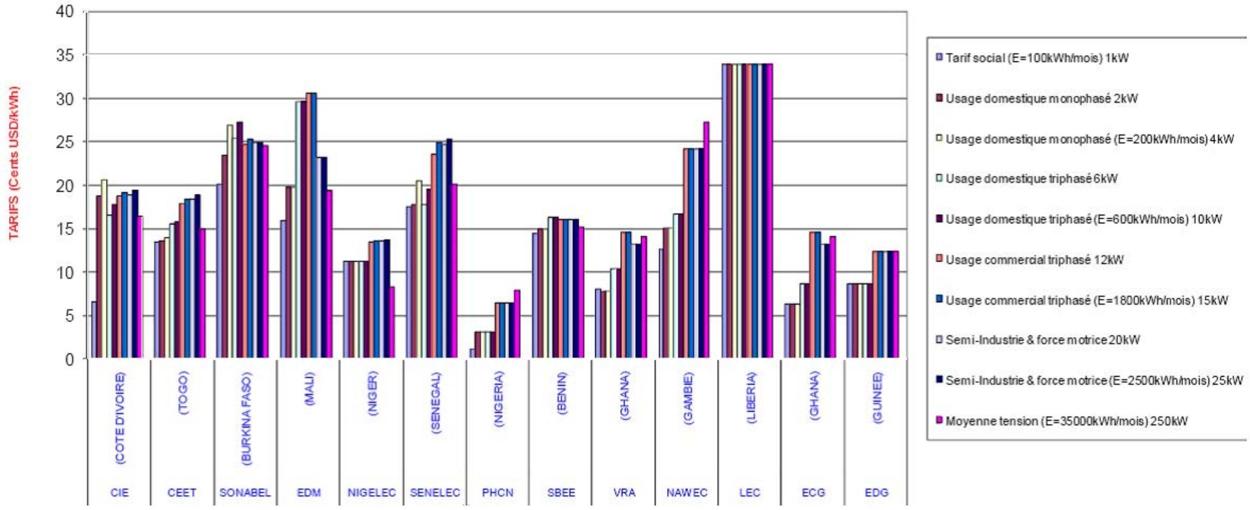
The following are the conclusions that can be highlighted:

1. Institutional frameworks and incentives are not appropriate to attract private investors. In many countries failed attempts for power sector reform have hindered the private sector opportunities or willingness to invest in the sector.
2. For many countries, the limited technologies options (dependence on oil products and conventional thermal technologies) have not been encouraging for private investors to develop projects proposing acceptable tariffs level. The success stories of IPPs are mostly limited to the fossil fuels sector.
3. Although some RE technologies (for instance biomass, small scale hydro, wind) are attractive from an economic and financial point of view, it is a fact that national utilities and/or new investors are generally culturally reluctant to technological change or innovation.
4. Emergence of IPPs has been tied to certain conditions: access to a cheaper fuel as for example natural gas or coal (e.g. of Cote d'Ivoire and Ghana), conducive frameworks (to some extent the public vertically integrated power system has been replaced by a private 'vertically' integrated supply where the operator that manages IPPs on gas and power production is the same operator of the national utilities).
5. Except for Cape Verde, Ghana and Cote d'Ivoire, and to some extent Nigeria, access to electricity for rural population has not been a national priority for many ECOWAS members.

Even if political will is often directed towards the rural world, the financial viability for an electric operator is not obvious in this domain which is characterized by low energy consumption density and a limited power purchase possibilities in relation to the investment required. And for a utility to initiate significant infrastructure costs seen in light of this low turnover is not a viable financial option. And yet, in most cases, rural electrification has been developed, or at least planned, on the principle that grid based solutions are on the average more economical than decentralised options and are easier to manage in terms of tariffs (cross subsidising). This contradiction in approach has prevented development of alternative routes to rural electrification.

6.1.1 Tariffs and subsidies

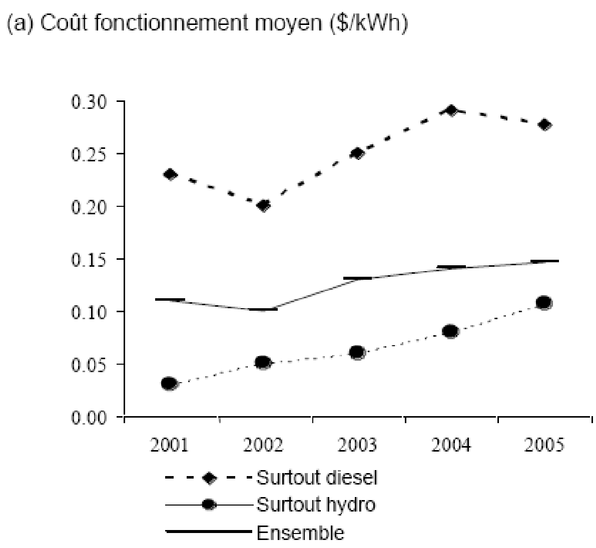
The average consumer tariff per kWh is relatively high in the ECOWAS area. It is about 13.6 EUR/cents on average. This average covers a wide disparity between countries as shown in the diagram below. In Cape Verde the consumer tariff reached a level of more than 30 EUR/cents per kWh. In countries such as Liberia and Guinea Bissau it is even higher.



source : UNDP

Figure 21: Average consumer tariff per kWh in ECOWAS area

On the other hand, in some ECOWAS countries, where electricity production is mainly based on imported diesel or heavy fuel, average consumer tariffs remain significantly below the average operating costs which appears to be about 20,4 Euro cents (with diesel).



Source: AICD

Figure 22 : Average operating costs

Thus, in almost all countries in the region, the rates charged to residential, commercial or industrial consumers do not enable full cost recovery. To balance these deficits, subsidy policies have been implemented in almost all countries, having their origin in social equity concerns (access to the poor) and industrial policies (increase the competiveness of the sector through lower industrial tariff).

However, subsidies have seldom had the desired effect. They end up offering large blocks of highly subsidized energy to all customers regardless of their income, and have seldom addressed the issue of high connection fees which excludes the poor households from getting subsidised electricity or is an incentive for illegal connections. For those who live in off grid areas, subsidies create another type of inequity. They don't benefit from the ODA financed power infrastructure and they cannot afford access to modern energy on a private basis. The upfront cost of, for example, small SHS are generally too high for them to purchase and they have to rely on low-grade and expensive energy options like candles, kerosene lamps or batteries. Moreover, power utilities have high distribution losses, and they do not bill a substantial part of the actually distributed electricity, and do not collect a substantial portion of what is billed. So the World Bank considers that these hidden costs are absorbing in Africa 1.9 percent of GDP on the average (Briceño-Garmendia and others, 2008). This aspect is discussed in the policy document of energy efficiency.

In conclusion we can affirm that:

- High consumer tariffs in some countries of ECOWAS are favourable to introduction of RE into the system (grid-connected or decentralised).
- Subsidies create distortions among supply options encouraging investments in cheaper conventional technology, but also in diesel based grids, and discouraging investments with high upfront capital cost (typically RETs).
- For many reasons, (generous demand forecast, average cost methodology, political decisions favouring supply to administrative centres from grid) non-profitable grid network is extended which further impedes decentralised options based on renewable energy.
- Subsidies create inequity between those who are connected and those not, both in urban and rural settings. Integration of RETs into development policies and strategies aimed at poor populations should also consider implications of such subsidies for conventional electrification so that distortions are not created.

6.2 Renewable energy investments

Technical potential for RE resources such as wind, solar, hydropower, biomass or geothermal energy is considered high in most developing and emerging countries. ECOWAS member countries are no exception. Hydroelectric potential is mainly concentrated in five of the 15 member states, with a total estimated capacity of 23,000 MW, only 16% of which is currently exploited. Nigeria, Guinea, Ghana, Côte d'Ivoire and Sierra Leone account respectively for 37.6%, 25.8%, 11.4%, 10.9% and 5.2% of the total hydroelectric potential. There are also some medium large hydro potential in Benin, Togo and Mali as well as a number of sites where small-scale hydro-plants can be erected. Apart from large hydro, the installed power capacity from RE in the ECOWAS zone remains very low. It is estimated, that in 2011 an overall RE power capacity (excluding large hydro) of about 124 MW was installed in the ECOWAS region.

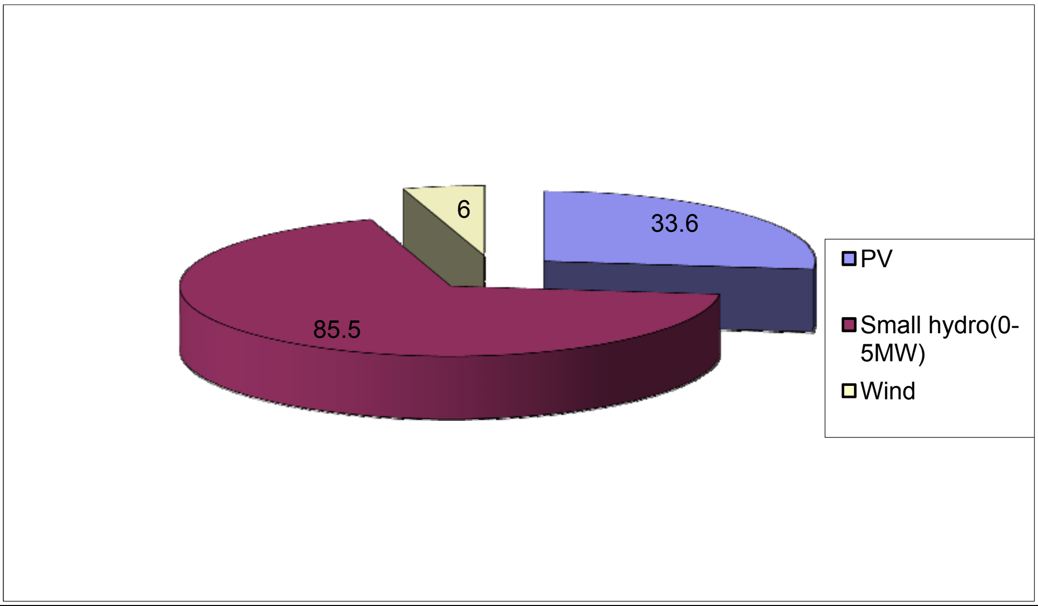


Figure 23 : Installed RE power capacity in the ECOWAS (in MW) -

6.2.1 Renewable energy investments

The flow of investment in power generation from renewable energy sources (excluding large hydro) has also been very low in value as shown in the table below:

Table 12 Financing flows to new RE in ECOWAS (excluding large hydro)

	2006		2009		2011	
	In Meuro	overall %	In Meuro	overall %	In Meuro	overall %
Public sector	0.91	4%	2.2	7%	4	4%
ODA	17.4	81%	25.7	83%	24	25%
Others (NGO)	3	14%	2.2	7%	1	1%
IPP	0.15	1%	0.76	2%	66	69%
Total	**21.46**	**100**	**30.86**	**100**	**95**	**100**

source
OCDE/AIE/AFD/WB

Investments mainly originate from ODA and public sources in the form of grants and soft loans. Grants are used for pre-investment activities (e.g. measurements, feasibility studies, financial structuring) as well as the investment phase (investment subsidy, interest rate subsidy, element of soft loan). Direct private investments are so far not common and mainly deal with investments in SSHP. The volume of investments in new RE in the ECOWAS region, compared with the overall volume of RE investments on the African continent of 1.9 billion Euros (2009), represents a tiny share of 2%. According to the latest REN-21 status report it is estimated that the overall investments into new RE sector amounted worldwide to around 250 billion USD in 2011. Most of the additional investment in new RE in the region in 2011 originated from the implementation of wind power projects in Cape Verde (e.g. Caboélica-PPI).

In conclusion:

- The investments in the West African power sector remain quite conventional with a predominant share of ODA funding. The same pattern is valid for new RE investments with ODA representing 82% of all investments.
- The investments in smaller RE in 2009 represent only 2% of the overall RE investments in Africa. The same can be stated for 2011 if we exclude the Cabeolica project.
- Recent and growing interest in renewable energy in Africa has been driven by important key drivers often tied to economic or environmental hexogen developments:
  - the recurrent and irrevocable increase in oil prices;
  - the recurrent drought-related crises faced by power utilities as well as impacts of general climate change on consumptions patterns (higher temperatures, weather unpredictability);
  - And global environment initiatives that have also stimulated greater interest and hopefully commitment in renewables in Africa.

6.3 Renewable Energy Finance

At this stage, it is necessary to distinguish the financing of large-scale projects from those of medium to small-scale. In the ECOWAS framework, the priority is given through the WAPP strategy to larger RE (mainly large hydro) capacities connected to high voltage transmission/distribution networks. Smaller grid-connected or off-grid projects are more relevant for the national context and are not covered by the WAPP mandate. Whereas most of the large-scale projects are commercial, smaller RE project require other financing models. The approach of financing the different types of technology capacity is shown in the following continuum:

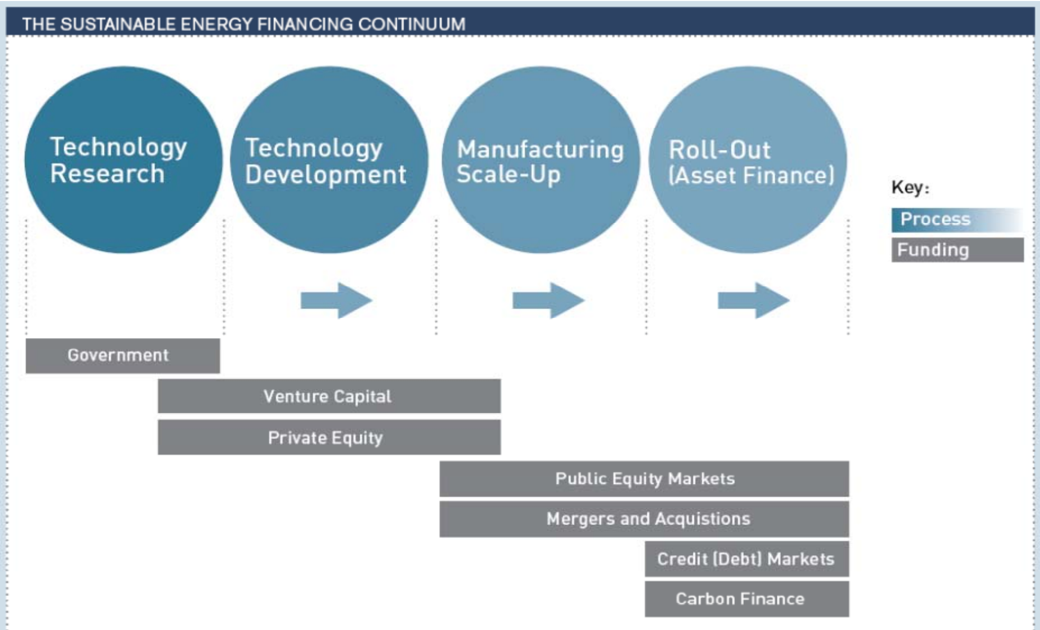


Figure 24: The sustainable energy financing continuum Source (UNEP/Bloomberg)

The graph gives an overview on the investment flows into the RE sector by technology phases (from research to development, manufacturing and scale-up to enter the financial phase): [9]

[9] Public equity= share issue open to all public

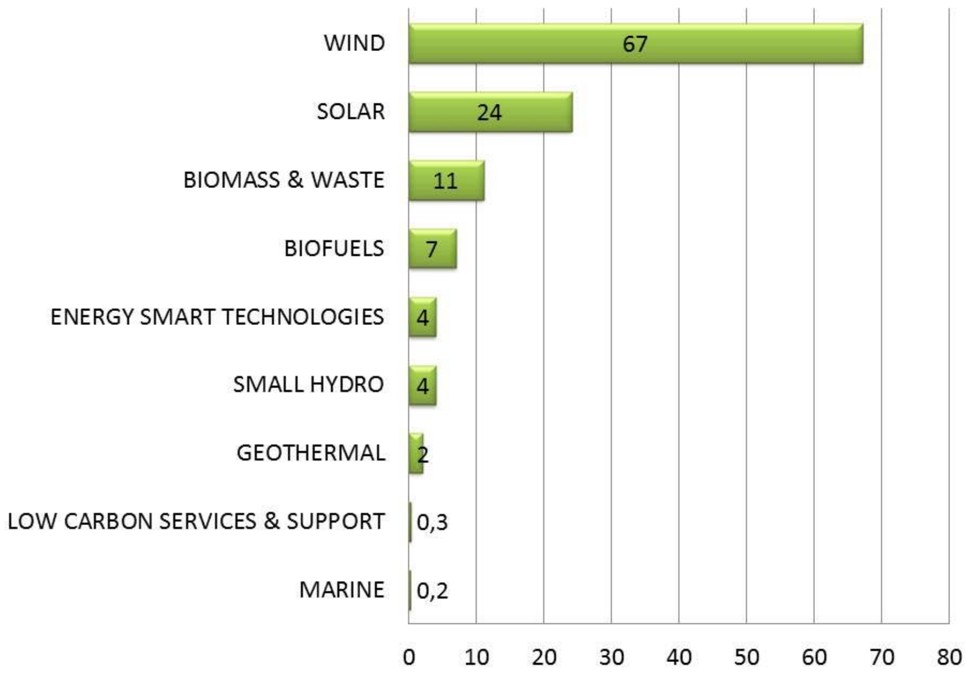


Figure 25: New Financial investments by technology, 2009, and growth on 2008, billion USD. (UNEP/Bloomberg)

The major players, who finance these technologies, are essentially private banks as well as investment funds. Over the last 10 years, the clean energy sector has moved from being niche to be mainstreamed. At the start of the decade, the sector was the preservation of small venture capital funds, but as time went by, larger Venture Capital firms joined them. In more recent years, investment banks and large private equity and mutual funds have shown increasing interest for this sector, with hedge funds also devoting some portion of their portfolios to clean energy.

These elements illustrate the investors growing interest in clean technology:
Funding and increasing production capacity does not appear as a major problem for the diffusion of clean technologies. Private investors have already shown their interest for those technologies when they are implemented in transparent and stable institutional frameworks and with financial guarantees.

As the ECOWAS region is concerned, the lack of appropriate regulatory framework enabling the RE promotion constitutes a barrier for private investors. The generally tense financial situation of the public utility and the reluctance in proactive tariff adjustments are also limiting factors in the confidence of potential investors.

6.4 Financing large-scale RE projects

An important sign of 'clean technology' maturity is the growing investment of World Bank Group in renewable technologies. In 2010 the World Bank Group announced that funding of energy efficiency and renewable energy projects and programs in developing countries has increased by 24% during the last fiscal year to total 2,5 billion Euro, its highest level ever reached. Total commitments to energy efficiency and renewable energy for the year ending by June 30, 2009 represented more than 40% of loans to energy provided by the World Bank Group (includes large hydro).

Another promising sign is the fact that all international donors finance large projects through private investments via their financial branch dedicated to commercial projects (IFC, PROPARCO, KFW, PIDG). In Turkey, IFC financed a 135 megawatt wind farm enabling an increase of 30% of the country's capacity in wind energy while reducing pollution levels; In Chile, IFC financed the construction of a wind farm, the largest to date in the country. It will reduce environmental pollution while increasing the energy provision of the national grid. In South Africa, Proparco financed a 1MW solar plant while in Burkina Proparco intends to finance a 20 MW solar plant.

Funding and increasing production capacity, therefore, does not appear to be a major problem for the diffusion of clean technologies. Private investors have already shown their interest in those technologies when projects are implemented within a transparent and stable institutional framework and with financial guarantees. As far as the ECOWAS region is concerned, the lack of an appropriate regulatory framework enabling RE promotion, constitutes a significant barrier for private investors. The generally difficult financial situation of the public utilities and the reluctance to make proactive tariff adjustments are also limiting factors to generate confidence amongst potential investors.

The most common price-setting instrument and incentives is a feed-in tariff, which provides financial conditions to reduce the cost of developing RE by instituting favorable pricing regimes for RE compared to non-renewable alternative. However the regulatory design of FiTs is a dynamic process: Feed-in tariff policies need to be adjusted continuously. The challenge has been to offer *just enough* incentive to attract the private investment *but not so much* that free-riders are involved. This regime is yet to be developed.

In developing countries the Project Financing approach for RET is developing. Most of the time this type of larger projects gather together actors into consortiums, that implement the project.

In general this consortium comprises a manufacturer; an operator specialized in power generation, a pool of banks.

Of course the key factors for projects' promoters are economic and financial viability. The two key elements of sustainability are:

(i) the selling price per kWh produced and the purchase guarantee by either the national operator or by a new operator in the field of distribution (ruled by the PPA) and
(ii) the access conditions to the transmission/distribution grid securing the delivery of produced energy (wheeling rules)

These two conditions then require contractual commitments that are clear and stable over time to understand and monitor, and being part of a national favourable regulatory framework. Furthermore RET access to the grid requires clear technical regulations, that need to be approved by the regulatory authority and applied to the sectors operators. Currently this framework is missing. All these components need to be put into place to attract private sector and funds to invest in RE projects in this area.

6.5 Financing small-scale RE projects

Development aid is very active in the small-scale RE segment. These projects are often too small to attract private capital, and require high level of capital and transaction costs during their preparation and implementation (organizational and social engineering and intermediation, difficulty of managing a broad customer base,...). The private sector hesitates to take the risks and banks are hesitant due to the small size of the investments.

Insert 5 - The dissemination of SHS in Bangladesh

The World Bank decided in 2009 to intervene strongly in support of the government agency, IDCOL (Infrastructure Development Company Limited), responsible for developing solar energy which is a major focus for the national energy access strategy in Bangladesh.

IDCOL relies on a dense network of SHS distributors and on a major player Grameen Shakti, a subsidiary of Grameen Bank, which has established an important organization to penetrate the rural areas. This organization and this support has achieved impressive results:

- The number of distributed SHS has reached 645,000 units in 2010
- Currently more than 35 000 SHS are distributed monthly

At the end of 2010, the installed SHS capacity for domestic segment is of 45MWp, and the World Bank considers that 1.2 million households will be equipped with SHS by the end of 2012.

The financing aspects rely on matching grants from the GEF to a line of credit allocated to microfinance institutions and NGOs dedicated to acquisition of solar systems. In turn these organizations provide small loans to individuals and cooperatives asking for SHS. By transferring the share of their monthly energy budget usually spent on oil and batteries to solar energy, families can afford a modest investment in solar home systems ranging from 20 to 40 watts.

Multilateral and Bilateral Development Banks also play a key role in the development of RET in this segment. The World Bank Group remains a major contributor in financing projects with small capacities.

Indeed, these institutions can help countries in designing such programs and projects by using their technical expertise in the domain of rural activities and encouraging international networks to help these countries to find creative ways to finance such renewable energy projects as well as to design cost-effective procurement standards and procedures (additionally ODA support may concern: Capacity Building, Market Monitoring Activities, Coordination, Public Information Program; Business Development Support, Rural electrification fund (REF) support).

In conclusion, the development of RE in developing countries passes mainly through three approaches:

(i) decentralized electrification,
(ii) micro-grid, and
(iii) centralised approach aimed at integrating RE production on electricity transmission network.

The financing needs and patterns are very different.

6.6 Financing bioenergy

Energy produced from biomass represents the bulk of the final energy consumption in Africa. The strong dependence on biomass is particularly evident in sub-Saharan Africa where it represents 70 to 85% of the primary energy supply in some countries. Most of the biomass energy used in rural areas is conventional biomass, e.g. fire wood and charcoal fetched in forests and savannah woodlands. The use of traditional biomass has serious drawbacks for the environment and in terms of indoor air pollution, when it is used indoor. It is important to make the difference between rural biomass supply and urban biomass supply. If it is true that the biomass collection is a physical burden for the rural women and girls, its impact on the resources is moderate as trees remain a part of the traditional belief and faith in nature. But the fast increasing demand of urban areas in fuel wood (particularly in the form of charcoal) accelerates dramatically forests' and savannah woodlands' degradation, when it is not controlled. Efforts to improve and modernize fuel wood production, to pass the resources management responsibility to the local population and to develop programmes for urban small-scale biomass stoves, are an important component of national energy strategies and may rapidly lead to positive impacts for rural areas both in terms of social, environmental and economic.

6.6.1 Improved cook-stoves

The improved cook-stoves are one of the pillars of the domestic energy strategy. Despite their low cost (depending partly on the production and assembly at the local level) and their ease of use with a better burning process and less smoke production, the improved cook-stoves dissemination has been partially successful and the type of domestic appliance begins to be adopted by the urban population in West-Africa. Thus, dissemination programs of improved stoves often offer better cooking conditions, and lesser smoke and an efficiency gain of over 75% compared to a traditional one, generating a reduction of local pollution due to a near complete burning and of fuel wood consumption and on the household economy through reduction of fuel wood expenses.

Insert 6 - The improved cook-stoves in West Africa

This type of technology is mainly funded by NGOs and by GEF-UNDP, involved with training in new techniques of improved stoves and by extension operations that allow local manufacturers to distribute products at accessible prices.

In West Africa a range projects financed by the DGIS and implemented by the GIZ (former GTZ) have been developed under acronyms FA-FASO, FA-MALI, FA-SEN. In Burkina Faso, the project is deemed successful with the sale of more than 200,000 metal stoves for fire-wood and charcoal during the last 5 years. That means 1.6 million inhabitants are using hopefully these appliances.

In Mali M. Ousmane Sory Samasekou and his company 'Katène Kadji' has developed a successful experience of efficient charcoal cook stove with metallic body and ceramic insert. He provided knowledge, training and assurance quality to the local blacksmiths building the metallic bodies and to the ceramists burning the inserts. Part of the production is assembled on location for local sales with the Katene Kadji label. The remaining is gathered together and assembled in a work-shop and sell through a retailer network in Bamako and others larger cities. The experience is unique as associating the entrepreneurship principles with the local traditional networks.

6.6.2 Biogas

Biogas is another technology for small scale use of biomass of a growing interest. From a conceptual standpoint, biogas technology appears to be relatively simple and the technical viability of this technology has been proven repeatedly in many Asian countries. However, in Africa, biogas production has been controversial with experiments that resulted in only a small number of facilities most of which have fallen into disuse.

From these experiments, it appears that it is necessary to develop a specific market approach among suppliers, contractors, consumers and credit institutions. It should also have a robust and reliable technology because it is an important investment for rural populations. Successes in Asia in the dissemination of biogas technology for domestic use have led some twenty international development partners to launch the African Initiative on biogas.

However, we need to stress that success of biogas in Asia can be explained by the fact that they can develop under propitious conditions: huge concentration of population, lack of wood, easy access to water and manure, and less psychological barriers to use manure for cooking. A good example is Nepal. The SNV has implemented a successful program based on quality assurance, quality of the masonry of the digesters and piping systems, and training of the users. For many of these poor Nepalese farmers the alternative is the LPG to be transported on their back on distance of 10 to 25 km in mountainous landscape. That constitutes also a good reason to nurse its biogas plant.

In West Africa at least in many countries in the South, access to biomass is not a major problem for the rural population. Gathering manure can be a problem as cattle live outside. And water is definitely a problem in the Northern part of the ECOWAS regions. Therefore, efforts should be focused on industrial biogas at the dairy and slaughterhouses, where the resources are available and where there is a need for heat and power.

Insert 7 - African Initiative on biogas

Its vision is to contribute to the creation of a viable and permanent framework for biogas by building appropriate partnerships between governments, the private sector and civil society in African countries. Its objective is to provide, by 2020, two million households with biogas facilities that enable rural families to meet much of their energy needs for cooking and lighting and improved their way of life. Financial partners currently operating on this technology are the German and Dutch cooperation, UNDP, FAO, CILSS (Biomass energy programme), AfDB.

6.7 Solar thermal applications

Solar thermal technologies that were applied in Africa relate to solar water heaters, solar cookers, and solar dryers. With improved performance and lower cost, smaller solar water heaters have a payback period of 3 to 5 years. However, the diffusion of these systems has been slower than expected. In some developing countries, in fact, the solar water heaters have competitive difficulties due to the subsidization of LPG and electricity. However, in Botswana, for example, approximately 15,000 domestic solar water heaters were installed. About 4000 solar water heaters are used in Zimbabwe. In West Africa, the production of solar water heater remains a niche production with high price as consequence (400 to 600 €, when a cheap electric water heater costs 150 €). The quality of this equipment needs to be controlled and be granted with a quality label on their life time.

Insert 8 - Dissemination of solar water heaters in South Africa

The dissemination program is supported by the CTF (Clean Technology Fund). The CTF is a multi-donor fund created in 2008 which aims to ensure more sustained activity demonstration, deployment and transfer of low-carbon technologies with a significant potential for reducing emissions of greenhouse gas in the long run. The investment plan provides South African futures installing a million solar water heaters. The CTF financing will accelerate the market penetration of solar water heaters and the development of a local industry of these devices by reducing the installed cost, market development and demonstration of business models. Business to Business support has been tried in some West African countries without major breakthrough.

With regard to technologies with low investment costs (solar cookers, solar dryers), dissemination programs have so far relied on funding from NGOs and bilateral cooperation. Two major stumbling blocks for these technologies are their prices for the poor families and the fact that solar cookers cannot be the primary appliance in countries when it is dark after 18:30/19:00. Parabolic cookers (solar concentration on the cooking pot) cost around 100 to 120 €. Solar oven are cheaper around 20 to 25 €. This price level has to be set in relation with an average monthly family income of 60 to 110 € for poor urban families.

The current trend is to abandon direct aid to strategies that enable the poor to finance their own energy needs. For example, microfinance providers, who offer small loans, are essential to overcome the issue of funding the initial cost of investment in off-grid solar systems. Many of these microfinance providers are supported by start-up funds from major donors like the World Bank, but become self-sufficient in the long term through loan repayments.

The Standard Bank South Africa has committed, in partnership with the Alliance for a Green Revolution in Africa (Agra), the allocation of Euros 70 million in loans to 750,000 small farmers in four countries in Africa (Ghana, Mozambique, Tanzania and Uganda) who may decide to purchase solar cookers. This decision should encourage other African banks to adopt more attractive rates for farmers wanting to develop alternative that are more economical and certainly more reliable.

6.8 Example of programme design: Stand-alone Renewable Energy Systems

For spread user market, the grid connection is not a financially viable option as investments and operation losses will be prohibitive. Therefore direct purchase/leasing/renting for various sizes of PV systems shall be made available through private vendors and operators and NGOs. Recognizing the generally low incomes of this disseminated rural energy market and the still high capital costs of PV systems, the Renewable Energy Funds will provide subsidies to lower the capital cost to consumers. In that case, the installations are financed by users themselves under the conditions that the REF advances the necessary funds as it is currently done for conventional rural electrification. Users will then have to reimburse these loans on a monthly basis, over a certain period of time to be fixed.

The suppliers will offer small PV system options (e.g. 20-60 WP) sufficient to provide basic services to households. Competing vendors would be enticed to do business through incentives that include assistance in market development and capacity building, product promotions and other risk-reducing activities funded by the REF. These subsidies would bring PV systems prices close to the willingness-to-pay levels of consumers. Further, to remove the barrier of credit access, this sub-component would provide a line of credit to financial intermediaries (such as rural banks and micro-finance institutions) to enable them to provide consumer loans for the PV systems and financing of incremental working capital for dealers. In addition, REF would support the provision of training in PV financing operations and partial risk guarantees for the suppliers and users of PV systems.

With a sales model, private dealers sell SHS to rural households, who pay cash or receive credit. Rural households have to maintain the systems and are responsible for debt service in the case of a credit sale. Credit may be provided by the dealer, by a micro-finance organization, or by a development bank.

The Achilles tendon of credit based delivery systems is the maintenance of the systems. As long as the system is working properly the user will repay its loans. As far as technical problems occurs (replacement of bulbs, battery control charger) the cost of this maintenance is often prohibitive if the user is not part of a critical mass that can enable the emergence of local support services to an affordable fee. Financial risks mitigation is important in order to create among the involved partners a better confidence. The user can be requested to finance the battery, as a show of its financial capability. Buy-back and resale agreement for the PV panel which keeps part of its value during its life time, can reduce considerably the financial risk of the lending institutions involved. As the wiring, battery and appliances remain the property of the insolvent user, he can however keep the system running by charging the battery.

Under a service model, a Solar Company (Solarco) supplies solar electricity for a monthly fee to rural households. The systems are owned and maintained by the Solarco. This type of energy service can also be implemented by a community based provider. Again the maintenance of the single system is the key issue for the sustainability of the supply. A service company will generally provide a better service than community based provider that doesn't have the same commercial motivation compared to a service company.

6.9 Example of programme design: Mini-grid and Esco (Energy Service Company)

In this approach a public utility or government-contracted ESCO operates a small, isolated local grid, having its own power generation sources. In this case, tariffs need to be regulated (e.g., set at a level equivalent to the lifeline tariff of rural grid customers). The utility or ESCO operator receives a subsidy from a public fund (cross-subsidy from the national tariff, allocation from the finance law, private contribution). The subsidy is designed to cover part of the high upfront capital costs and possibly part of operation-and-maintenance costs. This model is now being applied in China to operate more than 700 centralized, PV micro-grids, each with a 10–150 kW capacity. The Philippines has applied such an approach for many years to fund its isolated solar/diesel hybrid operations. Again the design of the subsidy scheme has to be done with a special attention to avoid a 'free riders' attitude by the operator

Since its creation in 1993, the Global Environment Facility (GEF) has been the traditional co-financier of World Bank off-grid electrification projects through grants provided for RETs that are ready for practical deployment but facing some market barriers. Grant assistance is well-appreciated by recipient governments as it not only reduces the subsidy burden but provides a level of comfort to planners and decision makers still unsure of the effectiveness of renewable-energy alternatives for electrification.

More recently, the Global Partnership for Output Based Aid (GPOBA) is becoming an important source of grant assistance for off-grid electrification. GPOBA's goal is to apply output-based approaches to support the delivery of basic services to the poor. The most common grant applications are one-off, transitional, and ongoing subsidies. One-off subsidies involve capital subsidies aimed at increasing access to services. Transitional subsidies help to fill the gap between what the user is able or willing to pay and the cost-recovery level of the tariff.

Other bilateral and multilateral funding agencies are also active in the field of RET and decentralized electrification; For example all the following projects have received financial and design support from GIZ, AFD, AfDB (...)

- PERMER Renewable Energy for Rural Markets Project (Argentina)
- PERZA Off-grid Rural Electrification Project (Nicaragua)
- PIR Rural Infrastructure Project (Honduras)
- REDP Renewable Energy Development Project (China)
- RERED Renewable Energy for Rural Economic Development (Sri Lanka)
- RERED Rural Electrification and Renewable Energy Development (Bangladesh)
- RPP Rural Power Project (Philippines)
- TEDAP Tanzania Energy Development and Access Project
- PERG solaire (Morocco)
- the ECOWAS Renewable Energy Facility (EREF), managed by ECREEE

For example, AFD is developing a specific approach in Kenya in order to promote and support the emergence of local operators in energy distribution (from renewable sources). These operators have access to financing schemes at subsidized rates that are accessible through local banks. These local banks are refinanced by AFD through a dedicated credit line.

6.10 Centralized Renewable Energy integration

The economic viability of the grid-connected RE projects can be facilitated through two different models:

- the signature of a specific PPA between the RE developer and the energy distributor or
- by establishing a regulatory framework for a Feed in tariff accompanied by technical rules for grid access and connection.

In both cases there is an obligation for the utilities to purchase electricity generated by RET within their service area at a fixed rate, decided by public authorities and guaranteed for a certain period of time. These guaranteed prices (feed-in tariffs) should logically reflect the long-run marginal cost of RE, including a reasonable profit rate for the promoter and must be sufficient, attractive and smart to make investments in the sector rentable.

All green electricity producers whose marginal cost is less than the guaranteed price, have an incentive to produce. This system generates an additional cost to the community which corresponds partly to a real additional cost (the difference between the RE production marginal cost and the average cost per conventional kWh or the FiT if this is lower than the average cost). These differences between green and conventional costs reflect usually negative externalities (social costs, environmental costs,…) that should be credited to conventional energy. Yet, a FiT does not operate in a policy or regulatory vacuum. In order to create an enabling environment for renewable energy technologies, each FiT should be supported by complementary instruments.

Information and skills-based instruments are necessary to fill knowledge gaps and to build essential technical capacities. In a favourable regulatory environment (FiT system, clear and transparent PPA) RE projects may be supported by private investors using bank loans, equity and grants. The additional cost is usually borne by the final consumer through a "public service fund" or a "contribution to public service" in order to compensate financial costs borne directly by the utility. Considering these last issues the limits of such a system have to be mentioned when RE integration is massive and implies additional costs per kWh which can quickly be unbearable for the final consumer. That is the reason why some countries, as Morocco, for example have adopted a progressive strategy, meaning:

- first step : introduction of RE through clear PPAs
- second step: implementation of FiT (once RE costs are decreasing)

Thus, before entering a FiT system for grid-connected renewables, tenders for a specific capacity volume defining a ceiling and floor price could be a hybrid incentive mechanism merging a price target with a quantity objective.

6.11 Source of funding

There is an abundance of funds dedicated to the energy sector. Several of them are linked to the fight against deforestation which are not directly useful for the RE strategies. Some others are linked to renewable energy and could be used to finance grants for FiT, construction grants, concessional financing, risk guarantees, and technical assistance. These funds often achieve significant leverage of private investment. However, in Africa they do not constitute a significant track record yet:

- **The Global Climate Change Alliance,** which is an EU fund
- **The Global Energy Efficiency and Renewable Energy Fund (GEEREF),** which is managed by the European Investment Bank (EIB).
- **Forest Carbon Partnership Facility,** which assists developing countries to reduce deforestation and forest degradation and is managed by the World Bank. Fourteen financial contributors have committed about $165 million, which is divided between a Readiness Fund and a Carbon Fund.
- **The Congo Basin Forest Fund,** governments, civil society, and the private sector. The fund is initially being financed by a grant of £100 million from the UK and Norway.

6.11.1 Carbon financing:

There are opportunities within the Clean Development Mechanism, as well as the voluntary carbon market (VCM) (an informal carbon market). As a non-Annex I party to the UN Framework Convention on Climate Change (UNFCCC), ECOWAS member states are eligible to host GHG mitigation projects to earn certified emission reductions (CERs). ECOWAS commission should opt for the establishment of an office for a Regional CDM Authority (RCDMA), possibly hosted by the WAPP or the ECREEE secretariat and staffed by experts from both organizations. Financial means should be made available to employ for short term assignments (project development and capacity building) of international CDM experts to the RCDMA. The RCDMA must be operational, and support member states through the Designated National Authorities (DNA) in developing an ECOWAS –CDM project portfolio eligible to carbon offset market, by pooling projects of similar nature to give the portfolio the critical mass and reduce hereby the transaction costs. Project idea notes, which constitute the very first step in developing a project that is to benefit from CERs, must be processed. The existing carbon market experience in the region in renewable energy must be strengthened. CDM project development in solar energy, small and medium hydroelectricity, wind energy and biomass must be supported by ECOWAS.

If the Clean Development Mechanism is effective in catalyzing investment in some emerging economies (South Africa, for example), Africa as a whole represents less than 2% of CDM projects.

While Africa still uses relatively little carbon finance mechanisms, the barriers are twofold:

- barriers capacity issues (inadequate human resources, projects size according to the transaction costs and lack of regional coordination enabling larger projects) and
- financial barriers (start-up costs, low level of local funding and high risk perception).

ECOWAS must help removing barriers to carbon offset market development in the region in order to profit from the carbon market and contribute to the international effort to mitigate climate change and support sustainable development of member states. Barrier removal must tackle capacity development related to CDM project, bundling renewable projects, the use of simplified methodologies for CDM project development, program of activities (Peas) in order to reduce transaction costs. In addition, the RCDMA must take the lead in coordinating and enabling larger CDM projects development. Furthermore, the RCDMA will provide grants for well-designed projects in order to alleviate financial barriers.

According to the World Bank's estimates, technically, sub-Saharan Africa could accommodate more than 3,200 CDM projects, enabling an additional power generation of 170 GW. Although the ECOWAS's CDM project potential is huge, the region benefits less from the carbon market.

An illustration is given in the table below.

Table 13 CDM projects managed at UEMOA level (UNEP Risø Centre)

Title	Region	Sub-region	Host country
Landfill Gas Recovery and Flaring Project in Akouedo, Ivory Coast	Africa	Sub-Saharan Africa	Côte d'Ivoire
Abidjan Municipal Solid Waste-To-Energy Project	Africa	Sub-Saharan Africa	Côte d'Ivoire
SANIA fuel switching from natural gas to renewable biomass Project	Africa	Sub-Saharan Africa	Côte d'Ivoire
Mali Jatropha Curcas Plantation Project	Africa	Sub-Saharan Africa	Mali

Félou Regional Hydropower Project	Africa	Sub-Saharan Africa	Mali
Energy efficiency improvement Project of CSS sugar mill	Africa	Sub-Saharan Africa	Senegal
M'beubeuss Landfill Methane Recovery Project	Africa	Sub-Saharan Africa	Senegal
Partial Substitution of Coal by Jatropha Shells and Biomass Residues in the Production of Portland Cement	Africa	Sub-Saharan Africa	Senegal
Oceanium mangrove restoration project	Africa	Sub-Saharan Africa	Senegal
Togo Compact Fluorescent Lamp (CFL) distribution project	Africa	Sub-Saharan Africa	Togo

In addition to multi-lateral and bi-lateral funds, there are a number of public-private funds including a core carbon component that generate revenues based on offset credits from the CDM. These funds include:

- *The Bio-Carbon Fund* is a program that is administered by the World Bank to fund demonstration projects
- The *Carbon Fund for Europe* (CFE), which was launched in 2007 with a capital of €40 million and is co-directed by the EIB and World Bank.
- The *Carbon Partnership Facility* is being designed to develop emission reductions and support their purchase in the post-2012 period.
- The *Community Development Carbon Fund* provides carbon finance to projects in poorer parts of developing regions. The fund is managed by the World Bank.
- The *Danish Carbon Fund* (DCF)
- The *Italian Carbon Fund*
- The *Netherlands CDM Facility*
- The *Netherlands European Carbon Facility*
- The *Prototype Carbon Fund* (PCF), which is a partnership between 17 companies and six governments, managed by the World Bank.
- The *Spanish Carbon Fund*,
- The *Umbrella Carbon Facility* was created to manage large volumes of emission reductions for different groups in multiple tranches.

Also, the process of the Nationally Appropriate Mitigation Actions (NAMA) may play an important role in future. ECREEE has initiated an initiative for the ECOWAS region in this regard. As for the voluntary market, it is still a new issue and is in its infant stage in the ECOWAS region. However, on the local level, ECOWAS commission through WAPP or ECREEE must consider some small scale projects that match the voluntary Carbon Market requirements. The overall goal of the ECOWAS carbon offset market will be to make a better use of the existing funds and carbon finance facilities.

In conclusion:

- Based on their specific energy consumption situation, ECOWAS member states should focus their efforts on renewable energy sectors and low-carbon economy. Increasing investment in greening the energy sector can make a substantial contribution to decreasing carbon emissions. Renewable energy sources can play an important role in a comprehensive strategy to eliminate energy poverty.
- The profits from carbon or energy taxes or from phasing out fossil fuel subsidies could be used to support incentives of greening the energy sector. As far as project financing is

concerned, public finance mechanisms, which can range from simple grants to complex conditional funding structures, can be deployed to support R&D, technology transfer, and skill building. The international community is supporting green economy and growth. Expected investments in green energy projects will reach an average of approximately US$650 billion worldwide over the next 40 years in power generation using renewable energy sources.

- The ECOWAS Commission shall take on greater responsibilities to promote harmonized regional approach through the development of green energy strategy in other to attract additional bilateral and multilateral funding to support the renewable energy sector development. "Green Fund" for a regional Green Energy Initiative for ECOWAS must be raised through a work in partnership with UNEP/UNDP/AfDB and other relevant international multi-donor and national institutions.
- There is a need for co-ordination amongst different funds so that bigger programmes across countries could be jointly funded. So far there have been small isolated projects and financing. The same approach is required perhaps for the various bilateral and other funding agencies.

6.12 Tariffs and incentives

Governments will face the choice between different families of instruments, those playing on prices – controlled purchase tariff - and those playing on quantities - national targets and competitive bidding, or imposition of quotas and trade of green certificates. As noticed earlier, the goal of government intervention is very specific: it is to stimulate technical changes and accelerate the learning technology processes to bring renewable energy fully competitive with conventional energy sources, after internalizing environmental costs. Comparison of instruments must be assessed in connection with the characteristics of innovative processes and conditions for their adoption - uncertainty regarding cost curves, learning dynamics etc.

6.13 Competitiveness of RE

Fossil fuel based generation technologies are connected with negative environmental and social externalities which are paid by the society but not the project operators (e.g. pollution of oil, soil and water, GHG emissions). If these costs are internalised, the competitiveness of some RE technologies improves considerably. Actual costs including environmental degradation value are not reflected in the market cost structure. Facing the difficulty of quantifying these costs, a solution could be to provide financial support corresponding to the unaccounted externalities for conventional energy technologies when shifting to renewables.

Indeed, a major obstacle to investment in renewable energy is the cost difference between power productions from renewable versus conventional power generation. The cost difference tends to decrease, especially for mature renewable energy technologies such as wind and hydropower, but there is still a relatively large difference for other sources of energy technologies (biomass, solar) that tends to be reduced by combining the technology learning curve and economies of scale. The upfront investment costs for some RE like PV are presently decreasing due to the economies of scales gained through increased industrial capacity and technological change and due to a higher level of competitiveness. For some thermal RETs like solar thermal and biomass, this trend will be slower as their price is tied with a given quantity of materials needed.

The chart below illustrates the different stages of the introduction of RE under the financial dynamic.

It shows that the development of RE is part of a progressive approach based on the establishment of different financing systems. So before reaching a RE environment supported by strong private sector and bank system involvement, it is necessary as part of an emerging market to support the development of RET by mixing subsidies, tax incentives and by the establishment of a favourable regulatory framework for RET IPP, and the feed in tariff approach.

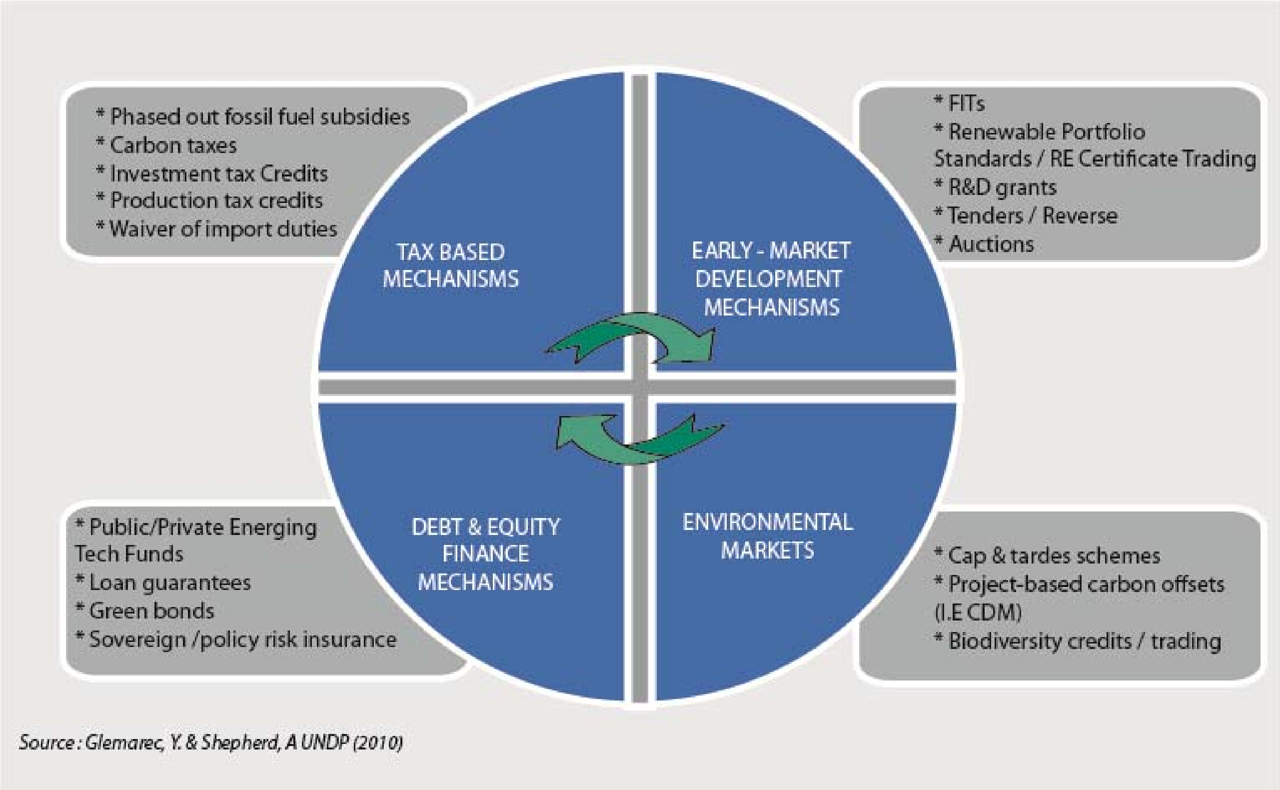


Figure 26: Different stages of the introduction of RE under the financial dynamic

7 Renewable Energy resource assessment

7.1 Hydropower

The overall hydroelectric potential (small, medium and large scale), located in the fifteen ECOWAS countries, is estimated at around 25,000 MW. It is assessed that only around 16% has been exploited. Around half of the existing large potential (around 11,5 GW) has been assessed technically and economically in the course of the elaboration of the 2011 Master Plan of the West African Power Pool (WAPP). Finally, a project pipeline of 21 large hydro power projects with an overall capacity of 7 GW has been approved for execution by the WAPP. It is projected that large hydropower will satisfy 25% of the overall installed electric capacity in the ECOWAS region by 2025 and 29% by 2030. The implementation of the WAPP project pipeline and attached transmission lines will allow regional power trade, and will lower the generation costs and consumer tariffs, particularly in countries highly dependent on expensive diesel generation today.

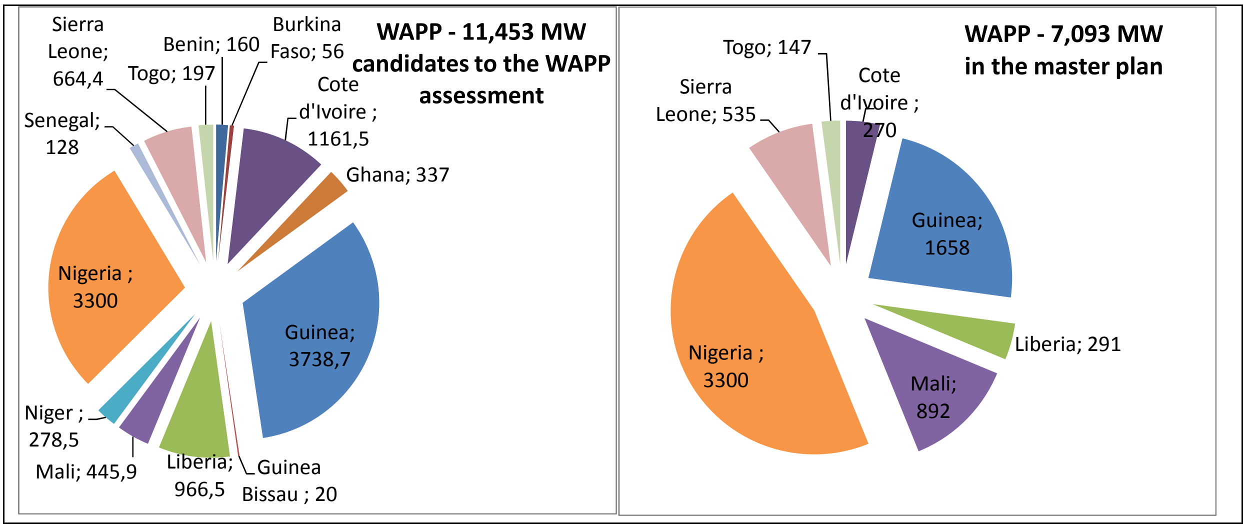


Figure 27: Renewable energy candidates in the WAPP resource assessment and in the approved master plan

The estimations of the SSHP potential (up to 30 MW) in the ECOWAS region differ widely and lack reliability. They range from 1.700 MW and 5.700 MW of feasible potential. The lower end was estimated by taking into account the provided site data by the ECOWAS countries to the ECREEE inventory during the workshop. Due to the lack of available hydrological data in the countries it remains difficult to give a comprehensive updated overview. In many countries the inventories established some decades ago have never been updated and gauging stations do not exist anymore. Many resource assessments have been carried out during the 70ies, 80ies and 90ies by foreign consultants (e.g. EDF for the French speaking countries) and the regional expertise in hydro resources assessment is poor, if any.

Both The Gambia and Cape Verde do not have hydropower resources. The countries endowed by an important potential are Nigeria and Guinea. All other countries dispose of a good potential except for Burkina Faso and, to some extent, Niger. Nevertheless, it should be noted that some hydro projects in Guinea, Sierra Leone and Liberia will face difficulties although many of those prove to be profitable from an economic standpoint. Indeed, financial budget constraints in some countries, environmental impacts, and access difficulties to the sites will play as inhibiting factors for the massive development of hydro resources. However, a number of these projects could be dedicated to local supply for mining activities. For Ghana, its potential is estimated at 2000 MW.[10] About 1,200 MW is expected to be produced from proven large hydro sources, while the rest will come from medium to small-scale hydro projects. About 70 Small-scale hydro Sites have been identified for a potential estimated between 5 and 12 MW.[11] A compilation of several data sources is summarized in the following table:

Table 14 : Summary of SSHP Potential

Countries	All hydro candidates assessed by the WAPP in MW	WAPP projects in the Master Plan in MW	No. of sites of less than 30 MW	SSHP potential (<= 30 MW) in MW	Remarks on SSHP potential
Benin	160		102	307	-
Burkina Faso	56		70	138	-
Cape Verde					
Cote d'Ivoire	1161,5	270	5	58	-
Gambia			No information available		
Ghana	337		69	5-12	all < 2 MW
Guinea	3738,7	1658	10	17	+ 4 pico
Guinea Bissau	20		2	48	-
Liberia	966,5	291	24	66	-
Mali	445,9	892	15	70	-
Niger	278,5		5	About 30	-
Nigeria	3300	3300	65	370	-
Senegal	128		no information available		
Sierra Leone	664,4	535	17	330	-
Togo	197	147	40	229	-
Total	*11.453,5*	*7.093*	*424*	*1,672*	

A UNIDO leaflet highlights a number of relevant barriers regarding implementation of small-scale hydro projects. There is (...)

- a general lack of legal framework to develop small-scale hydro projects
- a lack of financing means at national level. Therefore, IPP or PPP have to play a role
- are some climatic constraints as in some cases production is available only 8 months a year.
- a lack of regional qualified human resources dealing with all aspects of Small-scale hydro power projects; particularly to assess the resources and to carry out feasibility studies
- little experience with IPPs

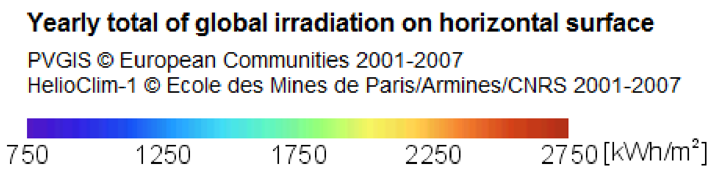
[10] Implementation of Renewable Energy Technologies, Ghana Country Study, UNEP-RISO, 2002
[11] ECREEE assessment

7.2 Solar energy

7.2.1 PV potential assessment

The solar energy potentials in the ECOWAS region with regard to the use of PV were assessed via the online calculator "PVGIS estimates of solar electricity generation", developed by the Joint Research Centre of the European Commission[12] (http://re.jrc.ec.europa.eu/pvgis/imaps/index.htm). The calculator is based on the database PVGIS HelioClim which operates with relatively conservative values. The following maps show the radiation data by using the following indicators:

- Average daily electricity production from the given PV system (kWh)
- Average monthly electricity production from the given PV system (kWh)
- Average daily sum of global irradiation per square meter received by the modules of the given PV system (kWh/m2)
- Average sum of global irradiation per square meter received by the modules of the given PV system (kWh/m2)



The four countries **Senegal, The Gambia, Guinea Bissau and Guinea** are endowed with a relatively homogenous solar irradiation. The electricity production for 1kWp PV connected to the grid including 28% system losses is estimated as follows:

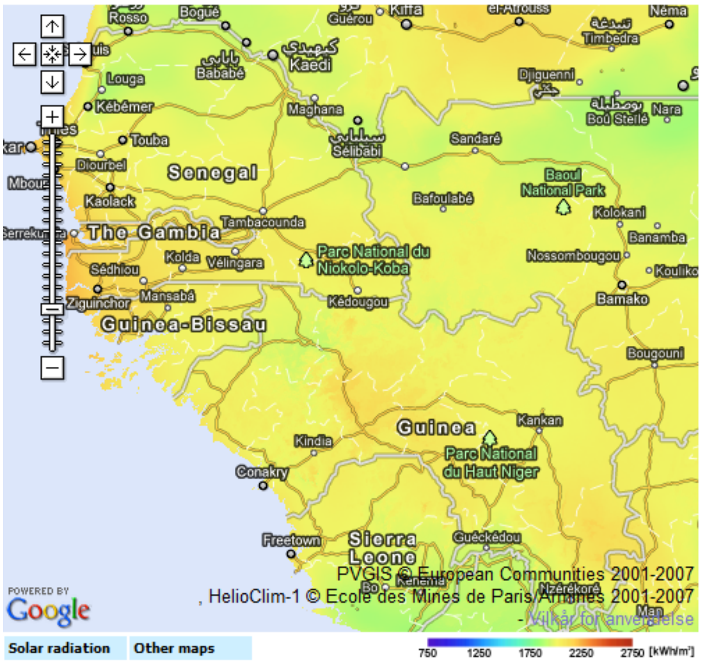


Figure 28: Solar radiation in Senegal, Gambia, Guinea Bissau and Guinea

	Fixed mounted equipment		Tracking system	
1 kWp installed	**kWh/year**	**No hours/ year**	**kWh/ year**	**No hours/ year**
Average irradiation	1,490	2,060	1,815	2,510
Best irradiation (Casamance coast)	1,620	2,270	2,130	2,965

[12] © European Union, 1995-2012 Reproduction is authorized, provided the source is acknowledged, save where otherwise stated.

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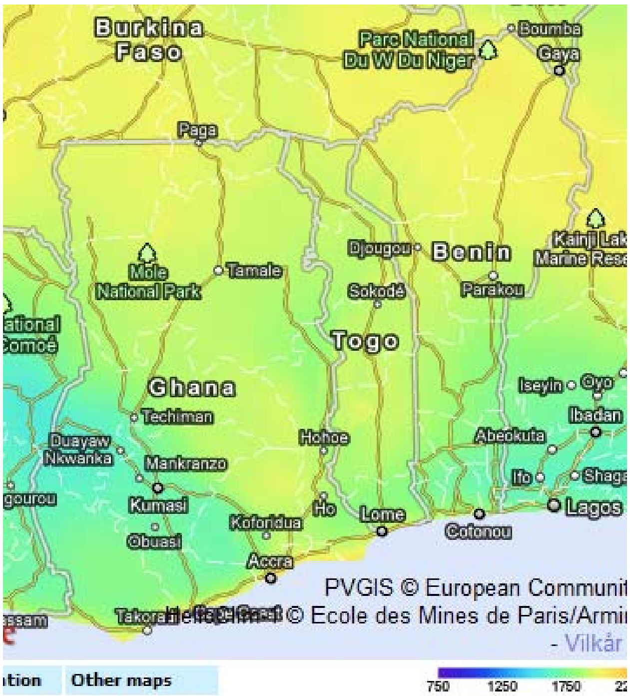
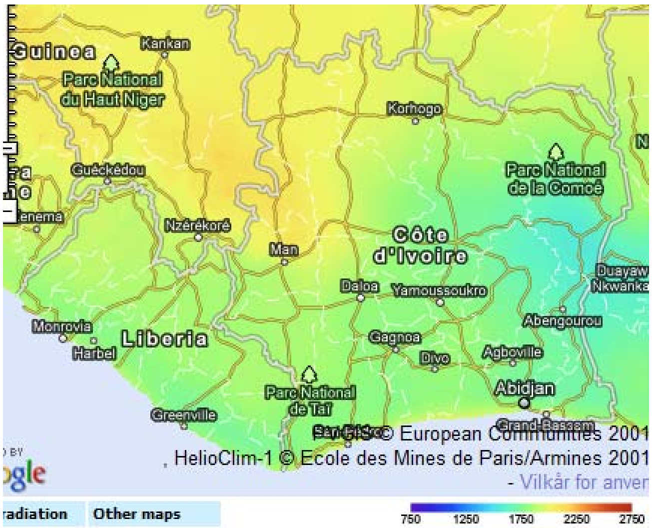
Countries such as **Ghana, Togo and Benin in the southern part** of the region are receiving less solar irradiation than the Northern regions.



	Fixed mounted equipment		Tracking system	
1 kWp installed	kWh/year	No hours/year	kWh/year	No hours/ year
Best	1,470	2,050	1,825	2,535
Average	1,420	1,990	1,750	2,435
Worst	1,190	1,650	1,450	2,000

Figure 29: Solar radiation in Ghana, Togo and Benin

The solar potential for **Liberia and Cote d'Ivoire** is quite moderate. Only the North-eastern part of Cote d'Ivoire has a better solar potential



	Fixed mounted equipment		**Tracking system**	
1 kWp installed	**kWh /year**	**No hours/year**	**kWh/year**	**No hours/year**
Best	1,530	2,110	1,925	2,645
Average	1,390	1,920	1,725	2,390
Worst	1,150	1,600	1,380	1,910

Figure 30: Solar radiation in Liberia and Cote d´Ivoire

The Northern areas of Niger have the highest solar potential of the region. The challenge with regard to the development of these potentials is the lack of available transmission and distribution infrastructure. One of the opportunities is to associate to the planned coal- with some solar capacity which could use the same transmission HV line. There are also interesting resources on each side of the eastern part of the border between Niger and Nigeria (Kano, Zinder, Diffa, Maiduguri). The solar resources for the coastal areas of Nigeria are less interesting.

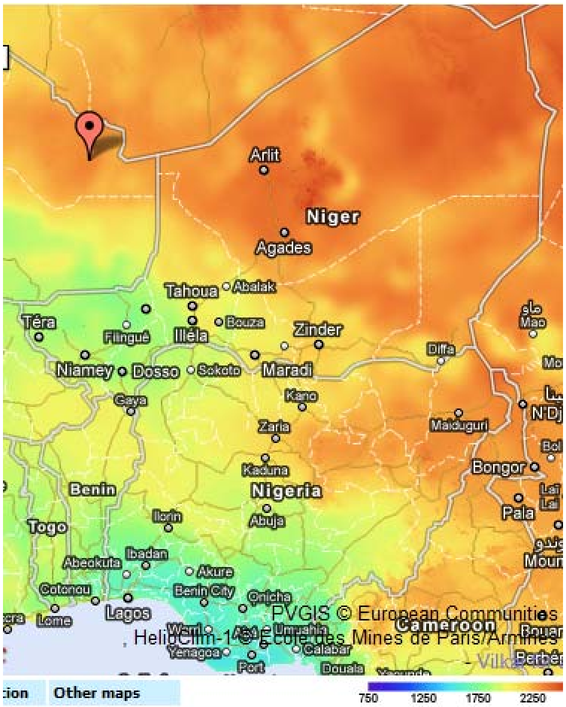


Figure 31: Solar radiation in Niger and Nigeria

	Fixed mounted equipment		Tracking system	
1 kWp installed	kWh/year	No hours/year	kWh/year	No hours/year
Best	1,730	2,470	2,295	3,275
Average	1,670	2,360	2,200	3,095
Worst	1,110	1,540	1,330	1,840

Burkina Faso and the Southern Mali benefit of a solar potential similar to that of Guinea. Rich potential is available in Mali but in areas quite far from an existing HV grid. The region of the Niger interne delta receives less solar radiation than the rest of Mali.

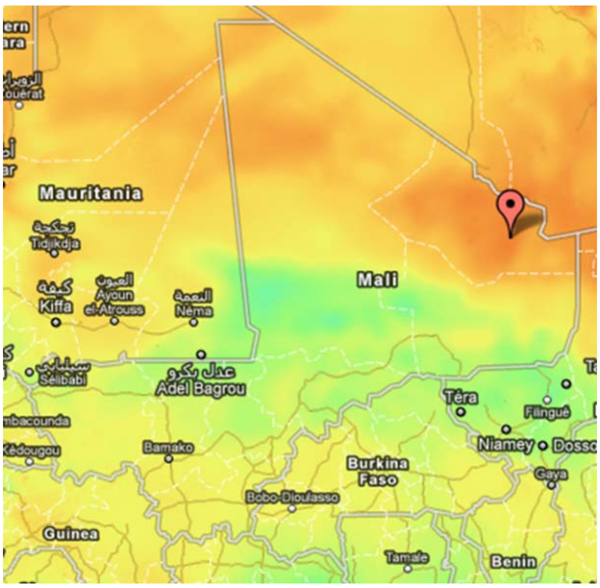


Figure 32: Solar radiation in Burkina Faso and Mali

	Fixed mounted equipment		Tracking system	
1 kWp installed	kWh/year	No hours/year	kWh/year	No hours/year
Best	1,650	2,370	2,175	3,120
Average	1,470	2,070	1,830	2,555
Worst	1,290	1,820	1,565	2,215

7.2.2 Demand driven PV projects

Another way to assess the RE potential is to find out who as private investor could be interested to invest in medium sized RE technologies. A comprehensive study has been carried out in the UEMOA countries in 2011 financed by the AFD: "Funding RE and EE investments for enterprises in the

UEMOA area". It identified a total number of 34 potential projects with around 20 based on PV and 14 based on bioelectricity.

UEMOA	No	Capacity	Costs in M €
PV projects	20	69.7	171.5
Biomass industrial projects	14	65.5	52.9
Total	34	135.2	224.4

These projects are expected to be completed before 2017. A rough extrapolation based on a correlation between the two economic entities, population and GDP, could lead to the following global assumption for short term commercial potentials for the ECOWAS region.

UEMOA	No	Capacity	Costs in M €
PV projects	72	251	617.4
Biomass industrial projects	50	236	190.4
Total	122	487	807.8

Based on solid data surveyed in the UEMOA countries the magnitude of industrial PV can be estimated at 251 MW on short term up to 2016. 72 projects could be realized for a total investment of 617.4 M€.

7.2.3 CSP potential assessment

ECREEE in cooperation with CENER in Spain has launched a CSP potential assessment which is based on Solar Direct Normal Irradiance (DNI) data. First results show that around 87% of the total surface of the ECOWAS region has long term annual DNI values greater than 1800 kWh/m^2 and would have theoretically sufficient potential for CSP development. However, due to scarcity of transmission and distribution infrastructure, only some sites are technically feasible. The non-blue in the graph below are considered feasible areas.

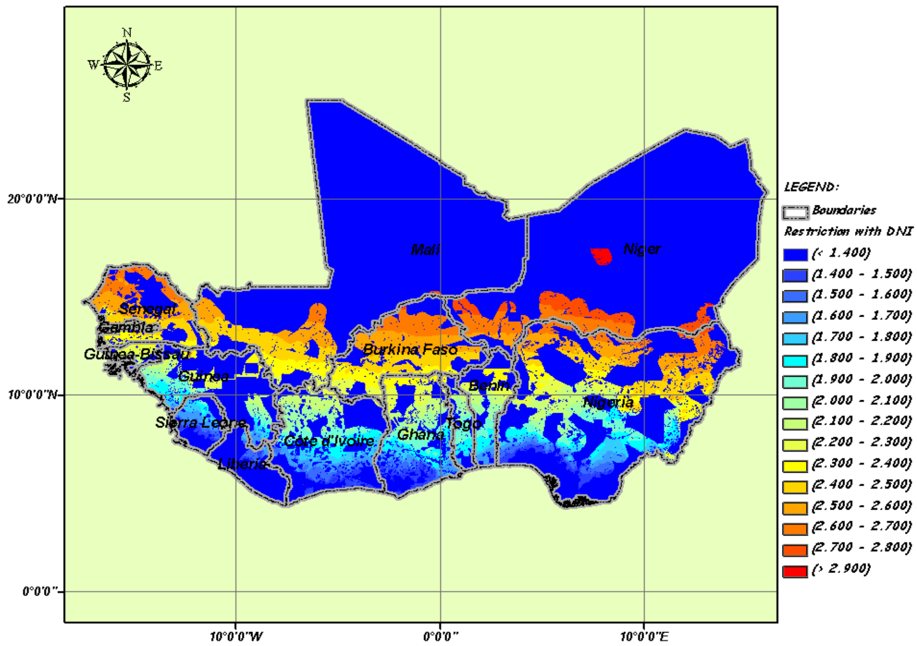


Figure 33: CSP potential mapping

7.3 Wind power potential

A Strategic Study on Wind Power Deployment in Africa was financed by the AfDB and the Canadian International Development Agency (CIDA) in 2004. For the study, a quantitative map of wind speeds for the African continent was prepared at a resolution of 50 km, using a WEST model. The speeds indicated on this map represent average speeds of winds at 50 m in the regions identified by each of the 50 km by 50km simulation tiles. The study concluded that the best winds in Africa are found in the north of the continent and to its extreme east, west and south. In West Africa two countries were identified for having the best wind potentials: Cape Verde and Mauritania.

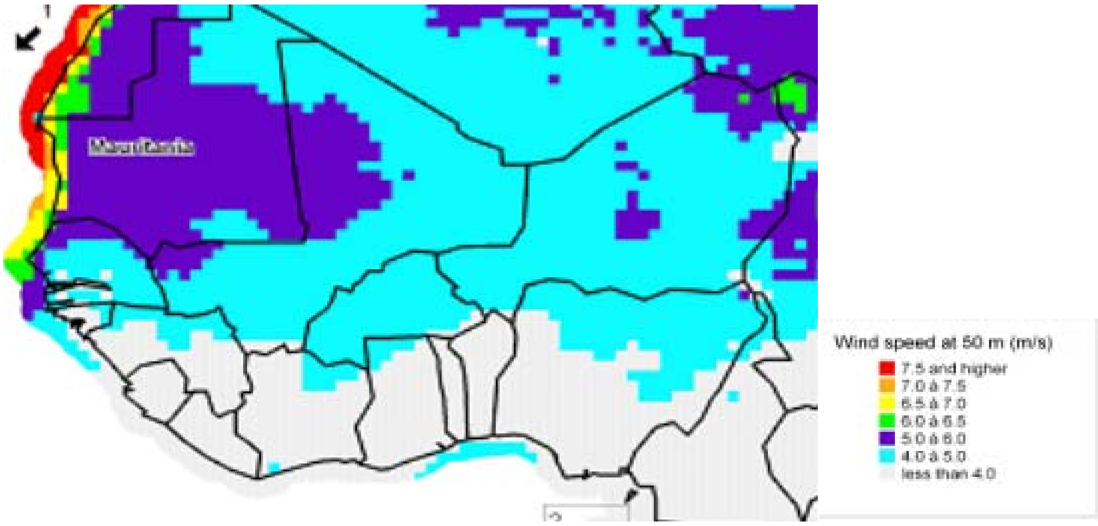


Figure 34: Result of the wind study for WA

The synthesis map shows clearly that the coastal countries alongside the Gulf of Guinea have poor wind resources (Average speed < 4.0 m/s). The potential becomes interesting in terms of power generation alongside the coast of Senegal and the Gambia with wind speed close to 6.5 to 7 m/s. There are some areas with potential around 5 to 6 m/s north of Timbuktu in Mali and in Niger. A detailed wind assessment was carried out for the Malian potentials by the Risø laboratory and the preliminary result seems to confirm that the potential is at the margin of what will be required for developing a fully commercial use of wind energy on large wind turbines.

Other reports came to a more optimistic assumption of wind power resources (for instance in the WAPP master plan study – Volume 1). This data has to be confirmed by more detailed wind assessment measurements. Of course, some specific locations can have a special wind regime due to the landscape or thermal conditions. But in general, macro modelling of wind resources, gives an acceptable indication of areas where detailed wind surveys can be carried out. In any case, other sources of more detailed data exist. Therefore, information collected, for example, for Ghana need to be thoroughly verified[13].

[13] The strongest wind regime along the Ghana/Togo border: 9.0-9.9 meters per second wind speed that can yield a wind power density of 600-800 Watt/m2 in the mountains over an area of about 300-400 square kilometers. The total wind energy potential of this area has been estimated at around 300 MW in capacity or 800 GWh in generation. Over a large area along the coast, high winds (6.2-7.1 meters per second at the height of 50 m) are also present reflecting a total potential of around 3000 MW capacity or 7,300 GWh of electricity.
Marginal or moderate wind power density (200-400 W/m2) occur in other parts of the country putting the estimated potential of scattered off-grid wind turbines at about 500-800 MW capacity or 1,100-1,700 GWh electricity.

Table 15: Wind potential identified by the WAPP

Ressources éoliennes - Potentiel éolien des meilleurs sites identitfiés (cf cartes)			
Pays	**Vitesse de vent moyenne (m/s)**	**Production (MWh/an/MW)**	**Commentaires**
Senegal	6	2588	
Gambie	6	2588	
Guinée-Bissau	5	1717	Ce niveau de production est généralement trop faible pour motiver un investissement.
Guinée(Conakri)	8	4051	
Sierra Leone	trop faible	x	Développement éolien pas possible : faible vitesse de vent entre 3 et 3.5 m/s ou forêt dense ou montagne trop pentue
Libéria	trop faible	x	Développement éolien pas possible : faible vitesse de vent entre 3 et 3.5 m/s
Mali	7.2	3531	
Côte d'Ivoire	4.8	1565	Ce niveau de production est généralement trop faible pour motiver un investissement.
Ghana	6	2588	
Burkina Faso	6.5	2999	
Togo	5.8	2451	
Bénin	6.5	3006	
Nigéria	7.8	3933	
Niger	8	4051	

For commercial application of large wind turbines, the required average wind speed has to be higher than 6 m/s. And the production will depend also on the regularity of the wind. It does not appear that the wind potential is very attractive, except for some areas. What is needed is a detailed re-examination of the areas identified as having highest potential by different studies and where site conditions would allow wind turbines to be installed, including larger machines. Generally off-shore wind turbine can produce about 50% to 70% more energy than a land-based turbine. Experience from Denmark shows that for a favourable location, a wind turbine can produce up to what correspond to 1,700-2,000 hours operation at its nominal effect. For offshore wind farm, the production is about 2,800 to 3,500 hours of the installed capacity. ECREEE is currently undertaking another wind assessment in the ECOWAS region in cooperation with USAID.

7.4 Bioenergy potential

7.4.1 Biomass assessment

Biomass resources cover many different energy products. The first biomass resource is the wood-fuel from the forest and wooded lands. It can be used as fire-wood or as charcoal.

Statistics on woody biomass are often scattered and unreliable. For example, the population of Nigeria is about 170 million, whereas 70% live in the country side. LPG is not used as it is considered too expensive for the population. Cooking is based on kerosene and woodfuels. The kerosene consumption is about 7,745 GWh or 666,000 tons of kerosene. The wood-fuel consumption is reported to be 0.156 GWh or 561.7 GJ - what corresponds to 13 toe. However, this figure is insignificant and cannot be right. A rough estimate of the wood fuel consumption based on an average unit consumption of 0.8 kg/day/capita deducted for the kerosene used for cooking (with correction for stove efficiency) will give as order of magnitude a value of 15 million toe. For the ECOWAS region, when taking into account the LPG consumption, the wood fuel consumption is estimated at 20 million toe.

From the timber industries there is also a potential waste resource at the saw mills. In northern countries, like Sweden and Finland, the sawdust is used to fuel cogeneration plants for timber drying and electricity needs. The surplus is sold to the grid. Agricultural wastes need to be divided into two categories, the residues remaining in the fields or at the villages and the agro-industrial wastes resulting from a production process, like groundnuts shells, cotton seed shell, rice husks, etc.

The first type of residues is often used in different ways: first as feeding stuff for the animals, as constructions material to fences and some is burned for cooking or pottery. Generally, there is no surplus available from cereal straw. In many countries, the farmers have been trained to prepare some compost based on surplus straw and animal manure.

As a rule of thumb, a capacity of 10 MW biomass based power capacity running 5,000 hours a year will produce 50 GWh. It will demand a quantity of dry biomass of 53,000 t (13 kJ/kg). Depending on the technology and the yield of the waste to energy process and the moisture of the biomass, this quantity will vary between 42,000 and 60,000 tons. The few coherent data collected are the following:

- A project in Mali based on 168,000 of rice straw to produce 126 GWh
- Nigeria, overall potential of 28 million toe/year
- Cote d'Ivoire potential of 6 million toe/year
- Ghana, overall potential of 1.8 million toe/year
- Guinea, overall potential of 0.8 million toe/year
- Sierra Leone, overall potential of 0.2 million toe/year

7.4.2 Demand driven biomass projects

Based on data surveyed in the UEMOA countries, the magnitude of industrial waste to energy projects using industrial biomass can be roughly estimated at 236 MW for the short term up to 2016. 50 projects could be realized for a total investment of 190 M€.

7.4.3 Biofuels

So far, three countries are really involved in biofuel production: Senegal, Mali and Burkina Faso. These three countries have developed a specific strategy for biofuel, and two of them have already created a regulatory framework: Senegal with a Department within the Ministry of Energy and Mali with an Agency, ANADEB, under the Ministry in charge of energy. The three approaches are based on use of jatropha curcas to produce raw oil that can be used as such or processed into biodiesel (esterification process demanding methanol and producing glycerine). Sierra Leone is currently developing a MW-scale ethanol plant for export and electricity generation.

The present surface used to grow jatropha remains modest, 3,000 ha in Mali and 5,000 to 7,000 ha in Burkina Faso. The figure is unknown for Senegal. There is a commercial biodiesel production in Mali with Mali Biodiesel (a private promoter), and an experimental production in Burkina Faso with Belwet and Agritech as stakeholders. One key problem is scarcity of the jatropha seed on the market and its (kilo) price. At 100 FCFA/kg and a ratio of 5 kg seed for 1 liter raw oil, the production cost for raw oil alone is not competitive compared to the economic cost of DDO.

ECREEE in cooperation with UNIDO and Quinvita has recently launched a regional potential assessment on the sustainable use of biofuel-crops. The assessment covers the following crops: Jatropha, Camelina, Sweet Sorghum, Cassava and Crambe, Castor, Ground Nut and Cashew. In the table below first results are summarized. Each crop has a colour reflecting the level of opportunity for biofuel production in the respective country. Table 4 clearly reflects differences in the opportunities of the various countries for specific crops. For example, Camelina and Crambe are not suited for the ECOWAS region. Cape Verde is not suited for rain-fed agriculture. Countries with (a lot of) potential for rain-fed production of several bio-energy crops are Benin, Burkina Faso, Ghana, Mali, Nigeria, Senegal and Togo. Among these states, Togo already has the highest percentage of arable land in use, but because it is a great net exporter of food, the country is still regarded to have potential for production of bio-energy crops. But, this may change when all the other criteria have been evaluated.

Table 16: Present point of view on the opportunity of the selected bio-energy crops for ECOWAS countries

Country	Camelina	Cashew	Cassava	Castor	Crambe	Ground-nut	Jatropha	Sweet Sorghum
Benin	Red	Light green	Green	Orange	Red	Light green	Green	Light green
Burkina Faso	Red	Orange	Red	Yellow	Red	Light green	Green	Green
Cabo Verde	Red	Red	Red	Red	Red	Red	Red	Red
Ghana	Red	Light green	Green	Light green	Red	Green	Green	Light green
Guinea	Red	Orange	Light green	Yellow	Red	Light green	Yellow	Light green
Guinea Bissau	Red	Light green	Yellow	Red	Red	Orange	Yellow	Yellow
Ivory Coast	Red	Green	Green	Red	Red	Light green	Light green	Light green
Liberia	Red	Red	Light green	Red	Red	Red	Red	Red
Mali	Red	Orange	Yellow	Yellow	Red	Light green	Green	Green
Niger	Red	Red	Orange	Light green	Red	Light green	Orange	Yellow
Nigeria	Red	Green	Green	Light green	Red	Green	Green	Green
Senegal	Red	Orange	Yellow	Light green	Red	Green	Light green	Light green
Sierra Leone	Red	Red	Light green	Red	Red	Yellow	Red	Yellow
The Gambia	Red	Red	Orange	Yellow	Red	Yellow	Light green	Yellow
Togo	Red	Orange	Light green	Orange	Red	Orange	Light green	Green

Legend: Green: great opportunity, Light green: opportunity, Yellow: less opportunity, Orange: limited opportunity, Red: no opportunity.

8 RE technology and cost assessment

Summary

There are several benchmarks in the ECOWAS region to estimate the competitiveness of RETs with conventional energy solutions in urban and rural areas.

In the case of grid-connected projects, RETs compete with power generation costs in the range of 70 to 90 €/MWh in countries such as Cote d'Ivoire, Ghana and Nigeria. These countries mainly rely on large hydro and natural gas. In Gambia, Guinea-Bissau, and Cape Verde, which are dependent mainly or completely on oil products, the generation lie between 210 and 230 €/MWh. Through the establishment of a regional power trade, WAPP aims at reducing the generation costs to the range between 45 and 75 €/MWh for all ECOWAS countries by 2020. For decentralised RE solutions in rural areas the benchmarks are as follows:

- *Small diesel generators: produce in the range of 250 to 300 €/MWh*
- *Grid extension: Grid based electricity costs with an additional marginal cost for distribution range from 10 to 56 €/MWh depending on the financing conditions*

The results of the cost assessment show that biomass, SSHP and wind power are the best options for countries with enough resources. Already today they can provide electricity on a competitive basis.

- *Hydropower is the champion among RETs. It can provide electricity at a cost of 44 €/MWh for large hydro (>30 MW) and 78 €/MWh for Small-scale hydro small-scale hydro resources.*
- *Biomass plants are competitive particularly if the feedstock is free of charge and available in sufficient quantity to operate at full capacity.*
- *Wind power is also competitive. However, there is no guaranteed capacity and it requires operating adjustable capacity to regulate the production. To be fully competitive with the best existing productions some incentives could be needed.*
- *At the present time, under commercial conditions, solar energy remains expensive. It can only match high diesel thermal production costs under favourable conditions. This means that PV would not be able to kick start the market without some financial support. The roof-top opportunity has to be compared with the consumer tariffs. CSP with full storage capacity is slightly more expensive than PV, but it is not required to be regulated and will produce all night through. Cheaper solutions with light storage capacity (0.5 hours) could provide competitive supply during the day.*

In the light of the assessment, priority shall be given to biomass, SSHP and wind power. Solar remains the most expensive RE source for power production. However, it should already be competitive with the daily diesel peak load mobilized to cover the needs of air conditioning. Taking into consideration the expected evolution for price falls for solar technologies, incentives should be provided to initiate a learning process of integrating this resource in the panel of candidates for the future power supply. All the simulations are summarized in the following table:

	Present costs (In €/MWh)		Cost estimate in 10 years (in €/MWh)	
	Commercial conditions	ODA conditions	Commercial conditions	ODA Conditions
Wind farm	66-120[1)]	42-76	55-85	30-53
PV power plant	200-280	110-160	140-200	80-115
Roof top	260-400	152-225	190-260	112-162
CSP	240-280	147-180	160-195	100-120

CSP without heat storage	100-120	62-75	Na	Na
Biomass 10 MW	49-84 [2)] 62-97 when biomass has to be purchased	Generally commercial plants		
Biomass 2 MW	91-161			
Larger hydro plant[4)]	44		44[3)]	
Small-scale hydro plant	78		78	

1) The cost range represents the variety of resources conditions from acceptable to very good
2) The lowest cost corresponds to a full load operation (no restriction for biomass availability) while the highest cost is determined when the plant operates at half capacity due to scarcity of the biomass.
3) Cost regression is not expected for hydro
4) Capacity larger than 30 MW

8.1 Grid-connected technologies

8.1.1 Wind power

A wind turbine converts kinetic energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a wind generator for the larger capacities or wind charger for the smaller ones. If the mechanical energy is used directly to drive machinery, such as for grinding grain or pumping water, the device is called a windmill or wind pump. The smallest turbines are used for applications such as battery charging or auxiliary power on sailing boats, while large grid-connected arrays of turbines are becoming an increasingly large source of commercial electric power.

Wind pumps are operating at low speed winds cutting in at a 2.5 m/s wind and operating up to a 6/7 m/s wind. The wind velocity must be in average higher than 6 m/s to secure the economics of power production on the large wind generators. However, they cut in at 4 m/s.

The range of commercial wind generators to be connected on the grid is from 850 kW to 3 MW per unit for onshore wind generators and from 3 to 7 MW for offshore machines. The largest installed machine has a capacity of 7.58 MW, and several companies are presently developing a 10MW unit.

Small wind turbines ranges from equipment with a capacity ranging from 15 W to 1kW for the smallest producing DC electricity to battery charging and from 2 kW to 50 kW producing tri-phase AC electricity to supply a mini-grid.

The average market price for the larger on-shore wind generator is about 1.25 M€/MW as the price for steel and copper has increased in recent years. In West Africa, the price is higher as the capacity of a single machine is presently limited to 850 kW due to the lack of heavy crane to install higher unit capacity. The price for the Cape Verde 25.5 MW wind farms presently installed is about 2 M€/MW. But it is expected that the price should decrease by the time to reach a level of 1.4 M€/MW in 10 years.

Table 17 kWh costs produced on large wind turbines (2M€/MW)

Capacity factor	No of hours at max capacity	Int. Rate 10%	Int. Rate 6%	Int. Rate 2%
25%	2,190	12.0	9.8	7.6
30%	2,628	10.0	8.1	6.3
35%	3,066	8.5	7.0	5.4
40%	3,504	7.5	6.1	4.7
45%	3,942	6.6	5.4	4.2

The assumptions used to produce the price curbs are the following:

- Unit price: 1.4 M€/MW installed
- Life time: 20 years
- Running costs: 2.7 % of investment per year
- Calculation for different capacity factors corresponding to different qualities of wind resources (45% is more or less the case of Cape Verde)

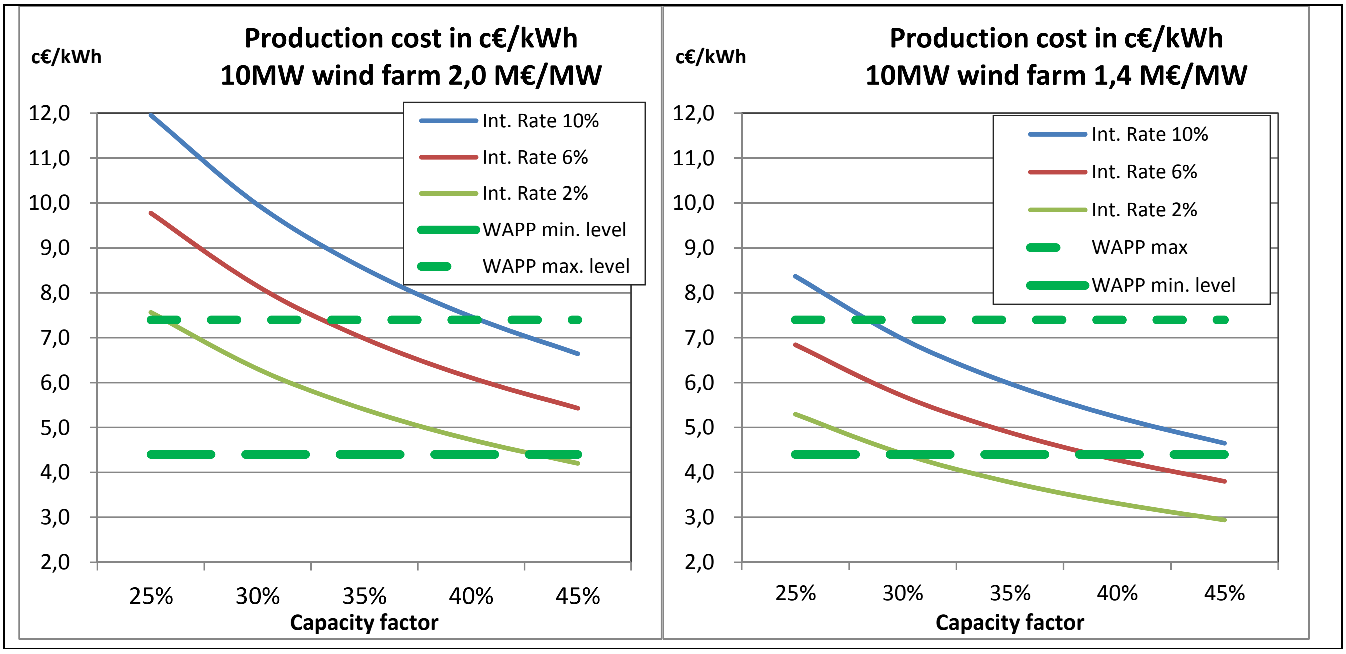


Figure 35: KWh price produced on large wind turbines

The simulation with the present price level for wind farms shows that under commercial conditions the production costs inclusive of O&M will range from 12 to 6.6 c€/kWh. This will make the best locations quite competitive to the foreseen marginal costs for the regional grid supply in many countries (4.5 to 7.5 €/kWh). For projects with ODA financing conditions, the wind energy costs will be in the same range than the regional project marginal costs (from 7.6 to 4.2 c€/kWh). With a price assumption of 1.4 m€/MW, the wind energy will become practically fully competitive with the regional project's marginal costs.

For smaller turbines, the investment costs differ from small wind chargers (from 15 W to 1kW with DC production) to small wind turbines (from 2 kW to 100 kW with AC production), and in relation to where they are produced. The prices for small turbines range from 2 to 3 €/W for the range 5 to 250 kW and from 3 to 3.7 €/W for smaller turbines and wind chargers. However, the Chinese market for this type of machines will boom in the coming years with a price that will be around 30% lower than the present price level.

Wind technology will be relevant to be combined with solar PV in off -grid areas having an acceptable wind potential (30%). It could provide energy at about 23 c€/kWh for fully commercial projects and a system loss of 25% (storage in battery)

8.1.2 PV and CSP

Two solar technologies for power production are considered:

- the photovoltaic technology converting directly solar radiation into DC electricity using semiconductors like mono-crystalline silicon, polycrystalline silicon, amorphous silicon etc.
- and the solar thermal concentration system (called CSP technology) concentrating solar heat to high temperature (300 to 700 °C) into a heat carrier (molten salt) that is used further to supply a traditional steam turbine technology to produce electricity.

Solar PV

The advantages of the PV technology are its robustness, as it is static equipment which does not require specific or complicated operation and maintenance skills, and its price.

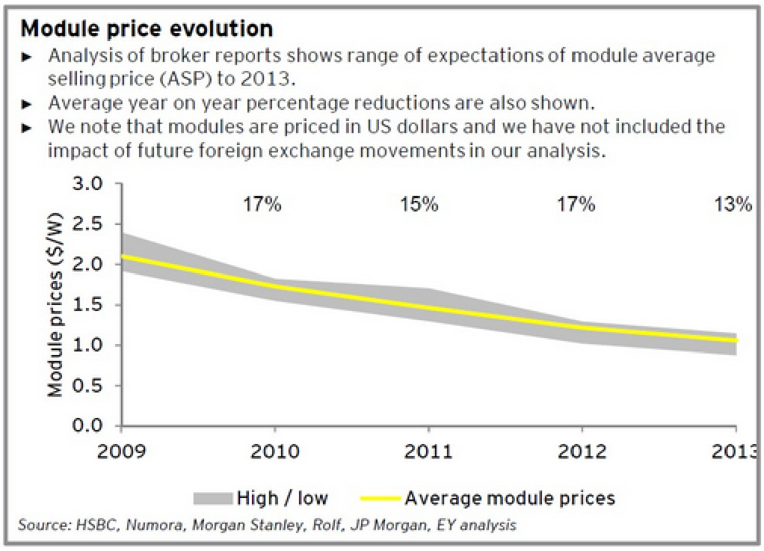


Figure 36: PV module - price evolution

Depending on the size of the farm, a 33 kV or often a 90 kV line will be required to evacuate the power produced. The general benchmark cost for a typical solar power plant is about 2.7 M€/MWp, but recent projects in Mali and Burkina Faso show that the cost is closer to 3 M€/MWp. The connection costs to the grid are not included in the price. It is expected that very substantial cost reduction of up to 50% could take place by 2020.

PV panels can be used in several ways: (i) as grid connected application like solar PV power plant with capacity ranging from 1 to 20 MW or even more, (ii) as PV roof-top promoting the consumers' self-supply with or without battery, which could also be supplying to the grid, (iii) as smaller PV plants of up to 100 KW to supply mini-grid, or even captive uses, with or without a small or medium sized diesel generator and (iv) as solar home system with battery for domestic or community applications.

The price for PV in the ECOWAS region is still quite higher than the prices presently experienced in Europe. This is due to the narrowness of the market without real competition on price and/or quality and the niche position that the PV dealers have and possibly the lack of awareness and the recent drastic price regression.

The investments costs are summarized in the following table.

Table 18 Price information on Solar PV

	Present price	Price assumptions in 2020
Solar plant > 5 MW	3 €/Wp	2.2 €/Wp
Solar roof top (without batteries)	1,9 to 3,8 €/Wp[14]	3.3 €/Wp
Small PV plant /hybrid system	7.9-5.6 €/Wp	6.1-4.3 €/Wp
Solar home system	9 €/Wp	7.5 €/Wp

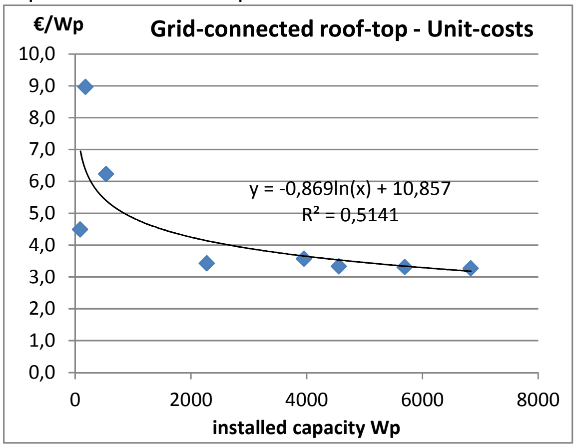
PV plants

Based on these price assumptions a series of costs simulation have been carried out to illustrate the impact of the solar irradiation (PVGIS information) and the financial conditions (from commercial to ODA conditions).

Three PV plant situations have been simulated for the following potential:

- In the less propitious areas with a capacity factor of 13% corresponding to an average production of 1,140 kWh/kWp installed/year. These locations lie mainly in Cote d'Ivoire, Ghana and Nigeria along the coast, and around the tropical forests.
- For the average potential value valid for most of the countries with a capacity factor of 16% (1,400 kWh/kWp installed).
- For the best potential corresponding to a capacity factor of 19% (1,665 kWh/kWc installed) in Northern Mali, North and South Eastern Niger and North Eastern Nigeria.

[14] experience from several installations in Cape Verde
Experience from Europe



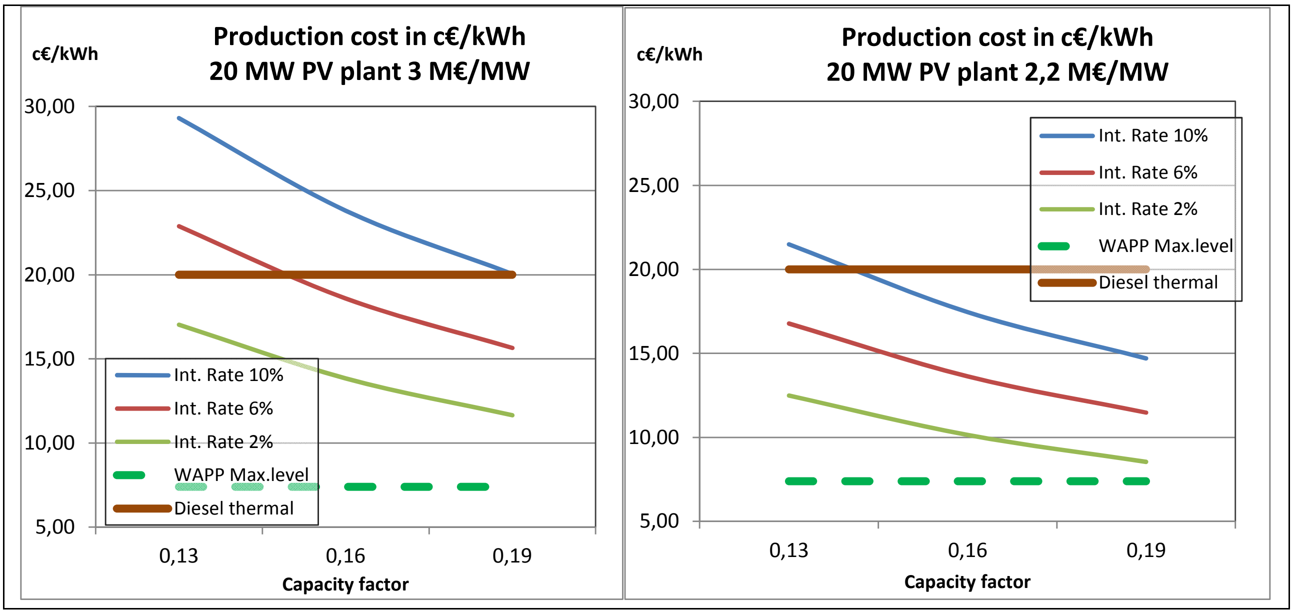


Figure 37: Costs simulation for Solar PV Plants

At the present price levels, and under commercial conditions, large arrays of PV cannot be competitive alternatives (between 19 and 28 c€/kWh) to diesel generation on larger motors (20 c€/kWh) and are far away from the WAPP marginal costs (4.5 to 7.5 c€/kWh). However, for the average and good potential, with softer financing conditions, this becomes competitive with diesel generation (from 19 to 23 c€/kWh) but will still remain more expensive than the future proposed WAPP regional supply.

With lower investment levels due to lower costs which are likely to occur in the next 10 years, solar PV power from larger plants will definitely be more competitive than the diesel thermal alternative and will come much closer to the regional supply price.

Roof top application

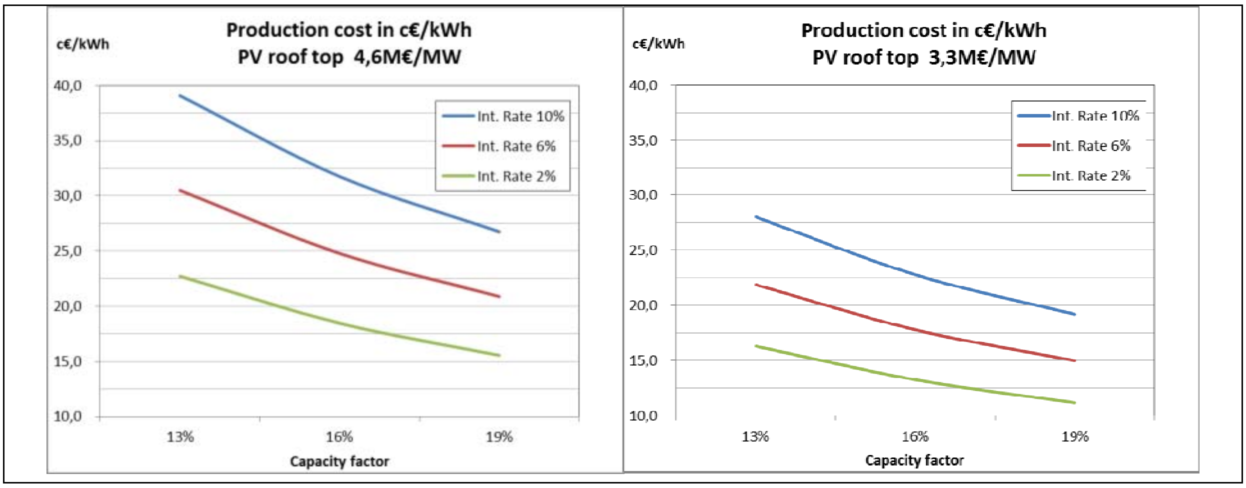
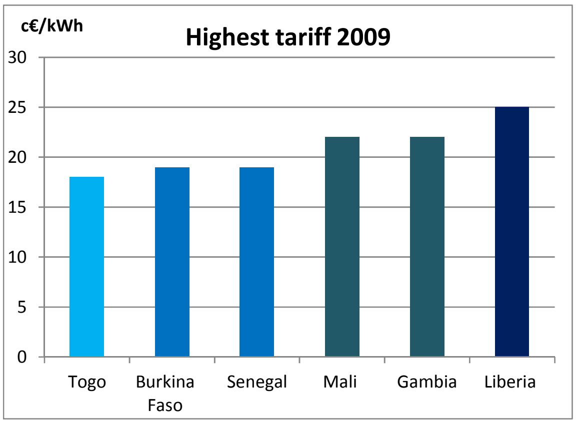


Figure 38: Costs Simulation for Roof Top Applications

The major barriers for roof top applications are the actual price that only reflects the narrowness of the markets and the lack of regulatory framework. Here, the costs have to be compared with the tariffs applied to the different categories of customers, mainly the well-off domestic consumers that can afford the systems, the administration and industries.



Sources UPDEA report 2009 on tariffs in Africa

Figure 39: Highest electricity tariff in the ECOWAS

As shown in the figure above, the consumers of six countries in the ECOWAS region suffer from very high tariffs. For some of those, efforts have been made to reduce tariffs for industries through cross-subsidizing. The tariffs shown are applied to middle and up to large income domestic consumers, and generally to consumers having a tri-phase meter (office building, smaller enterprise, tertiary sector).

Under the present price assumptions, the roof top can only be considered for good to excellent solar conditions and with soft to softer financial conditions. In other words, incentives are required to promote private investment for roof top.

With a reduction of the investment cost from 4.6 €/Wp to 3.3 €/Wp, the roof top will become an interesting alternative in the area of best potential even though it may still require some incentives. Generally, the utility should consider that the savings on the system provided by the roof tops occur in two ways: reduction of very expensive peak load due to the air conditioning appliances and reduction of transmission and distribution losses due to the local excess production. This area is, therefore, likely to grow.

Concentrated Solar Power (CSP)

Concentrating Solar Plants are gaining ground in developing countries as thermal power production technology. The first thermal solar plants had been built in the late seventies as an answer to the first energy crisis. The new technology develops higher temperature and more efficient fluids to transport the solar energy that is concentrated on a special coated glass pipe to heat storage and a boiler that converts the high temperature heat into steam. The remaining part of the plant is a traditional steam turbine plants. Currently, all parabolic trough plants (US terminology) are "hybrids," meaning that they use fossil fuels to supplement the solar output during periods of low solar radiation. Typically, a natural gas-fired heat or a gas steam boiler/re-heater is used. Troughs can also be integrated with existing coal-fired plant or biomass plant. CSP cost is still high and needs financial incentives to face the market. The International Energy Agency (IEA) estimates a current investment cost for Parabolic Trough plants between 3000€/kW and 6300€/kW (depending on local conditions, solar irradiance and – not least – the maturity of the project, i.e. pilot, demonstration, commercial) and project costs decline up to 50% in 2020 due to a larger industrial production of CSP components. The Global CSP Outlook (Estela-Greenpeace, 2009) envisages steady declining investment costs from a today's level of 3700€/kW (2010) to 2500€/kW by 2030 plants.

The NREL, National Renewable Energy Laboratory of the US, has posted on line information on a long range of CSP plants[15]. Unfortunately, information regarding investments is not largely shared.

The data on the ANDASOL plant in Spain are in line with the data given below for a plant with a 7,5 hours storage for full last capacity, e.g. 50 MW. As interesting data the PPA-tariff paid to the owner is 27 c€/kWh for a 25-year period corresponding to the results of the simulation.

Parabolic troughs can also operate without heat storage or only with a buffer storage capacity. It is the case of the Nevada Solar One with a capacity of 64 MW for an investment cost of 266 MUS$, corresponding to a unit cost of 4.2 MUS$/MW or 3.0 M€/MW. Its net yield in regards to solar irradiation is 14.4%. Its heat buffer capacity is 0.5 hours, enabling to regulate the power production if clouds shadow the plant.

The technical assumptions used in the simulation are summarized in the table below.

Table 19 Data for a 50 MW CSP plant

Capacity	50	MW
Investment cost	7.5	M€/MW
Total investment	365.50	M€
OM	3.4%	Initial investment/year
Heat storage	7.5	28,500 tons molten salt hours at full last
Captors area	497,000	m2
Yield	17%	Planned outage for maintenance 2%
Solar irradiation DNI	2050/2450	kWh/m2/year
Life time	25	years
PPA tariff	27	c€/kWh during 25 years

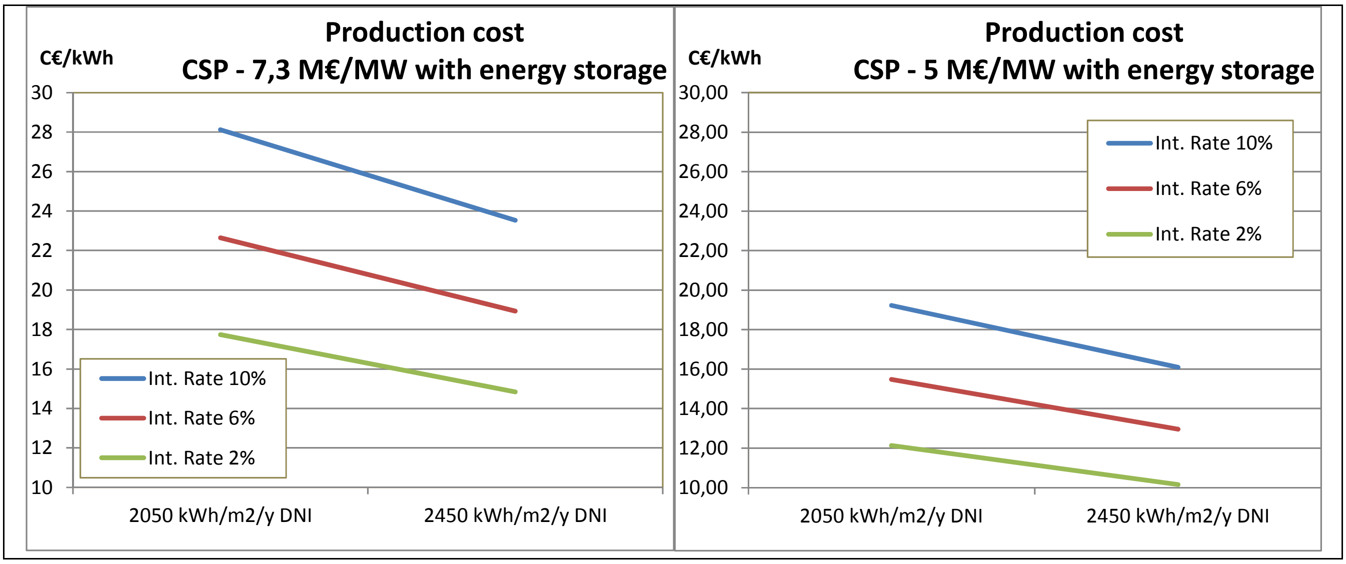


Figure 40: Production cost for a 50 MW CSP with a 7 hour storage capacity at full last.

[15] http://www.nrel.gov/csp/solarpaces/project_detail.cfm/

At the present investment costs, the production cost per kWh (24 to 28 c€/kWh) is rather high compared to the most expensive large diesel generation (19 to 23 c€/kWh). Soft financing can bring the CSP generation cost to the same level than large diesel generation. However, these level remains far from the expected future regional marginal cost.

With a foreseen reduction in the investment level (7.3→5 m€/MW), the CSP will become fully competitive with the large diesel generation which costs will have probably at that time. Even if ODA financing conditions can be provided at that time the resulting production costs (10 to 12 c€/kWh) will remain slightly higher than the expected regional marginal costs (4.5 to 7.5 c€/kWh).

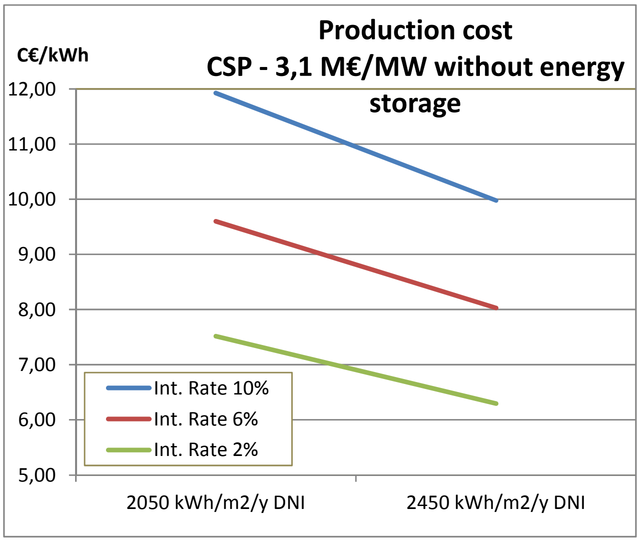


Figure 41: Production costs for a 50 MW CSP without storage capacity

Based on the data collected for the Nevada Solar One with an investment unit cost about 3.1 m€/MW, the resulting commercial production costs are in the range of 10 to 12 c€/kWh which is quite promising compared to large diesel production. With softer financial conditions, the production cost can be reduced to 8-9.5 c€/kWh in case, for example, of creating a PPA where the utility share is financed on ODA conditions or to 6.3-7.5 c€/kWh if all the investment is financed on ODA conditions. These are assumptions, but this technology has to go through more maturity.

8.1.3 Biomass

Biomass combustion is a carbon-free process because the resulting CO_2 was previously captured by the plants being combusted. At present, biomass co-firing in modern coal power plants with efficiencies up to 45% is the most cost-effective biomass use for power generation.

Dedicated biomass plants for combined heat & power (CHP), are typically of smaller size (1 to 20 MW_{power}) and have a lower electrical efficiency compared to coal plants (26%-30% using dry biomass, and around 22% for municipal solid waste). In cogeneration mode the total efficiency may reach 85%-90%.

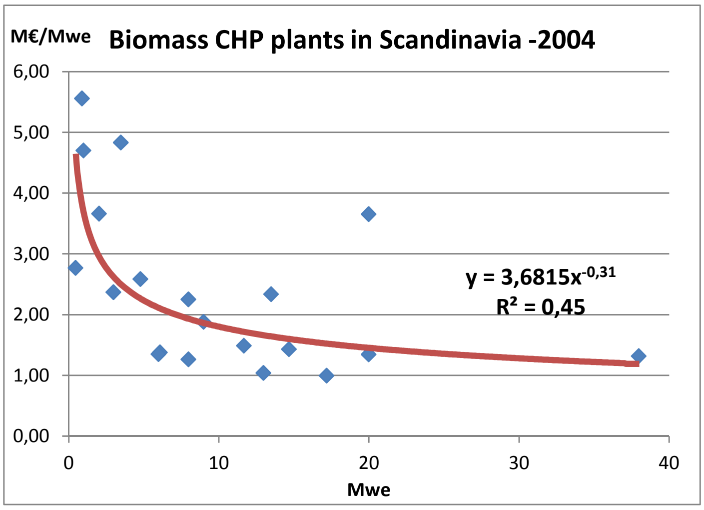


Figure 42: Investment cost for Biomass CHP plants in Scandinavia

The advantage of the biomass power plant compared to solar or wind power is its ability to produce power constantly unlike the intermittent nature of the other two. If biomass is available in sufficient quantity, the plant can operate during 8000 hours a year reducing dramatically the capital costs that are in the same order of magnitude than the other technologies (from 1,5 to 5 M€/MW depending on the ratio heat/electricity production and the size of the plants). Furthermore, if the biomass is free of charge, the electricity price will depend only on the technology choice and on the value given to the processed heat production.

However in most cases, the biomass is not likely to be free of charge as it has an alternative commercial value as cattle feed, domestic energy or building material. Logistics and storage to secure a continuous production also has a cost. In Europe, a typical cost for biomass is between 2.2 to 2.6 €/GJ or 35 to 40 €/tons. As an example, cotton plant stalks have no value on the fields as long as these are not collected. As soon as they are collected, they automatically get a value for the local farmer, and the price rises if this demand increases. The second factor that adversely affects biomass power production is the logistics required to gather, transport and store sufficient biomass quantity to feed a power plant. For this type of residue the transport cost is about 8 to 23 €/tons/100 km.

Table 20 Assumptions for biomass CHP plants

Plant	10	MW CHP
Power yield	27%	
Heat yield	61%	
Losses and plant consumption	12%	
Operation	8.000	hours
Power generation	80.000	MWh el
Heat production	180.741	MWh heat
	650.667	GJ heat
Biomass consumption	296.296	MWh biomass
	1.066.667	GJ biomass
	71.111	Tons biomass (15 Gj/tons)
	0.889	tons/MWh el

Investment	2.5	M€/MW
O&M	3.50%	of initial capital cost/year
Transport cost /tons/100km	15	€

The simulation is carried out for two different sizes of plants (2 and 10 MW el) and for a transport and storage cost for biomass of 15 €/tons/100 km and an average transport distance of 50 km. Only commercial conditions are considered in the simulation. Furthermore, an additional calculation has to be done if biomass is not free and needs to be purchased. The price is set to 1€/GJ biomass or 15 €/tons: this could be a reasonable price in WA (10.000 FCFA/tons).

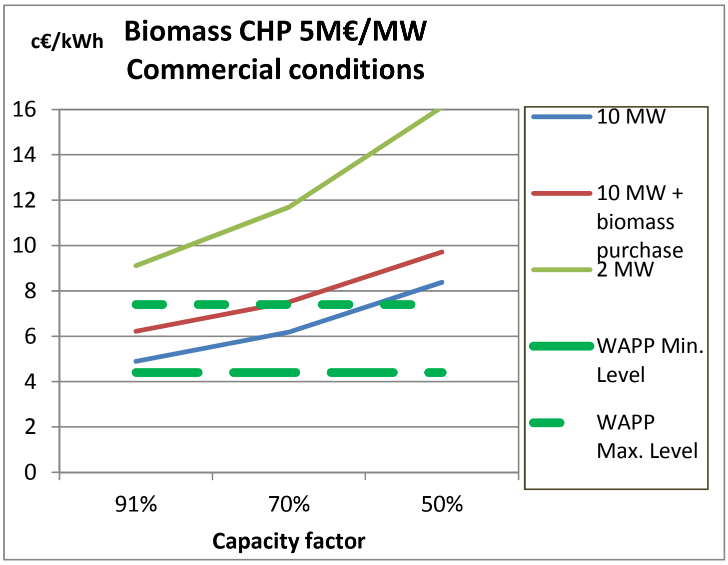


Figure 43: Production cost for biomass CHP plants

The price for a 10MW biomass CHP plant is in the range from 5 to 8.4 c€/kWh depending on the availability of the biomass (capacity factor ranging from half to full utilization). In that case, the cost of the logistic must be calculated on an average distance of 50 km and the electricity sale pays the whole operation of the plant, e.g. the process heat used by the plant owner is free. This cost estimate is fully competitive for the future regional marginal cost for grid electricity. However, for a 10 MW plant the amount of biomass required exceed 70.000 tons/year for an average calorific value of 15 kJ/kg. For smaller plants, the cost of investment (5M€/MW) and the production cost is higher and ranging from 9 to 16 c€/kWh, which is still competitive energy compared to the large diesel generation alternative. However, the biomass availability issues could be much easier to resolve with small biomass plants provided their economy is acceptable, as the needs are less and they are likely to operate at higher capacity utilisation than larger plants. Further, the cost of collection, transport and storage will also be less. Costs could be further rationalised if there are dedicated energy plantations and a network of supply through biomass depots. If biomass has to be purchased (1 €/GJ in the simulation corresponding to 15 €/tons), the production costs for electricity increase of 1.33 c€/kWh, keeping the electricity competitive with the regional future marginal costs.

Following the IEA Energy Technology Essentials, dedicated biomass power plants are more expensive. Electricity costs in cogeneration mode range from 3 to 6.6 c€/MWh. Electricity cost from new gasification plants is around 7.4-9.6 c€/MWh, but with significant reduction potential in the future. These prices correspond to developed countries' price level.

Provided that biomass is available in sufficient amount at a reasonable cost, the CHP, back-pressure or gasifier technologies are fully competitive with the large diesel generation cost. Furthermore, the CHP and backpressure turbine technologies already offer costs that are close to the expected costs for the future regional power supply. Therefore, a special attention in the regional policy has to be paid both to the evaluation of the biomass resources, and to the technical capacity development as the skills and qualifications to design, operate and maintain biomass plants and steam turbines is poor in West Africa.

8.1.4 Small-Scale Hydro Power (SSHP)

Hydropower is the extraction of energy from falling water (from a higher to a lower altitude) when it is made to pass through an energy conversion device, such as a water turbine or a water wheel. A water turbine converts the energy of water into mechanical energy, which in turn, is often converted into electrical energy by means of a generator. Alternatively, hydropower can also be extracted from river currents when a suitable device is placed directly in a river. The devices employed in this case are generally known as river or water current turbines or a "zero head[16]" turbine. Hydropower systems can range from 10 W to hundreds of MW. In the ECOWAS context, Small-Scale hydropower (SSHP) is defined up to a maximum capacity of 30 MW. (Medium-scale hydropower (MSHP) is up to a maximum capacity of 100 MW and large-scale hydropower (starting from 100 MW upward). The different sizes of hydro power in the ECOWAS region are defined as follows:

Table 21: ECOWAS Hydro Power Definitions[17]

<table>
<tr><th>Terms</th><th></th><th>Power output</th></tr>
<tr><td>Pico hydropower</td><td rowspan="4">"Small-scale" Hydro-power "SSHP"</td><td>< 5 kW</td></tr>
<tr><td>Micro hydropower</td><td>5 - 100 kW</td></tr>
<tr><td>Mini hydropower (MHP)</td><td>100 – 1 000 kW (=1 MW)</td></tr>
<tr><td>Small hydropower (normally "SHP")</td><td>1 MW - 30 MW (!)</td></tr>
<tr><td>Medium hydropower</td><td></td><td>30 MW - 100 MW</td></tr>
<tr><td>Large hydropower "LHP"</td><td></td><td>> 100 MW</td></tr>
</table>

The applications of small-hydro facilities include base, peak and stand-by power production or stand-alone applications. Hydroelectric plants typically generate power between 15 to 100 per cent of the time. In base loading applications, units must be able to operate at least 85 per cent of the time. SHP installations commonly last without the need for major replacement costs for 30+ years. Within the limits of water resources available, SSHP installations are characterized by reliability and flexibility of operation, including fast start-up and shut-down in response to rapid demand changes. SSHP electricity can be tailored to the needs of the end-use market, avoiding balance and power reliability concerns. Small-scale hydro-power is in most cases "run-of-river"; in other words the dam or barrage is quite small, usually just a weir, and little or no water is stored. Therefore, run-of-river installations do not have the same kinds of adverse effect on the local environment as large-scale hydro.

[16] "Head" is the difference in elevation between upstream level (reservoir or tank) and the downstream level (usually turbine) in a hydropower scheme. It is possible to express head in either units of height (e.g. meters) or in units of pressure such as Pascals (the SI unit).

[17] Determined in the ECOWAS Workshop on Small Scale Hydropower, 16 to 20 April 2012, Monrovia, Liberia

Table 22 Strengths and weaknesses of Small-scale hydro power systems

Strengths	Weaknesses
Technology is relatively simple and robust with lifetimes of over 30 years without major investment	Very site-specific technology (requires a suitable site relatively close to the location where the new power is needed)
Overall costs can, in many cases, undercut all other alternatives	For SSHP systems using small streams the maximum power is limited and cannot expand if the need grows
Automatic operation with low maintenance requirements	Droughts and changes in local water and land use can affect power output
No fuel required (no additional costs for fuel nor delivery logistics)	Although power output is generally more predictable it may fall to very low levels or even zero during the dry season
Environmental impact low compared with conventional energy sources (incl. large hydro)	High capital/initial investment costs
Power is available at a fairly constant rate and at all times, subject to water resource availability	Engineering skills required may be unavailable/ expensive to obtain locally
The technology can be adapted for manufacture/use in developing countries	

Large hydro

Large Hydro is characterized by the possibility of energy storage in a reservoir which permit to manage the production in the best economic interests, to store energy during off-peak hours and to release it during peak hours (these property is particularly interesting in complement of other sources of energy like nuclear power or wind and solar energy,…). However, large hydro besides the huge upfront construction costs has major environmental impacts and complex licensing procedures.

Table 23 Strengths and weaknesses of large hydropower systems

Strengths	Weaknesses
Long life span of 50 to 100 years or more	Only grid connected and no suitable for decentralized production
Operation and maintenance costs of hydropower plants are very low	Very high upfront investment and long term planning.
Hydro power projects have the highest energy payback ratio[18] among other electricity generation options.	High environmental and in same case social impacts

Production costs for hydro power

According to the European Small-scale hydro power Association (ESHA), the average production cost in the EU-15 range from 4.5 to 13.5 c€/kWh[19]. Large hydro's production costs are around 1.5 to 3.7

[18] Energy payback ratio is the ratio of energy produced during the normal life span of a power plant divided by the energy required to build, maintain and operate it

c€/kWh. An analysis of the 81 hydropower plants included in the WAPP portfolio of potential candidates gives a rather good knowledge of the hydro resources in West Africa.

Table 24 Unit capital cost and capacity factor of the hydro resources in WA

	Investment Costs M€/MW	Investment Costs M€/MW	Capacity factor	Capacity factor
	0-30 MW	> 30 MW	0-30 MW	> 30 MW
Min	1.699	700	29%	28%
Max	7.500	7.101	91%	85%
Average	4.278	2.072	55%	51%
Median	3.683	1.904	53%	49%

On average, the unit cost for large hydro is about 2 M€/MW and the capacity factor is 50%. With an O&M cost estimated at 1.5 €/MWh produced, the commercial cost for large hydro power production is calculated at **4.39 c€/kWh.** For the SSHP, an average unit cost of 3.9 M€/MW and a capacity factor of 54%, lead to a commercial production cost of **7.81 c€/kWh**[20], which is quite satisfactory compared with many other supply alternatives. For the countries endowed with a sufficient hydro resource, the simulation indicates that developing small-hydropower for grid supply and rural off-grid electrification, could be rentable on short and medium terms without having significant impact on the future tariffs as their cost is close to the WAPP marginal supply costs. Since the initial concentration will be on hydro sites which are most suitable, the costs will be lower than average and capacity utilisation higher, thus, making the unit power production cost even lesser and much more competitive. Therefore, development of hydro resources, both large and small, deserves to get the highest priority. However, since small hydro may not produce power for known months of the year, alternative sources of power generation or supply in the concerned areas would also have to be simultaneously considered.

[19] Renewable Energy Technologies REEEP Toolkit, Module 7

[20] The baseline price level is coherent with the ESMAP study. ESMAP proposes a production cost at 7.77 cUS$/kWh (6 c€/kWh) with a higher capacity factor of 65% and a lower unit investment cost of MUS$ 3.0 (M€ 2.3); the costs are also coherent with similar SSHP project experiences in Indonesia where the average generation costs lie at 7,77 cUS$/kWh (source: entec Swizerland).

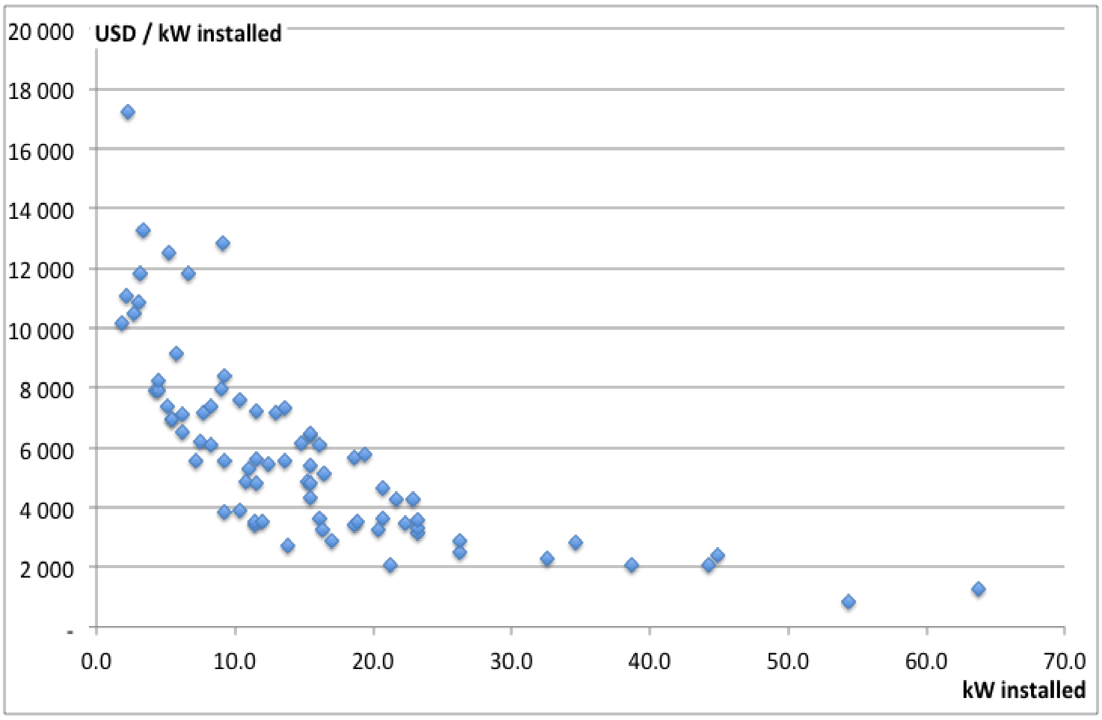


Figure 44: Range of investment costs for SSHP projects (defined with 10 MW) in Indonesia[21]

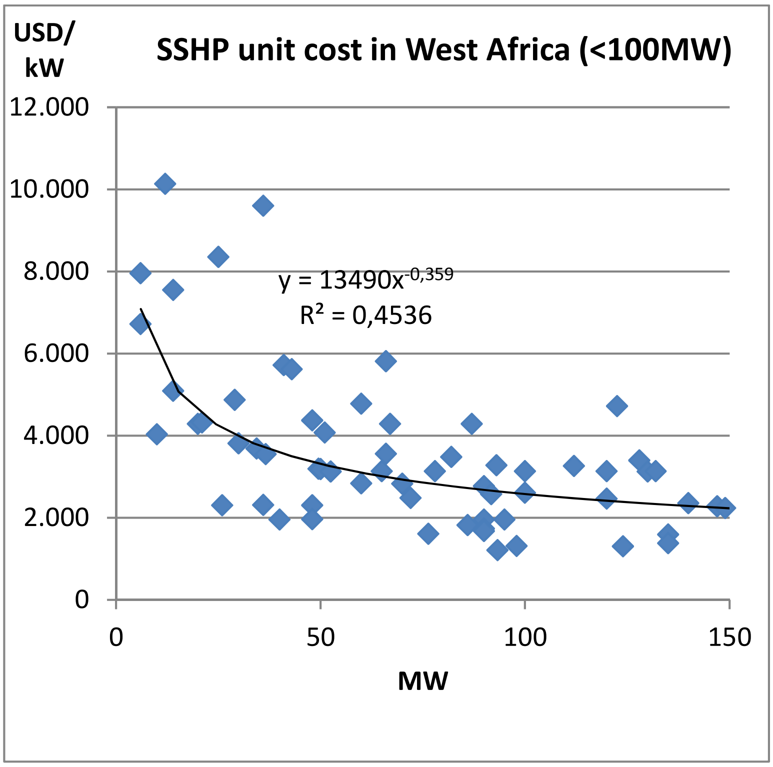


Figure 45: Unit-costs for hydropower in West Africa[22]

[21] Data of Entec Swizerland presented at the ECOWAS SSHP Workshop in Monrovia, 16 to 20 April 2012
[22] WAPP master plan volume 1

8.2 Off-grid technologies

The reference price for RE off-grid technologies is the stand alone diesel generation with a price level of 25 c€/kWh with optimal operating conditions for an oil price on the world market at 70 €/bl (as illustrated in figure 8 below).

The reference marginal costs for the regional power supply will range from 45 to 75 €/MWh (give in kWh) from 2018 with an increasing trend (45 (2018)→ 75(2025)).

In order to provide energy to rural areas, countries have to develop distribution grids at a voltage of 33 kV.

This involves three types of costs:

- Capital costs for investments in the lines (15.3 k€/km)
- Operation and maintenance costs estimated to be 0.5% of the initial cost per year
- And the losses estimated to be 4% of the energy transported.

To illustrate the cost of energy distribution to rural areas, a simulation has been carried out for a 100 km 33kV line (with 75.5 and 54.6 mm^2 section). The maximum capacity of such a line is 6.6 MW and it will supply 26,400 rural households with an average consumption of 500 kWh/year.

If the line supplies a rural area with a high population density (175 inhabitants/km^2) living in villages alongside the 100 km line, **the distribution cost is calculated at 20.0 €/MWh** for commercial financing environment, and provided that the line is fully loaded after 10 years (40% load at year 1, 80% load at year 10, 100% load at year 30).

If the same line supplies a less populated area (70 inhabitants/km^2), the distribution costs for the same financial conditions increases to 45.2 €/MWh. The outputs of the simulation are summarized in the figure below.

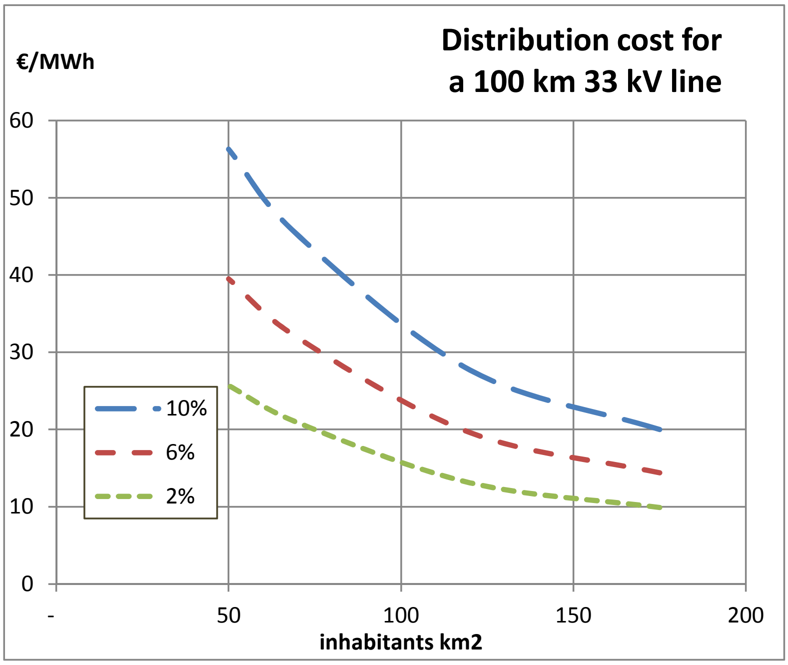


Figure 46: Simulated distribution costs for a 100 km 33 kV line for different population density and financing options

The lowest costs for the high population density relate to an optimal loading of the line. According to different financial market conditions (2% as ODA and 10% as commercial conditions in WA), the distribution costs will range from 10 to 20 €/MWh. In less populated rural areas it will vary from 26 to 56 €/MWh representing at least 2/3 rds of the future marginal costs for the regional supply.

Generally, these costs are not added to the tariff of the population served by the line, but are equally distributed among all consumers thereby becoming hidden costs for the marginal supply, shadowing the potential uses of alternative least cost RE technologies.

8.2.1 Bio-fuel

ECREEE in cooperation with UNIDO and Quinvita has recently launched a regional potential assessment on the sustainable use of biofuel-crops. The assessment will provide more information on the economics of the following fuel-crops: Jatropha, Camelina, Sweet Sorghum, Cassava and Crambe, Castor, Ground Nut and Cashew.

Diesel generator sets with bi-carburation devices enable the use of vegetal oil as jatropha raw filtered oil. In some case, the piston can be modified to ensure a better combustion of jatropha oil. The technology is the same as the diesel gensets. The extra costs are tied to the fact that an additional oil tank is necessary for the jatropha oil as the motor has to be started and stopped on diesel oil. The cost for jatropha raw oil (76 c€/l) is at present higher than the economic cost of diesel oil (57 to 69 c€/l depending on the countries). Biofuel production doesn't presently constitute a real alternative to diesel generation as the raw jatropha oil remains more expensive than the economic cost of the diesel oil. Local production of biofuel could be an alternative when supply cost and availability of the diesel oil in remote rural areas make the biofuel more competitive. However, the quality of the local oil production will remain an issue to be solved to secure the motors.

8.2.2 Biomass (gasification)

Shredded solid or loose biomass like shells and husks can be used in gasifiers to produce CO gas to supply gas motors or dual fuel motors. The size of this technology ranges from scale (30-200 kWe) well developed and used in the South-Eastern Asia and India where the technology is fully developed. Larger applications are being developed with capacity up to 1 to 1.5 MW (South Africa). For smaller technologies, the price of the system including gas cleaning and motor ranges from 1.1 to 1.3 M€/MW and can produce at a price of 15/21 c€/kWh.

8.2.3 Solar PV plants

Generally, the price of PV in this region is still over the world market price as the market is not fully developed. It is expected that the price will drop down when the PV will be no longer perceived as an expensive technology. For smaller Solar PV plants including a three phase inverter and battery storage capacity for night consumption, the investment cost remains high at about 8 to 10 €/ Wp installed. Hybrid systems can reduce the cost of investment as the combination of solar PV production and diesel generation enables the down-sizing of the storage capacity. The cost of hybrid solar system with storage is about 6-7 M€/MWp (Mali) for the solar plant.

Hybrid systems without storage are also experimented at lower costs (4 M€/MWp) if the solar production is designed to cut the diesel production when the system is fully loaded. From full load to 60% load, the diesel oil consumption is more or less proportional to the load, and the solar power injection is totally turned into diesel oil saving. At low load (< 30%), the diesel motor is inefficient and has the same consumption independent of the load and the solar injection becomes useless. In such cases, solar power should entirely replace the generator which should be shut down for certain hours during the daytime, because diesel consumption and costs are high.

The figure below illustrates the savings realized by installing a PV production on a fully-loaded stand-alone diesel production for increasing the installed capacity. The fuel consumption is calculated with an economic fuel cost at 0.611 €/l for diesel oil in remote areas corresponding at the time of the simulation to a barrel price of 70 €. The benefit, illustrated by the figure, will grow overtime with the price reduction of the PV and the incremental increasing price for fuels.

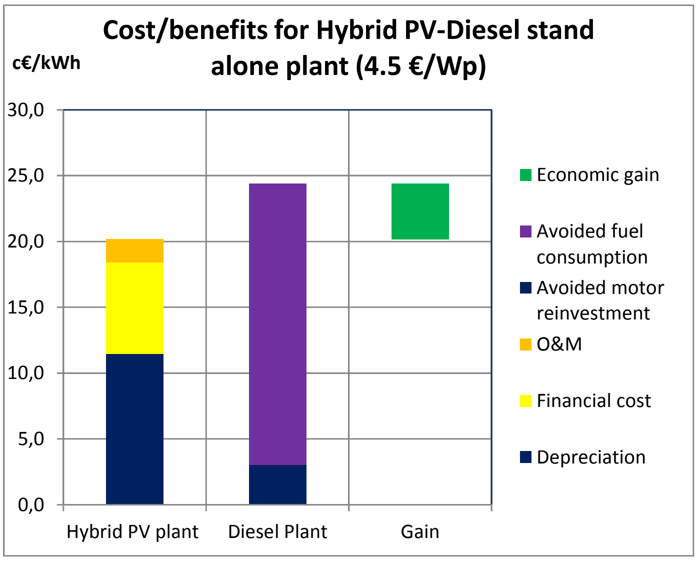


Figure 47: Costs for hybrid PV system without battery storage[23]

8.3 Stand-alone technologies:

- Small wind turbine for battery charging in a range of 10-20 W to few kW.
- PV panels with battery and charge controller in a range of few W to charge solar lamps to few kW for institutions. Generally, in the range between 30 and 100 W for households application. The present cost is about 6-8 €/Wc. Systems are becoming more cost effective with use of LED lamps reducing the size of the solar panel.
- Solar water heaters producing hot domestic water are alternative to electrical water heater (1 to 2 kW electrical thermal patrons). Generally, the cost remains high with regards to the electrical alternative (for 400 to 1000 € versus 150-200 € for the electrical heater). The savings can be in the range of 60 to 115 €/year depending on the size of the heater and the level of tariff. The period of return is comprised between 6 to 8 years[24]. Application for preheating process water up to 60-70 ^{o}C can also be considered.
- Solar dryers to be used in agro-processes (fruits, meat, steamed products). Various and extensive research work has been carried out in many West-African research centres (Niger, Ghana, Bamako) but generally the cost remains too high, and drying processes are not always totally controlled by the users (air flow, temperature and moisture).
- Household biogas production for cooking and lighting and cooling energy. The digester is an underground tank built with bricks that needs to be airtight as the methane production occurs anaerobic. It has an inlet and outlet shaft for the fresh and the out-gassed slurry. The gas needs to be purified before uses. The cost of a household biogas digester is about 85 €/m3 of tank, and the general size is between 3 to 6 m3. A well-functioning biogas plant needs to be regularly fed with slurry of animal manure mixed with water.
- Solar cookers for households. There are two different types of solar cookers, the first one is a solar oven (isolated plywood box covered with glass and with an adjustable mirror enabling some additional indirect exposition). Its price is around 30-45 € depending on the size. Food

[23] The consultant's own assumptions
[24] With an annual el consumptions of 300/600 kWh/year for a 20/30 l electrical water heater and an average tariff at 0.2 c€/kWh the yearly expense will be 60/120 €. Depending of the price of the solar water heater (400 to 1000 €) the period of return is about 6 to 8 years.

preparation can be started on traditional stoves. The second type is the parabolic concentrating one where the solar irradiation is concentrated on the cooking pots placed in the focal point. The price of this type of cooker is high: about 110-135 €. Larger models can be developed for community kitchens (schools, barracks, and hospitals) as combined wood and solar stoves.

9 Woodfuel and domestic energy supply

Summary:

- *The forest and other wooded land areas of the ECOWAS region have reduced by 14.8% during the period 1990-2005 (FAO 2005) and this trend continues even though it has slowed.*
- *Only four countries have succeeded in maintaining or increasing their forest areas: Cape Verde, Cote d'Ivoire, Burkina Faso and Gambia.*
- *However, the most exposed country in terms of deforestation is Nigeria, which has lost 62% of its forest areas since 1990, due to the pressure of the 7th world largest population on its forestry resources.*
- *In terms of balance, the overall actual regional woodfuel resources is not sufficient to cover the rural and urban demand for a business as usual scenario.*

9.1 Resources

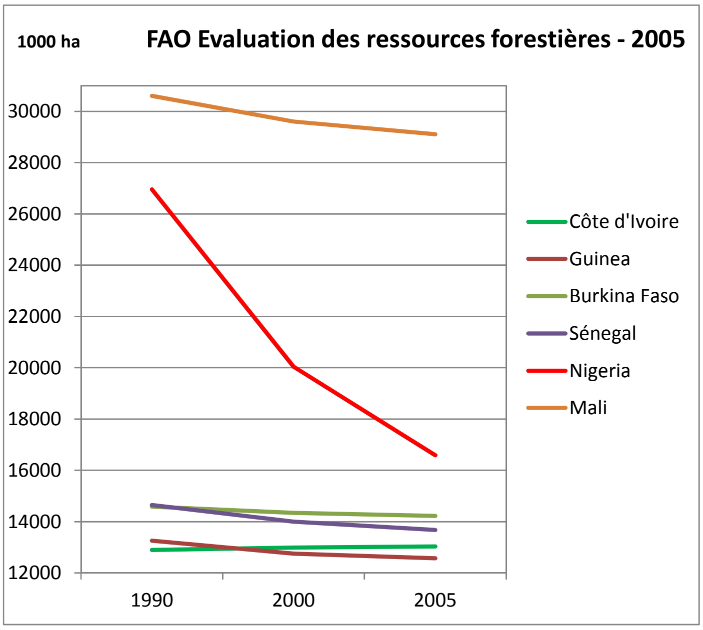
The assessment of woody biomass resources is based on FAO Global Forest Resources Assessment done by FAO in 2005 (FAO – 2005). The forest area in the ECOWAS region has been continuously reducing since 1990, from 133 million hectares to an estimated 116 million hectares in 2005, a 14% reduction over 15 years or average of 0.9% per year.

These wooded lands cover both forests and savannah woodland following the FAO categories.

Under sustainable management, the sustainable logging per hectare varies depending on climate zone. In the Sahelean region, it is about 0.3 t / ha of forest; in Sudan it may be estimated to be 1.1 tonnes / ha, and in equatorial zone it can exceed 1.8 t / ha.

Since four ECOWAS countries (Mali, Burkina Faso, Niger, and Senegal) are mainly located in the Sahelean and Sudano-Sahelean zone, an average conservative assumption regarding sustainable logging quantities per hectare of forest for all ECOWAS is set at 0.8 tonnes per hectare.

Based on this estimated sustainable logging ratio per ha, the potential volume of sustainable fuel wood for 2005 can be roughly estimated at 93 million tonnes. Given the continuing decline in forest areas, the potential sustainable supply is estimated to be 89 million tonnes in 2010.



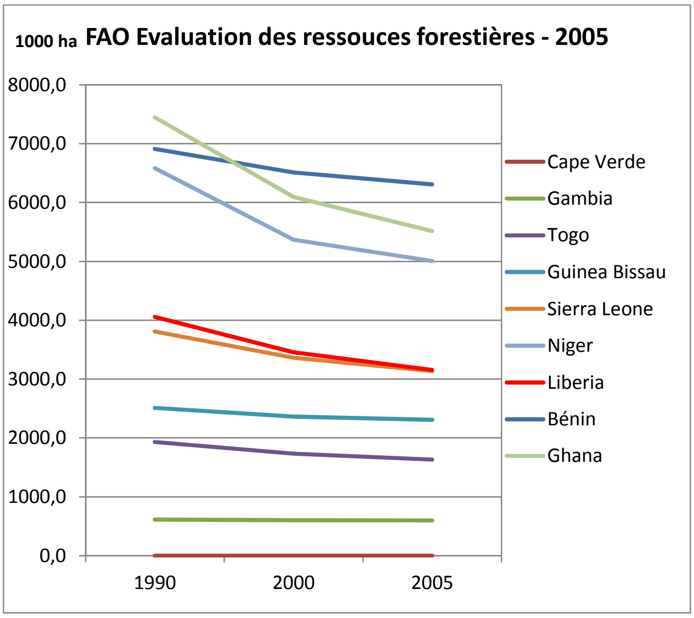


Figure 48 : FAO Global Forest Resources Assessment 2005

Four countries maintain or increase their forested areas: Cape Verde, Cote d'Ivoire, Burkina Faso and the Gambia. For most of the other ECOWAS countries, these surfaces are strongly declining, particularly for Nigeria which has lost 62% of its forest area since the 90s.

As part of the evaluation of the CILSS fuel wood program (PREDAS), funded by the European Union, a number of conclusions have been drawn for six CILSS countries which are part of ECOWAS, namely Senegal, Mali, Burkina Faso, Niger, Cape Verde, and Guinea Bissau. As a general statement, forestry potential remains adequate to meet the fuel wood demand of these countries, although tendencies towards over-exploitation emerge, especially for countries such as Mali, Niger and, to a lesser extent, Burkina Faso. The analysis shows that, even if these countries are mainly Sahelean, it would be possible to restore the balance between supply and demand through a proactive policy of sustainable natural resources management involving the participation of the local population and by developing and implementing a policy for efficient use of resources through the promotion of improved stoves. This should be done through public-private partnerships and through a moderate support to a fuel substitution policy from fuel wood to LPG.

The CILSS countries

According to an annex to the PREDAS evaluation report done for the EU in 2010, the overall woodfuel situation for the 6 CILSS member countries and also members of the ECOWAS was the following.

Cape Verde with 0.5 million inhabitants is a highly urbanized society (60% in 2010) and an atypical country regarding woodfuel situation. Having no forest resources left in 1975, Cape Verde has now at its disposal a resource producing about 90,000 tonnes of wood needed for rural households consumption. The Cape Verdean economy has ensured that 80% of urban households use gas. The charcoal is hardly used.

Three CILSS countries should have sufficient resources for their present and future demand provided that efforts are made to expand the use of efficient stoves:

Guinea-Bissau (1.6 million) has a high productivity forest (1.9 million ha). The domestic energy supply is mainly covered by wood (910.000 tonnes) and charcoal (44.000 t). The gas is about 1000 t. The often illegal production and export of charcoal to neighbouring countries is not controlled by the authorities, which may eventually constitute a threat to its resources. Promotion of LPG combined with dissemination of efficient stoves should limit the magnitude of sustainably managed forest areas to 1.2 million ha in the future.

Senegal (11.5 million) has significant wood resources in the south and east of the country and is presently implementing a participatory management system of these resources that should ensure their sustainability. In addition, Senegal has made a special effort to introduce gas in Dakar with the result that over 80% of the population of Dakar uses butane gas. Senegal has the highest gas consumption of the nine CILSS countries with 110,000 t per year. However, it seems that gas sales of 2011 (?) reflect the upper limit of the consumers' purchasing power since subsidies were reduced. The present demand is estimated to be 1 million tonnes of fuel wood, 370,000 tonnes of charcoal and 100,000 to 120,000 tonnes of LPG.

The Gambia (1.8 million) has natural resources that are theoretically in line with demand, both urban and rural. Because of its proximity to the wood fuel resources of Casamance and the ban on charcoal production, the Greater Banjul sources its wood fuel energy from Casamance. The use of butane gas is not highly developed.

For the three most densely populated Sahelian countries that are Burkina Faso, Mali and Niger, the wood resources are becoming scarce because of the growing demand.

Burkina Faso (15.8 million inhabitants) has an overall consumption of wood energy that is at the margin of its theoretical resources potential. In 2008 the consumption was estimated to be 4.8 million tonnes of fire wood (850,000 t in the urban areas) and 180,000 tonnes of charcoal (mostly in the urban areas). However, significant efforts are being made for forestry management systems that are organized and administered by local people to extend the sustainable production of wood energy to urban markets (currently 30%). 20% of urban populations are now using gas with a total consumption of 20,000 t. A massive use of efficient cook stoves and a continued growth in LPG uses could create the balance between sustainable production and demand. Effort to extend the sustainable managed forest areas from 800.000 ha to 1,8 million ha is also required.

Mali (13.4 million) should be in a position similar to Burkina Faso. However, based on the information given in a series of woodfuel master plans of Bamako, Koutiala, Niona and Koro, it seems that the situation has deteriorated dramatically over the past 15 years, and that the resource is now showing an important shortfall because of the increased demand. Although the use of improved stoves is relatively developed in Mali, this has to be intensified.

The Niger (14.3 million) is the poorest sahelian country in terms of wood resources among CILSS/ECOWAS countries. Theoretically, the wood resources identified today correspond to 50% of demand. There are few statistics on the wood fuel supply to the rural populations, but the demand is being increasingly covered by the development of growing trees in the fields. In that case the forest resources are theoretically always sufficient to supply the urban markets with firewood (management by rural markets). Charcoal is practically not produced. Gas broke through with 1000 t in 2010 in order to reduce the use of wood. The new refinery should produce about 25.000 to 30.000 t LPG for essentially the domestic market. Keeping in mind that a kg LPG can replace from 4 to 12 kg firewood, depending on the efficiency of the cook stoves used, and their extended use, the LPG production will significantly ease the pressure on the wood lands supplying Niamey. Niger has also large deposits of mineral coal that once carbonised into coke could be used to substitute firewood.

For the other countries

For the other ECOWAS countries that are not CILSS, Cote d'Ivoire seems to be the only one that is developing its forest areas. Efforts for sustainable wood and charcoal production are also being made. Countries like Benin, Togo, Liberia, and Sierra Leone should not have major problems with their wood-fuel supply but efforts to disseminate efficient cook stoves will always be relevant, both for lessening the use of fuel wood and for health reasons.

In **Cote d'Ivoire**, there are 13 million ha covered by the forests and wooded lands, representing 41% of the territory. According to FAO statistics, forest coverage has increased slightly since 1990 (12,89 million ha in 1990). The contribution of wood-fuel was estimated to be 75% of the total primary 2007 energy balance which means 7500 ktoe or roughly 20 million tonnes wood fuel. The average wood production, if equally distributed on the forest areas, would be 1,5 tonnes/ha. This figure is high, though still within the range where it is possible to improve the sustainable management of the resources.

Nigeria, due to its high population density, has overexploited its natural forest resources. The total forest and wooded land areas has regressed – by a huge 38% during the period 1990-2005 from 26.9 million ha to 16.6 million ha (FAO stat 2005). Following our enquiry, the forest and wooded savannah land is shrunken today to 11.6% of Nigeria's total area which means 10.77 million ha, for a total consumption of 43.5 million tonnes of wood fuel. The average production, if it was equally distributed on all forest areas, would be 4 tonnes/ha. This figure indicates a serious over exploitation of the remaining resources. The overall biomass resources are estimated to be about 144 million tonnes.
Use of LPG as alternative to fuel wood is not very developed. On the other hand, kerosene is the preferred substitute to fuel wood, with a total consumption of 666 ktoe in 2010.

9.2 Demand forecast for the baseline

The present demand for the all ECOWAS region has been simulated as no reliable data exists on domestic energy consumption.

Based on average unit consumption for food cooking per capita and per day of 0.6 GJ, the baseline for domestic energy consumption has been estimated as shown in the following table:

Table 25: Rough assessment of the domestic energy demand for the baseline scenario.

ECOWAS POPULATION	2010	2020	2030
Population	300.7	421	600
Cooking energy needs 10^6 GJ	180.4	252.6	360.0
-urban	80.2	126.3	198.0
-rural	100.2	126.3	162.0
Modern fuel			
LPG 10^6 tons	0.3	0.5	0.7
Kerosene 10^6 tons	0.7	1.0	1.6
Woodfuel in million tons			
-fire wood 10^6 tons	61.6	73.2	76.4
-charcoal 10^6 tons	5.9	11.5	25.0
Woodfuel 10^6 tons	103.4	155.6	254.8

As the overall sustainable fuel wood production in the region has been assessed at 92.8 million tonnes in 2010, the ECOWAS forests and other woodlands are already overexploited and this problem will become very severe over time. Sustainable forest management and widespread use of efficient wood stoves and more efficient charcoal production is therefore of the highest priority.

10 Rationale and Focus of the ECOWAS Renewable Energy Policy

Summary:

Rationale:

Substantial renewable energy sources are available and some of the technology options are already or will be competitive in the near future in comparison to conventional options under specific conditions. In this context, the ECOWAS Renewable Energy Policy (EREP) aims at taking advantage of least-cost renewable energy options for bulk energy production and to boost off-grid rural electrification and access to other energy services.

Objectives:

At regional level, the main objectives of the EREP are:

- *To create a competitive market for renewable energy technologies and services to reduce the need for environmental adverse energy sources like coal and uranium.*
- *To install additional large-scale RE capacity to bridge shortfalls and delays in the establishment of the regional power market.*

At national level, the objectives for the EREP are as follows:

- *to assist and secure the mobilization of medium sized RE least cost options reducing durably the use of fossil fuel in power generation or/and enabling an increase of the overall power capacity alleviating the possible up-coming supply shortages due to delays of the WAPP Master Plan.*
- *To promote a conducive regulatory and financial framework enabling the private sector to invest in the RE sector.*

At off-grid level, the objective is to create the conditions for a market of robust decentralized solutions that are affordable for the local rural population with a low purchase power.

At household level, the objectives are to support sustainable management of forests and savannah woodlands, promote an efficient use of domestic energy (fuel wood as well as gas) through the regional policy for energy efficiency. It is also to promote solar applications such as solar driers and solar water heaters through information and sensitization activities. And finally, to promote the emergence of a market for solar lamps to create opportunities for regional mass production.

10.1 Rationale of the EREP

The rationale of the policy is to bring a fast and sustainable answer in terms of supply to a region facing an energy supply crisis since 2000, characterized by:

- A large volume of suppressed demand (7 to 10 TWh from 2006 to 2010)

- A general poor access to electricity (40% in average, but for many countries lesser than 20%), a deficit that is even more pronounced for rural areas
- A sustainable fuel wood supply that no longer meets the growing demand leading to a general overexploitation of woody resources and, in some countries, to deforestation.

As the region is endowed with large potentials of renewable energy resources, and as renewable energy technologies are approaching grid parity in certain circumstances, the ECOWAS region stands today at the threshold of a new regional power supply paradigm based on large bulk power generation provided and distributed by the WAPP and a substantial contribution provided by renewable energy options financed by the private sector and private banking institutions. Furthermore, some Member States have already developed effective renewable energy policies and strategies, and the EREP wishes to take advantages of these front liners.

Therefore, the definition of objectives and targets for the EREP will take into account the efforts already deployed by the WAPP through the establishment of a regional power market and by the PREDAS project for woodfuel in the CILSS countries, in particular:

- For electric power: the goal is to cover in short/medium term current national power supply deficits with renewable energy options and to promote access in rural areas, offsetting expensive diesel based power generation. In the medium and long-term view the goal is to develop a renewable energy power generation market based on an ECOWAS technology industry, which is able to compete commercially with large conventional power generation options.
- For wood energy: the focus will be on the technological aspects having significant positive impacts on the woodlands (improved stoves, carbonization) and on communication aspects
- For biofuels: the policy wishes to capitalize on the achievements of some countries (Mali, Ghana, Burkina Faso, and Senegal).

The development of renewable energy markets for the ECOWAS will (...):

- Be complementary to the WAPP regional power sector projects and will contribute to alleviate the negative effect of delays in implementation by proposing alternatives that can be implemented faster and contribute positively to the regional power mix.
- Include a whole range for small and medium sized renewable energy technologies (electricity and heat) which were not deemed relevant for regional power integration but which are particularly interesting for rural and peri-urban areas.
- Consider options for isolated and scattered population which needs are not covered by any form of grid-based or mini-grids options.
- Provide some reflections and recommendations on the domestic energy sector for which wood-fuel must become a renewable energy source in the future not only for domestic uses but also for modern energy applications.

10.2 Main objectives of the EREP

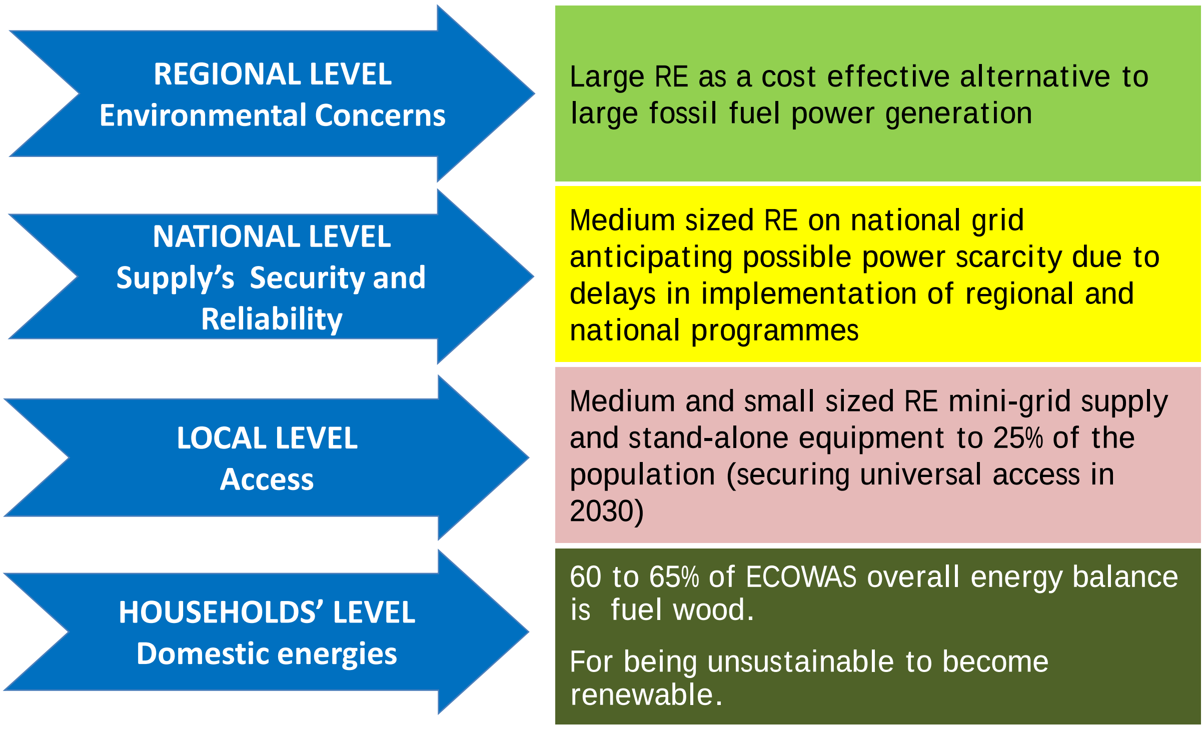


Figure 49: Four major focuses for the RREP

10.2.1 At the regional level:

One of the identified barriers is the fact that there is presently no substantial market for renewable energy technologies and services in the ECOWAS region. There is almost no enterprise which is producing solar water heaters, solar dryers, PV lamps or hydro turbines. A single PV panel assembly factory was recently established in Senegal and Ghana. In order to make the RE technologies more reliable and cheaper in use, it is necessary to promote the development of a local RE industry.

The large-scale power supply pattern will be based on an energy mix comprising roughly 60% of thermal power generation (50% large CC plants using natural gas and 10% coal fired power generation in Senegal and Niger), 30% large hydro power generation, and 10% 'other RE' as Wind and Solar farms and Biomass plants . Solar and Wind capacity will benefit from the large thermal and hydro installed capacity to balance in real time the variability of their production. Wind energy as an erratic source will only contribute to energy production on the regional grid and mostly on the national grid.

In terms of numbers, the WAPP master plan includes 800 MW of new renewable energy capacity (wind and solar), contributing to 3.4 % of the installed capacity in 2020 and only 2% in 2030. The IRED has not yet developed specific targets showing clearly how to reach the target of 78% RE penetration by 2030. There are some concerns or issues:

- The first critical concern relates to the approved 1075 MW coal based power capacity in Senegal and Niger (WAPP MS) which raises questions regarding sustainability. Most of the capacity (875 MW) is planned to be developed in Senegal (Sendou plant) by 2016, and 200 MW later on with the Salkadamma plant in Niger (2019/2020). A similar concern shall address the assumption proposed by IRED to include in the UEMOA power production basket, a 900 MW nuclear power plant. **Energy efficiency and medium sized renewable**

energy (mainly biomass, solar energy and SSHP) are competitive alternatives to coal nuclear energy.

- The second critical issue relates to setting up large hydro capacities which may, to some extent, constitute conceptual restrictions for planning projects of renewable energy technologies. The generation costs for large hydro will always be lower than most of the commercially viable RE technologies. However, the comparison is often biased by the fact that most medium sized RETs can be financed and implemented quite faster than larger hydro dams and with less environmental impacts. In that case, the availability of power 'here and now' can be a cheaper least cost solution than awaiting many years for a premium supply and applying during the waiting time expensive solutions like diesel generation. Clearly the policy should aim at simultaneous development of both resources.

- Developing medium to large sized RE options will also have positive impact on the energy balance by reducing the uses of fossil fuel such as coal but also natural gas that can be kept for the future generation as energy source as well as raw material.

At regional level the main objectives of the ECOWAS RE policy will be:

- *To develop a viable renewable energy market for RE technologies and services.*
- *To mobilize additional medium and large sized renewable energy options that could in the medium and long term reduce the need of environmental adverse energy sources like coal and uranium. These options could bring rapid supply solutions for countries which have a shortfall of capacities while waiting for the establishment of the regional power market of the WAPP.*

10.2.2 At the national level:

A large share of the urban and rural population of the ECOWAS region (64.3% in 2020 and 75% in 2030) will receive its electricity from the grid, provided that there is sufficient capacity. Most of the currently planned capacity increase is part of the WAPP project pipeline. However, it is not sure that the ambitious WAPP Master Plan will be executed without major delays.

Regarding the power sector, the policy will contribute to making the members states national electricity supply more reliable and secure by supporting/facilitating the development of least cost medium sized RE power generation.

As for the domestic energy sector, it should work towards a better monitoring of production, use and substitution of wood-fuel; this in collaboration with the CILSSS (Predas programme).

In terms of options:

- Securing a better and valuable knowledge on national RE sources and potentials in order to convince the potential investors and/or financial institutions on the viability of medium sized RE power generation projects.
- RE based power generation connected to the HV/MW national grid in particular for countries having a deficit of installed capacity in order to enhance national supply security. The possible options are PV farms, wind farms, SSHP plants, biomass plants based on agro-industries' wastes, filtered vegetal oil as jatropha oil to substitute heavy fuel in the diesel power generation.
- DSM measures as PV roof top to shave air-cond's peak demand (9:00 am to 4:00 pm)
- Solar water heaters to save energy and power demand in the morning (5-7) and in the evening (18-20)
- Cogeneration on industrial Biomass waste for heat and power production (solid waste, manure and dung and slaughterhouses wastes for biogas plants) with sale of excess production to the grid

- Solar heaters as pre-heater for industrial process.

The main objective will be to mobilize a long range of least cost energy options from kW to MW sizes enabling a flexible and sustainable transition from the present national supply strategy to a more integrated regional strategy avoiding short falls and expensive investments in emergency diesel power generation.

At national level, the objectives of the ECOWAS RE policy can be formulated as follows:

- *to assist and secure the mobilization of medium sized RE least cost options reducing durably the use of fossil fuel in power generation or/and enabling on the 'fast track' an increase of the overall power capacity alleviating the possible up-coming supply shortages due to the delays in the major regional strategies.*
- *To promote a conducive regulatory and financial framework enabling the private sector to invest in the energy sector.*

10.2.3 At the local (off-grid) level

Even though grid-based electrification remains an adequate supply option for the ECOWAS region, this option will not be able to fulfil the ultimate goal for universal energy access in 2030. The scenario shows that 25 % of the population will still not be supplied by the grid in 2030 within a reasonable period of time.

Therefore, specific strategy and goals for mini-grids systems have to be set to secure access to 17% of the ECOWAS mainly rural population by 2020 and additional 8% during the period 2020-2030. In terms of localities, the strategy will bring out of the dark 28% of the ECOWAS localities by 2020 and additional 32% by 2030. These strategies should be articulated with incentive measures promoting the emergence of local or national energy entrepreneurs.

Furthermore, specific goals and measures have to be set to promote the dissemination of stand-alone equipment to supply a remaining 6 to 7% fringe of the population living in very small settlements (lesser than 200 inhabitants). Credit facilities or promotion of RE service companies will be the possible paths to follow, in order to sustain the goal of universal access by 2030.

The ECOWAS vision for the rural areas is to accelerate the implementation of the regional white paper for modern energy access for rural population through an active promotion of local and/or decentralized least-cost RE supply system.

Access to modern energy in the rural off-grid area could build on the following options:

- PV, SSHP and wind mill for battery charging in the very scattered dwelling patterns
- PV as solar power plant or hybrid system and mini or local grid
- SSHP plants supplying a local or local grids
- Community Biogas Plants and gas motor and a local/mini grid
- Gasifier and power generation on a gas motor at village or local grid level
- Filtered raw Jatropha oil for power generation on a diesel motor (local and mini-grid).

At local (off-grid) level, the objectives should be to create the conditions for a real market for robust decentralised solutions that are affordable for the local rural population with a low purchase power.

- ***Shift in planning paradigms for rural off-grid areas from being the residual part of a well-conceived national electrification plan to be an integrated and fully developed and evolving plan*** giving for each localities supply options in terms of technologies and over a period of time (e.g. Mini-grid to socio-economic structures with PV→ integration into a local grid powered by a small hydro plant, existing PV connected to the local grid→ connection to the national grid, both PV and small hydro remain connected to the grid.
- ***Seeking acceptance from the national authorities to make a clear demarcation between grid and off-grid supply over a period of time.*** Today in most countries, this demarcation does not exist with the result that local least solutions are denied by the local politicians or the local population and are replaced by expensive grid-based solutions which aim at providing the 'real' electricity, but actually are unable to do so.
- ***Support in development and standardisation of delivery systems either as centralised system with RE service companies*** installing and monitoring/maintaining the equipment against a fee paid by the user ***or as decentralised delivery system based on equipment purchase, and a credit/subsidy/guaranty/financial risk monitoring system*** involving a national authority, private dealers/handy crafts and the banking system. In that case, the user is becoming owner of the system and a special attention has to be paid to the maintenance of the system during the repayment period.
- **Support to capacity development** for system designer (some of the few hybrid systems are not fully operational, often due to design inadequacy), crafts for installation and maintenance.

10.2.4 At the household level

The household sphere is by three major topics related to renewable energy:

- The omnipresent use of fuel wood for cooking activities and for water heating
- The use of different forms of energy (often fuel wood but also gas) for some productive activities carried out within the households
- The use of electricity for lighting and leisure (radio, TV) and ventilation

More than 65% of the overall energy balance in the ECOWAS region is based on fuel wood. Demographic growth and urbanisation will increase the share of the monetised woodfuel market which will in its wake accentuate pressure on the forestry and savannah woody resources and an increasing trend to unsustainable logging.

Water heating is a vital input for child care and a comfort element for the citizen. But the share of solar water heating is practically non-existent in the ECOWAS region except in Cape Verde.

Solar drying to process fruits, pre-cooked cereals etc. could be a valuable alternative to fossil fuel or electrical appliances. R&D activities have been developed in many countries (Mali, Niger, and Ghana) but the commercial market is nearly non-existent for this type of equipment.

At household level, the objectives should be to support at the regional level all relevant activities that will be promoted at the national level:

- ***the development of sustainable forestry, as well as***
- ***the sustainable use of domestic fuel for cooking*** through awareness campaigns showing the vital challenge of considering the fuel wood, not anymore, an energy for the poor but to develop the idea that biomass incl. the woody resources can also become the energy of the future.

Efforts towards the extension of activities regarding the use of solar heater for domestic and professional uses and solar dryers should be included in the regional policy for energy efficiency. Finally, supporting the emergence of local production and market development for local lighting appliances powered by small PV panels that will provide a minimum of modern comfort for many rural households must be considered.

11 Renewable energy market segments in ECOWAS

Summary

Modelling the regional electricity market

An analysis of the physical distribution of the overall population by dwelling sizes together with the modelling of the statistical link between dispersion rate (ratio related to dwellings) and access rate (ratio related to population) has allowed the development of a model enabling the quantification of electricity off-grid markets for mini-grids and stand-alone systems and also to check the validity of the WAPP forecast for grid-based supply up to 2030.

➢ *Grid-based supply*

According to the present trends/targets for grid-based electrification, the simulation leads to:

- *A doubling (factor 2) of the grid-supplied population in 2020 (access rate 64%; dispersion rate 24%);*
- *A tripling (factor 3.3) of the same segment of population supplied in 2030 (access rate 74.8%; dispersion rate 42%).*

These forecasts are perfectly in line with the WAPP electric capacity forecast, foreseeing the needs to increase the installed capacity (MW) and the supply (GWh) with a factor 2.3 by 2020 and 3.7 in 2030 compared to the reference 2010.

➢ *RE market segments for RE powered mini-grids*

The market for mini-grid systems will comprise RE electricity generating devices in the range of 10 to 100 kW with an average size of 50 kW corresponding to an average size of settlement of 1,200 inhabitants. An overall potential market of 156,000 RE powered mini-grid marked has been identified for the next 20 years covering the needs of 103.2 million inhabitants of the ECOWAS region living in localities comprised between 200 and 2,200 inhabitants. To cover the totality of these needs it will be necessary to respect the following implementation pace:

- *23 mini-grid/year/1million inhabitant (2010) during the period 2012-2030*

➢ *Stand-alone equipment*

To cover the residual demand coming from the isolated population, a need of 4.7 million stand-alone RE equipment has been identified, 2.1 million up to 2020 covering half of the demand and 4.7 million enabling the universal access by 2030.

In terms of market, the maximal contribution for stand-alone equipment will be of:

- *875 equipment/year/1 million inhabitant (2010) from 2012 to 2030*

Modelling the domestic energy market

To summarise this issue, which is recurrently characterized by the lack of consistent data and the absence of a consistent baseline and vision, it is assessed that around 45% of the total population are dependent on a monetized domestic energy market comprising products such as fuel wood, charcoal, LPG and kerosene. The remaining 55% rural population are collecting their fire wood from the forestry resources and the savannah areas.

Modern domestic energy like LPG and kerosene are essentially used by the urban population covering about 30% of the urban monetized demand. Except for Nigeria, where uses of kerosene for cooking seem to also be developed in rural areas, the majority of ECOWAS population relies on traditionally

collected fire wood and residues.

Taking into account the expected doubling of the demography in 2030, it should become a priority to develop a specific policy addressing the issues of efficient use of domestic energy and other modern fuel alternatives, of extended sustainable forestry incl. woody energy cropping, and of fuel shift to modern energy.

In order to set reasonable targets for the RE policy and strategy by 2020 and 2030, it is necessary to have a good estimate of the regional RE market segmentation:

- An assumption of the overall grid connected supply covering both urban and rural areas
- An assumption of the demand for off-grid systems that will not be covered by the centralized power generation and transport system.
- The magnitude of population living in the smallest settlements (< 200 inhabitants) for which RE stand-alone systems will possibly be more suitable.
- The magnitude of the urban and rural population for domestic energy demand.

The overall power demand forecast applied for the study is the one prepared by the WAPP master plan's report no 1. It is based on a compilation of the different utilities' demand forecast, including the supply of isolated local centres powered by diesel generation and assumptions for grid based rural electrification. This forecast does not include off-grid electrification and stand-alone energy systems. The WAPP forecast is not detailed enough to make demarcation between urban supply and grid-based rural electrification.

11.1 Modelling the ECOWAS population and settlements' distribution

An analysis of the link between population and size of their settlement gives some interesting indication in regard to the rate of penetration for grid based rural electrification. Detailed GIS[25] data were available for Benin, Mali, Burkina Faso, Niger and Ghana. This sample covers about 24% of the ECOWAS population, with two coastal states (Ghana and Benin) and three land-locked countries (Mali, Burkina Faso and Niger). It is deemed representative for the ECOWAS region for macroeconomic assessments. Based on this analysis, it can be stated that half of the ECOWAS population lives in towns or villages with 2,500 inhabitants and more. More than 30% of the overall population lives in towns that have at least 5,000 inhabitants. But in terms of number of settlements, the picture is reverse. 10 to 30% of the population live in very spread and small and numerous settlements with subsistence agriculture as way of living.

Table 26: Population and size of settlement

Settlements in no. of inhabitants	% of population living in	% of the total no of settlements
> 5,000	28 to 52%	3-6%
> 2,500	38% to 58%	7% to 28%

Even though these figures represent a small sample with regard to the ECOWAS member countries, it shows that 30 to 50% of the population can be considered as urban, living in towns, but in terms of number of localities this number is small (3 to 6%). While 28% to 52% of the population have potential access to electricity, only 3 to 6 % of the localities are supplied. Information regarding the percentage of urban population depends often on administrative rules between what is considered as rural settlements.

[25] IED, GeoSim© bases

In Cape Verde, 59.6% of the population was officially urban in 2008. The official number for Nigeria, Ghana, Senegal and Mali are respectively 49.8%, 46%, 41.6% and 30.5%. For Côte d'Ivoire, the figure swings between 45% and 55%. Following the data collected by the UNDP, 45% of the population of West Africa is living in towns.

Based on the available data and the sample of countries where more detailed data are at disposal, the following assumptions for the ECOWAS population and dwellings repartition in 2010 is illustrated in the following pictures:

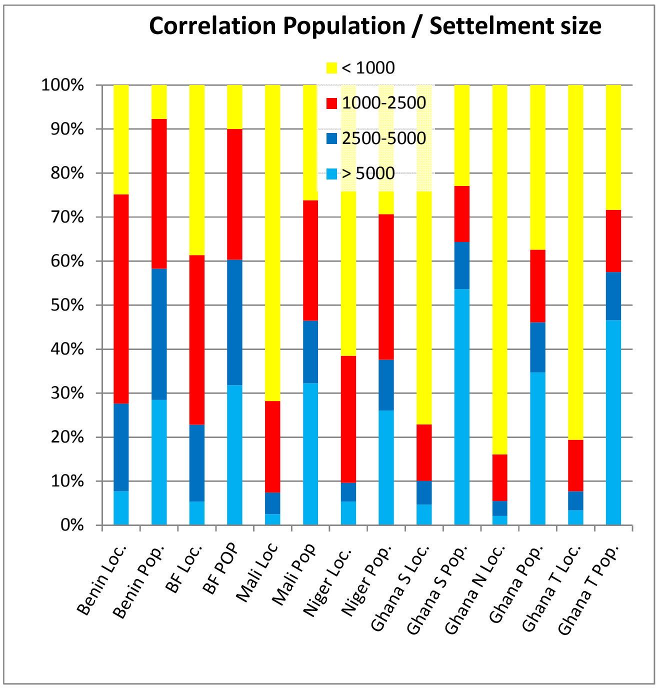


Figure 50: Correlation between no of population and settlement size

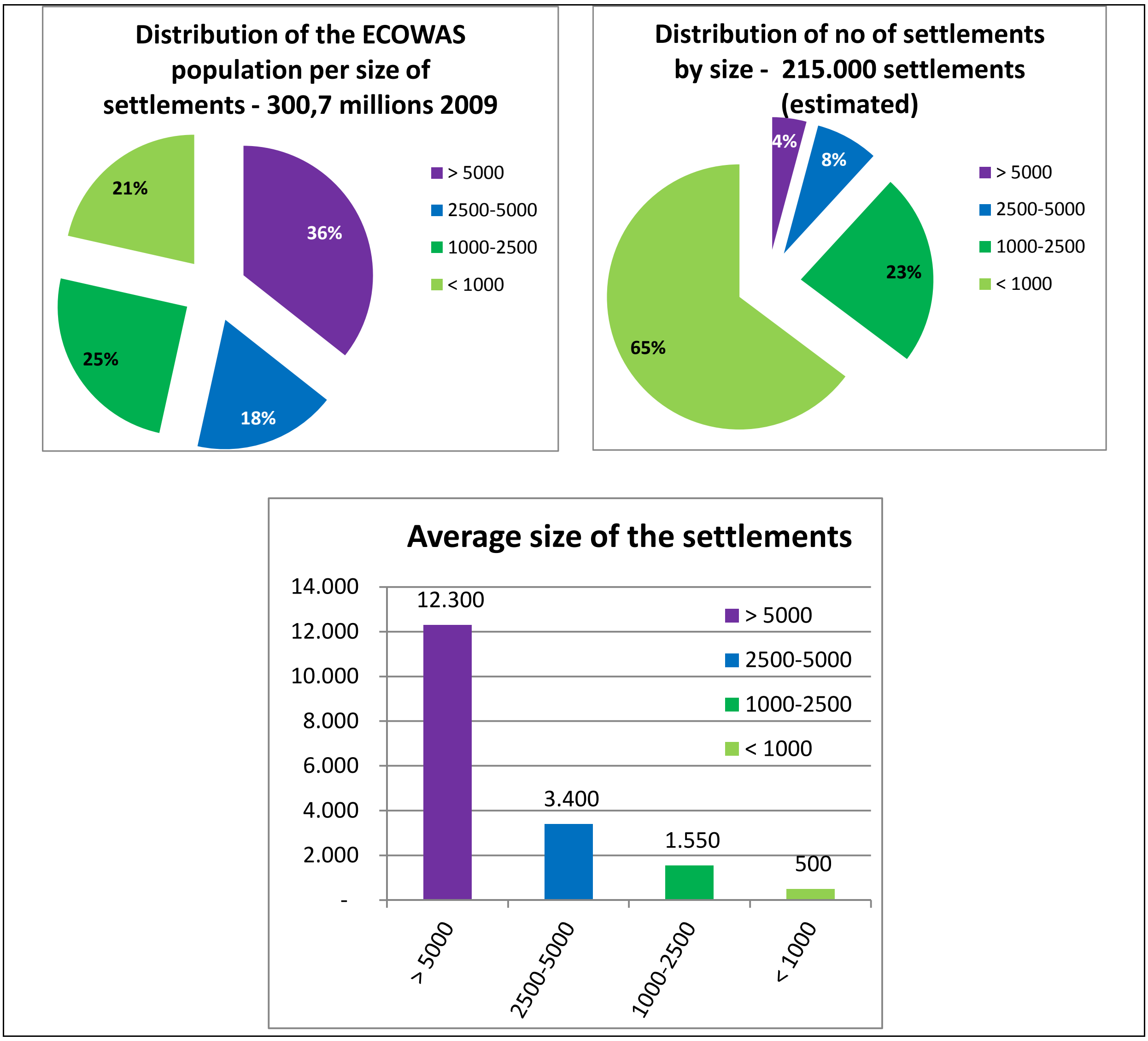


Figure 51: ECOWAS population and settlements (distribution by size of settlements)

The model is not totally consistent for the number of smaller settlements as these are treated administratively and statistically in different ways in the different countries. In some countries, the population of the smaller settlements are not listed separately. In other countries: Ghana, for example, has a specific data collection for 69,825 small settlements (less than 200 inhabitants with an average of 19 inhabitants); in Niger, the total number of settlements is about 38,879 about 4 times what can be found in the statistical database. However, in terms of magnitude, this fringe of scattered population does not exceed 5% of the total population. In terms of total number of settlements in the ECOWAS region, the following estimate has been computed. A total number of 213,700 main settlements have been estimated.

Table 27: Estimated no of settlements within ECOWAS distributed by size

Settlements in no. of inhabitants	Estimated no of settlements	Average size
> 5,000	8,700	12,300
2,500-5,000	16,000	3,400
1,000-2,500	49,000	1,550
< 1,000	140,000	500
Total	213,700	1,410

The three first size categories give an acceptable order of magnitude of population distribution in relation to the size of their localities. The number of settlements smaller than 1,000 inhabitants gives an indication for more agglomerated settlements for that category. Besides the 140,000 settlements estimated, there are hundreds of thousands of settlements gathering one or few families on their fields. As far as energy supply is concerned, the grid option will not be considered for this category and the size of this category in terms of population is the relevant data. To complete the population model, an average population growth rate of 3.5% per year has been stated for the forecast, resulting into an increase in population of 40% by 2020 (421 millions) and 100% by 2030 (601.4 millions).

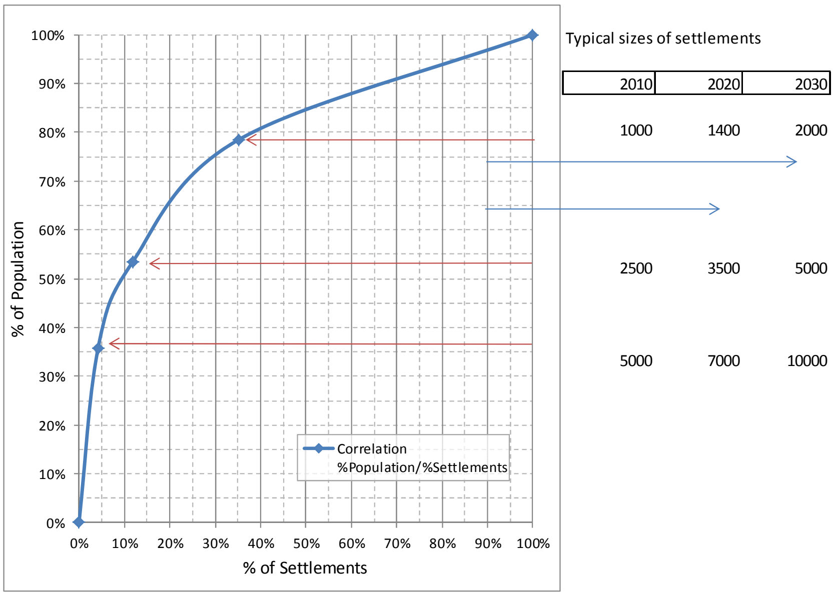


Figure 52: Distribution model between population and settlements for the ECOWAS region

The demographic growth is applied as a flat rate without differentiation for different urbanization rate in the ECOWAS countries. However, as Nigeria, Ghana and Cote d'Ivoire are determining factor for the population structure and growth, this simplification can be considered acceptable.

11.2 Modelling the electricity demand for grid- and off-grid power supply as well as for stand-alone systems

In terms of electricity supply, the analysis of the sample of detailed data for Ghana, Burkina and Benin establishes a clear correlation between dispersion rate (no of electrified settlements/no of total settlements) and access rate (population having potentially access to electricity/total population) as illustrated by the figure below.

The graph shows that the access rate grows faster than the dispersion rate up to a point where the tendency reverses (access rate of 45% corresponding to a dispersion rate of 12%). This phase relates to the electrification of the capital city and other major cities, as well as to the creation of the national grid and the beginning of grid-based rural electrification.

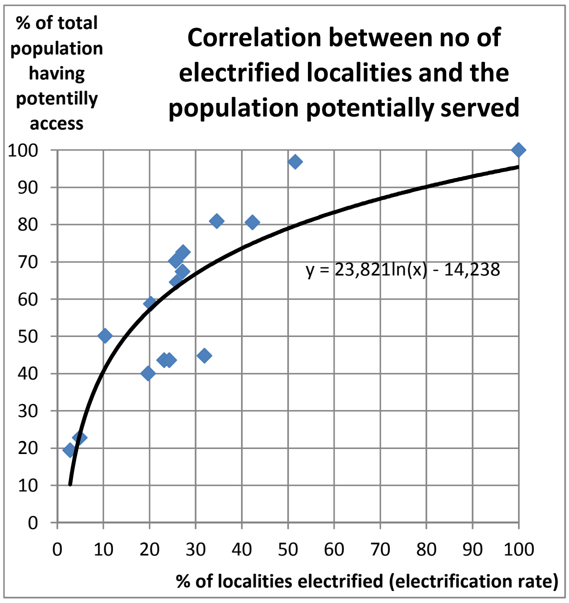


Figure 53: Correlation between dispersion rate and access

From that point (45%-12%) to a certain point to be defined, the curb relates typically to the area for grid-based electrification for settlements or clusters of settlements that can offer sufficient electricity demand to secure the pay-back of the line.

Assumptions for grid-based electrification are generally rather ambitious with a magnitude of 200 localities per year for a country with an average population of 20 million inhabitants (assumptions applied to Cote d'Ivoire and Burkina Faso). If this assumption is applied to the whole ECOWAS region, the target for grid-based rural electrification will be about 3,000 rural localities electrified per year or 30,000 rural localities for a decade. On the other hand, there is an economic limit to respect in terms of grid based rural electrification as the average size of the new settlements to be connected shrinks with time and the distance between the new villages to be connected increases.

As a rule of thumb based on experience, the limit to rural grid electrification is set in the statistical model to a population of 2,200 inhabitants. Both assumptions (number of connections/year and limitation of settlement size) are converging and thus leading to the following forecast:

Table 28 Model for the overall electricity supply in the ECOWAS region

	No of Settlements			Supplied Population in millions		
	2010	2020	2030	2010	2020	2030
Population having access in 2010	25,644	25,644	25,644	135.2	189.3	270.4
Grid-based Rural (extension)		32,055	64,110		81.3	179.5
Off-grid Rural (extension)		59,836	96,165		71.4	104.3
Stand-alone		22,438	27,781		21.0	47.2
Not supplied	188,056	73,726	0	165.5	58.0	0.0
Total having access	25,644	139,974	213,700	135.2	363.0	601.4
In %	12%	66%	100%	45%	86%	100%
Reference	213,700	213,700	213,700	300.7	421.0	601.7

It is foreseen that the access rate will grow from 45% to 86% by 2020 and reach the target of universal access by 2030.

Remarks:

1 Part of the off-grid rural electrification from 2010 to 2020 will be retrofitted into grid-based supply due to the extension of the grid. Generally, if the energy sources of the off-grid supply systems are RE, they can stay in operation connected to the grid providing active capacity and supporting the voltage.

2 The figure for settlements with stand-alone supply is underestimated as noticed before. The relevant number for the forecast is the population, giving an indication of the number of equipment to install. With an average of 8 people per households, 5.9 million households (corresponding to 47.2 million inhabitants in 2030) could benefit from this type of supply during the next 20 years, e.g. an average of 295,000 equipment have to be sold per year (solar PV, wind chargers, domestic biogas plants) or 1,000 for each million inhabitants in the ECOWAS region per year.

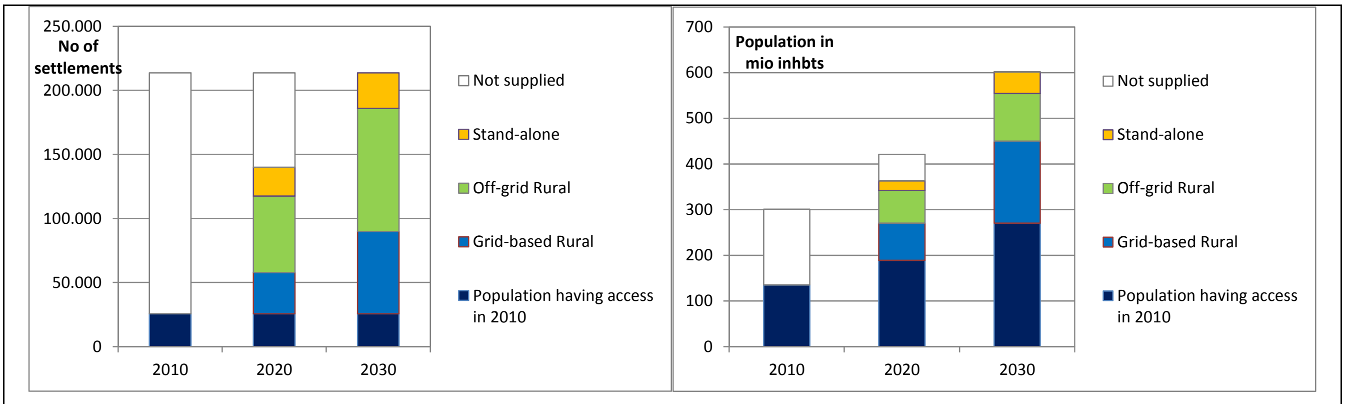


Figure 54: Scenario for electricity supply in the ECOWAS region

11.2.1 Grid-based supply market (urban and rural)

The scenario for electricity supply leads to:

- A doubling (factor 2) of population that will be supplied through the grid by 2020 (access rate 64%; dispersion rate 24%);
- A tripling (factor 3.3) of population supplied through the grid by 2030 (access rate 74.8%; dispersion rate 42%);

These figures are perfectly consistent with the WAPP supply forecast with a doubling of the demand (2.2) by 2020 and a tripling by 2030 (3.5) based on a MW and GWh approach.

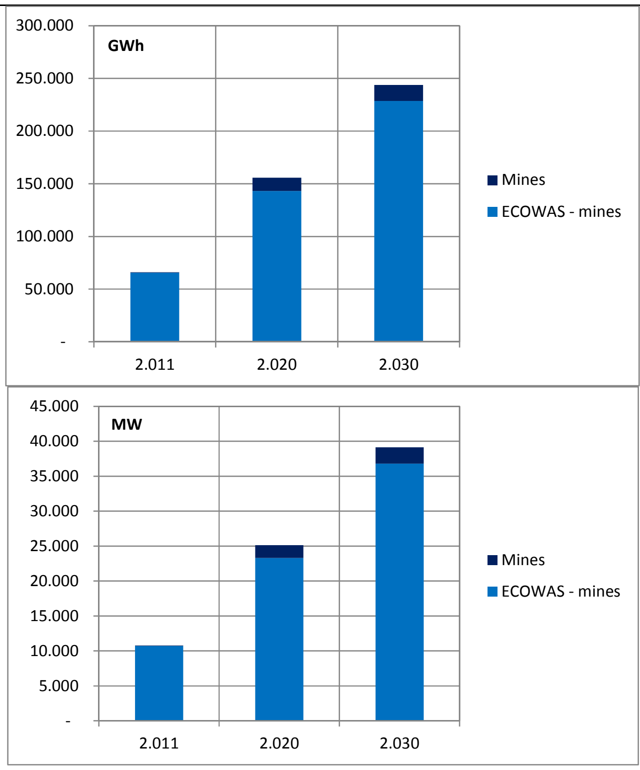


Figure 55: WAPP Energy and power demand forecast

The simulation shows that the WAPP grid-based supply model will not be able to provide electricity to the whole ECOWAS population: 36% to 25% of the population respectively by 2020 and 2030 have to find other supply solutions that will be based both on mini-grid supply systems for localities having a statistical size comprised between few hundred inhabitants to 2,200 inhabitants, and stand-alone systems. Of course, some isolated localities with bigger population could also benefit from mini-grid systems while waiting for the grid supply. And in the other way, smaller localities under the line could be supplied. But the limit in the model is 2,200 people.

With regards to the simulation, it is finally expected that 64,110 localities will be connected to grid during the next 20 years, corresponding to 81.3 million inhabitants by 2020 and 179.5 million by 2030 in terms of new population acceding grid-based electricity.

The market for RE will be governed by two principles, (i) the needs to secure physically the national power supply while waiting for the regional projects to become fully operational and (ii) the obligation to maintain a reasonable financial health for the national power sectors that have to face both the financial burden of comprehensive investment programmes and for some countries the volatility of the oil price.

11.2.2 Mini-grid supply market

This market should address the electricity needs of 59,836 localities with a population of 71.4 million inhabitants by 2020 (average size of 1,200 inhabitants) and 96,165 localities with a population of 104.3 million people by 2030 (average size of 1,085 inhabitants).

Some of the first mini-grids built between 2010 and 2020 will be integrated into the grid-based supply due to the growth of certain major cities and the expansion of the grid. Fortunately, most of the RE supply system that might be installed will continue to operate via connection to the grid.

Traditionally, the mini-grids are powered by small generator-sets operating with diesel oil. With an average population of 1,200 inhabitants the power capacity required to meet the demand is about 50 kW for an average capacity demand of 2 Amp per consumer (average among domestic, administrative and commercial demand). Due to the development of the system monitoring device and the price reduction for certain RETs, this market could be powered by RE such as PV plants, smaller wind turbines both with storage capacity, gas motors supplied either by a biogas plant or a gasifier. Finally, for the countries having good small-scale hydro resources, small-scale hydropower plants could be an opportunity.

According to the simulation, a market of 128,000 RE powered mini-grids has been identified for the next 20 years covering the needs of 103.2 million inhabitants of the ECOWAS region living in localities comprising between 200 and 2,200 inhabitants. Some of these localities can later on be embraced by the national distribution grid.

These mini-grid systems will have capacity ranging typically from 20 to 100 kW, with an average capacity of 50 kW. The statistical data does not exclude the fact that mini-grids powered by larger capacity (200 to 400 kW) can also be installed while waiting for the national grid for major localities that are quite distant from the grid.

To give an order of magnitude, for mini-grid systems' market, the pace of implementation for mini-grid systems is assessed to be of 23 mini-grids/year/1million inhabitant (2010) during the period 2012-2030. Therefore, the average need for mini-grid for a country of 20 million inhabitants by 2010 will be about 230 mini-grids per year up to 2030 or 4,140 mini-grids in total.

11.2.3 Stand-alone RE equipment market

The simulation is grounded on the assumption that universal access to electricity will be a reality by 2030. Some portion of the ECOWAS population will not have, during the next 20 years, a physical opportunity to get electricity access. For some countries like Cape Verde, Ghana and Cote d'Ivoire this target will be reached within the next 10 years.

The simulation shows that there will always be a remaining fringe of population that will live very scattered and isolated in small settlements close to their livelihood sources (forest areas, small islands, and remote pieces of lands in isolated valleys).

In 2010 165.5 million ECOWAS citizens were without physical opportunity to get electricity access. The number of citizens without electricity services is probably bigger.

The simulation proposes to reduce progressively this figure to 58 million in 2020 and nil in 2030.

Stand-alone equipment will contribute to this reduction by supplying about half of the very dispersed population by 2020 (21 million inhabitants) and the remainder by 2030 (47.2 million inhabitants).The potential market needed to cover this assumption is about 2.1 million up to 2020 and 4.7 million from 2020 to 2030 (1 equipment per household of 10 people).

In terms of market, the need for stand-alone equipment will be about 875 equipment/year/1 million inhabitants (2010) from 2012 to 2030.

For a country of 20 million inhabitants, the yearly potential market for stand-alone equipment should be about 17,500 equipment per year.

11.3 Modelling the domestic energy demand

11.3.1 Data background

The distribution of the population per dwelling sizes gives a good prospect for fuel wood supply issue. In 2010, 36% of the population (108 million inhabitants) is living in localities which sizes are greater than 5,000 inhabitants. Their supply in domestic energy is fully monetised, as the distance to the resource is too high. The main domestic energy sources are provided by the forest (firewood and charcoal). In some countries, supply of alternative fuels in the market is increasing t like LPG in Senegal (115 ktoe/year), Ghana (39 ktoe/year), Burkina (20 ktoe/year) or like kerosene in Nigeria (666 ktoe/year). It has to be noticed that LPG is only available in the cities. The kerosene is available almost everywhere as it is easier to transport and distribute. Charcoal production and demand is growing to the detriment of wood and wood resource as it is cheaper to transport and easier to use with less pollution.

On the other side, 46% of the population (138 million inhabitants) is rural and is distributed among 88% of the total localities having a size smaller than 2,500 inhabitants. This population is close to the wood resource and its supply can be assumed through traditionally collected wood by women. Except for kerosene that could be expensive for cooking and is distributed in small quantities, the LPG is rarely available and the costs of the deposit for the empty cylinder and of the appliance are severe barriers to LPG dissemination in rural areas.

About 18% of the population (54 million inhabitants) living in medium sized localities (2,500 to 5,000 inhabitants) get their domestic supply both from the market (wood, charcoal, LPG and kerosene) and from own collection of wood.

Data on domestic energy are few and not always consistent.

As long as the culinary traditions remain unaltered, the net energy needed to cook food for one person can be estimated to range between 500 and 700 MJ/year. That means, for an average urban household of 6 persons to cover the yearly consumption of 3-4.2 GJ/year, will have to consider the following option:

- To buy from 800 to 1,120 kg of fire wood used in efficient stove (yield 25%)
- To buy from 8 to 11 bag of charcoal (40 kg) used in efficient stoves (yield 35%)
- To buy from 7 to 10 LPG cylinders (12.5 kg) used with an efficiency of 75%

For rural population self-supply strategy associated with less efficient fire-places leads to a bigger fuel wood consumption. For the same household of 10 people, an average fuel wood consumption will be close to double, at 2,250 kg to 3,200 kg.

To have an order of magnitude for modern energy penetration in the domestic sphere, this simplified calculation can be shown:

- Net cooking energy demand for urban population in the ECOWAS
  600 MJ * 138 million inhabitants:
  $$82.8\ 10^6\ GJ$$
- Rough estimate of LPG consumption for domestic uses: 300,000 tons
  300,000 t * 46 GJ/t * 0.75 (yield)
  $$10.4\ 10^6\ GJ$$
- Kerosene consumption in Nigeria for domestic uses: 666,000 toe
  666,000 toe * 41.87 GJ/toe * 0.75
  $$20.9\ 10^6\ GJ$$

If 1/3 of the Nigeria kerosene consumption supplies the rural areas, the share of modern energy for cooking uses can roughly be estimated at 30% for the urban population.

As the urban demographic growth will be higher than the average, it is expected that 50% of the overall ECOWAS population will live in towns by 2020 and close to 55% by 2030. This evolution will result into a doubling of the domestic energy market, impacting severely the monetized share of fuel wood supply (increase in the demand, possible acceleration of the shift fire wood→ charcoal, higher pressure on the forestry resources).

11.3.2 Modelling the regional market for domestic energies

The assumptions of this model are:

- The average vital need for food cooking for a human being is estimated at 600 MJ in terms of useful energy, this corresponds to 731 grams of fire wood per capita per day for cooking yield by 14%.
- The current average yields applied in the modelling are :

Cook-stove- fire wood – urban dwelling	15%,
Cook-stove- charcoal – urban dwelling	20%,
Cook-stove- fire wood – rural dwelling	12%
Charcoal burning	12%

- The key entry data are demographic: a population of 300 million inhabitants, nearly 45% is urban. This population will double by 2030.
- The urbanization rate of 45% rises gradually to 50% by 2020 and 55% by 2025.
- The consumption of modern energies is estimated at 300,000 tons at LPG and 666,000 tons of kerosene mainly used in Nigeria. The cooking yield of these energies is estimated at 75%.

Due to urbanization, the share of consumption of charcoal in urban areas will increase from its current level of 50% to 80% by 2030. Currently, five countries are using charcoal as the first domestic fuel in urban areas - Senegal, Mali, Cote d'Ivoire, Ghana, and Benin. The migration from wood to charcoal is underway in Burkina Faso. Only Cape Verde and Niger use mainly fuel wood as primary energy. In the Gambia, the carbonization of wood is banned but The Gambia imports it from Casamance.

Reference Scenario

ECOWAS POPULATION	2010	2020	2030
Population	300,7	421	600
Urbanization rate	44%	50%	55%
Urban population	133,7	210,5	330,0

Unit consumption	0,6	GJ/cap/y
	0,731	Kg fire wood /cap/day

Cooking energy needs 10^6 GJ	180,4	252,6	360,0
-urban	80,2	126,3	198,0
-rural	100,2	126,3	162,0
Modern fuel			
LPG 10^6 GJ	10,4	16,4	25,7
Kerosene 10^6 GJ	20,8	32,8	51,4

Urban cooking energy 10^6 GJ

LPG	10,1	15,9	24,9
Kerosene	13,9	21,8	34,2
Urban modern cooking fuel	24,0	37,7	59,1
Urban modern fuel %	30%	30%	30%
Woodfuel	70%	70%	70%
Urban woodfuel 10^6 GJ	56,2	88,6	138,9
-fire wood %	50%	40%	20%
-charcoal %	50%	60%	80%
-fire wood 10^6 GJ	28,1	35,4	27,8
-charcoal 10^6 GJ	28,1	53,1	111,1
-fire wood 10^6 tons	12,5	15,7	12,3
-charcoal 10^6 tons	5,0	9,5	19,8
Woodfuel 10^6 tons	48,4	83,5	154,0

Rural cooking energy

LPG	0,3	0,5	0,8
Kerosene	6,9	10,9	17,1
Rural modern cooking fuel	7,2	11,4	17,9
Rural modern fuel %	7%	9%	11%
Woodfuel	93%	91%	89%
Rural woodfuel 10^6 GJ	93,0	114,9	144,1
-fire wood %	95%	90%	80%
-charcoal %	5%	10%	20%
-fire wood 10^6 GJ	88,3	103,4	115,3
-charcoal 10^6 GJ	4,6	11,5	28,8
-fire wood 10^6 tons	49,1	57,4	64,0
-charcoal 10^6 tons	0,8	2,1	5,1
Woodfuel 10^6 tons	55,0	72,1	100,8

Overall Woodfuel 10^6 tons	**103,4**	**155,6**	**254,8**
Needs of 10^6 ha sustainable forestry	129,21	194,54	318,55
Forest and wooded land 10^6 ha	111,40	102,02	93,43
Sustainable production 10^6t	89,12	81,62	74,74
Deficit in 10^6 tons	**-14,25**	**-74,01**	**-180,10**
Afforestation index	-16%	-91%	-241%

	2010	2020	2030
Efficiency cook-stove wood urban	15%	15%	15%

Efficiency cook-stove charcoal	20%	20%	20%
Efficiency cook-stove wood rural	12%	12%	12%
Efficiency charcoal burning	14%	14%	14%
1kg charcoal = kg firewood	7	7	7

In the reference scenario, the penetration of modern cooking fuel and cooking equipment is kept at their 2010 level, while the assumption of the consumption shift from fuel wood to charcoal is applied.

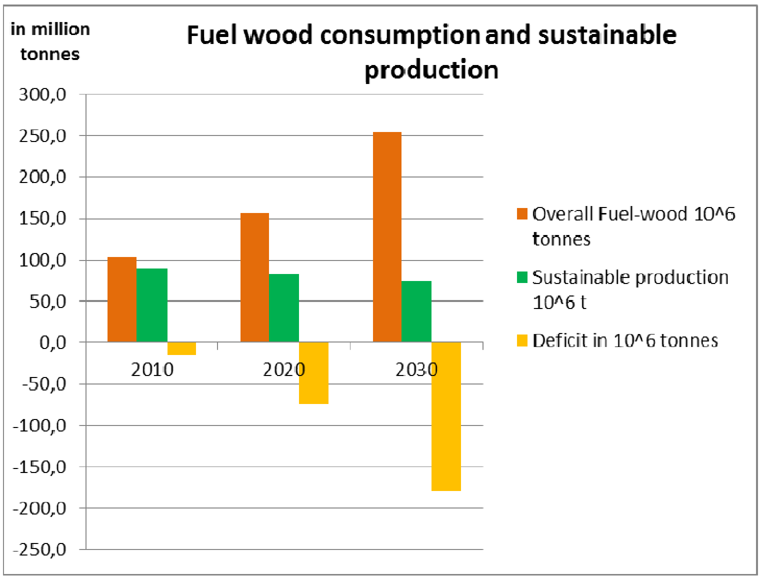


Figure 56: Reference scenario

In this case, the total demand for wood to meet the demand for firewood and charcoal grows from 103.4 million tonnes by 2010 to 155.6 million tonnes by 2020 and 254.8 million by 2030.

Already in 2010, the sustainable ECOWAS woodland's fuel wood potential is less than the actual demand resulting in overexploitation of the resource assessed at an 'over-exploitation' index of 16%, corresponding to the gap between demand and sustainable resource availability. If nothing is done, this index will increase rapidly to reach a value of 91% in 2020 and 241% in 2030, with rapid potentially irreversible deforestation as a consequence.

12 Targets of the ECOWAS Renewable Energy Policy (EREP)

Summary:

*Three groups of targets have been set for the ECOWAS Regional Renewable Energy Policy: for "**on-grid connected renewable energy applications**"; for "**off-grid and stand-alone applications**"; and for "**domestic renewable energy applications**" ranging from cooking related applications (cook stoves, household biogas, briquettes and LPG strategy) to energy efficiency measures such as solar water heater and distributed power generation (PV roof top and small wind turbines).*

Table 29: EREP Targets for grid-connected renewable energy

Installed electric capacity (in MW)	2010	2020	2030
Additional RE electric capacity in MW	0	2,425	7,606
RE penetration in % of peak load	0%	10%	19%
Total RE penetration (incl. medium and large hydro) in % of peak load	32%	35%	48%
Electricity generation (in GWh)	**2010**	**2020**	**2030**
Additional RE generation in GWh	0	8,350	29,229
RE generation in % of electricity demand	0%	5%	12%
Total RE generation (incl. medium and large hydro) in % of electricity demand	26%	23%	31%

Table 30 : Targets for off-Grid applications

Least-cost option	2010	2020	2030
Share of rural population served by RE off-grid solutions (mini-grids and stand-alone systems)		22%	25%

Table 31 : Target for Domestic applications and biofuels

Least-cost option	2010	2020	2030
Biofuels (1st generation)			
Ethanol as share of Gasoline consumption		5%	15%
Biodiesel as share of Diesel and Fuel-Oil consumption		5%	10%
Improved cook-stoves - % of population	11%	**100%**	**100%**
Efficient charcoal production share-%		**60%**	**100%**
Use of modern fuel alternatives for cooking (e.g. LPG) - % of population	17%	**36%**	**41%**
Solar water heater technologies for sanitary hot water and preheating of industrial process hot water:			
▪ Residential sector (new detached house price higher than €75,000)		At least 1 system	At least 1 system

		installed	installed
▪ District health centres, maternities, school kitchen and boarding schools		25%	50%
▪ Agro-food industries (preheating of process water)		10%	25%
▪ Hotels for hot sanitary water		10%	25%

12.1 Quantifying the RE targets for different market segments

A regional policy has to quantify attainable, feasible and realistic targets. Three groups of targets for new RE are set by the ECOWAS Regional Renewable Energy Policy: for "**on-grid connected renewable energy applications**"; for "**off-grid and stand-alone applications**"; and for "**domestic renewable energy applications**" ranging from cooking related applications (cook stoves, household biogas, briquettes and LPG strategy) to energy efficiency measures such as solar water heater and distributed power generation (PV roof top and small wind turbines). The share of new renewables in the penetration in WAPP grid system has to be determined. The number of mini-grid systems and stand-alone systems necessary to reach the objectives of the white paper in 2020 and of universal access by 2030 has to be quantified.

12.2 Modelling the grid-connected RE targets

12.2.1 Assessment of RE options in different ECOWAS countries

The grid-connected targets for the EREP are set based on the following assumptions:

- An **assessment of the national grid stability** for the period up to 2020. After 2020 it is supposed that the regional integration of the national grid has solved the issue of stability limiting the penetration of RE power production.
- An **assessment of the national RE potential** is illustrated in the table below. Based on the data collected, a tentative matrix was established to outline the potentials of various RE technologies in the respective countries. The matrix is indicating the type of resources that are available and to which extent they have the potential to contribute to the electricity mix effectively. It will be the decision of the respective countries and their key players (e.g. utilities) to which extent they will make use of the different RE options.

Table 32: Relative distribution of RE potentials per country

	Wind	PV	Mini-hydro	Biomass
BENIN	10%	20%	50%	20%
BURKINA FASO	0%	60%	30%	10%
CAPE VERDE	90%	10%	0%	0%
COTE D'IVOIRE	0%	10%	50%	40%
GAMBIE	60%	30%	0%	10%
GHANA	25%	35%	30%	10%
GUINEE	0%	20%	50%	30%
GUINEE BISSAU	0%	20%	40%	40%
LIBERIA	0%	10%	50%	40%
MALI	10%	30%	30%	30%
NIGER	30%	50%	0%	20%
NIGERIA	10%	30%	30%	30%
SENEGAL	70%	10%	0%	20%
SIERRA LEONE	0%	10%	60%	30%
TOGO	0%	20%	50%	30%
Mines	0%	30%	70%	0%

Relative distribution

(white)	less than 20%
(yellow)	from 30 to 40%
(light orange)	from 50 to 60%
(dark orange)	> 60%

The sum of the potential per country is 100%. 0% indicates that the resource is not available or not economically feasible, as for instance biomass and SSHP in Cape Verde. Three countries have a good wind potential (Senegal, The Gambia and Cape Verde), and therefore the wind resources for those countries are given high rankings.

Countries like Mali and Nigeria, which have an equal distribution of their renewable energy resources, are each given an average ranking of 30% for three resources (solar, biomass and hydro) and a 10 % ranking for wind, as wind is more intermittent compared to the other resources. Even if there are good solar resources in the Northern Mali, these resources cannot be fully exploited as it would require long transmission lines to transport the produced energy to the south. However, this resource can be used to supply the large cities in Northern Mali.

The line “Mines” shows that four countries with large mining potentials (Guinea, Liberia, Sierra Leone and Guinea Bissau) can draw advantages of their renewable energy potentials to supply directly their mining activities, which are located in remote areas far from the national grid. The two main sources are by order of priority, the Small-scale hydropower and the solar PV. The mining activities generally need capacity comprising between 30 to 150 MW.

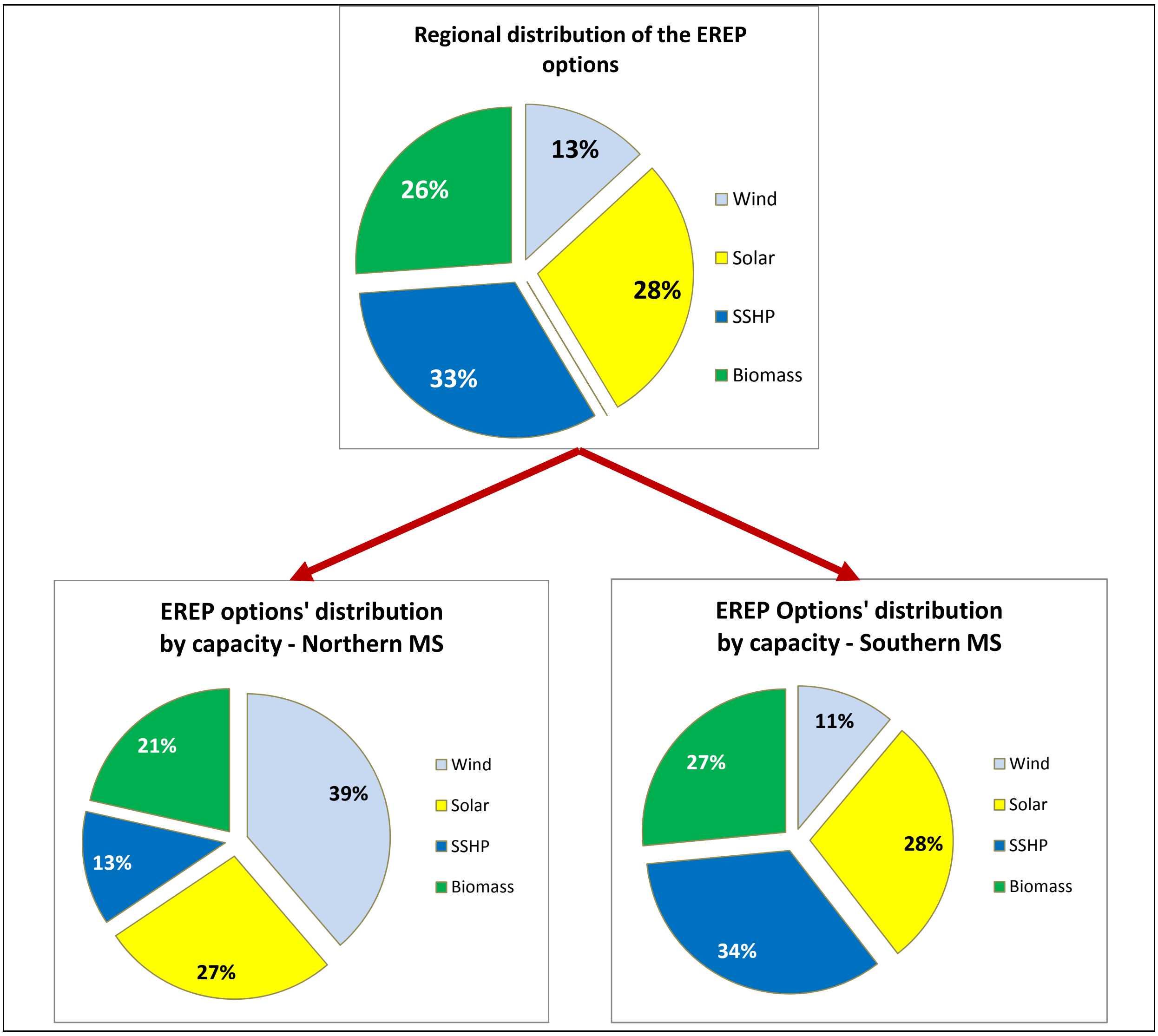


Figure 57: Distribution of renewable energy options in the ECOWAS region

As shown in the above figure, the tentative distribution of the renewable energy potentials for each country gives a regional picture with 13% for wind energy, 28% for solar energy (including CSP after 2020), 33% for SSHP and 27% for biomass. However, these options are not equally distributed throughout the ECOWAS countries. Wind opportunities are more present for the Northern Member States (Senegal, Mali, and Cape Verde) and small-scale hydro options are naturally more relevant for countries in the South. Solar opportunities as well as biomass seem to be more equally distributed.

12.2.2 Existing national RE targets

Ten of the 15 ECOWAS countries have already adopted RE electricity targets for different time horizons. It is the case of Benin, Cape Verde, Cote d'Ivoire, Ghana, Guinea, Liberia, Mali, Niger, Nigeria and Senegal. By harmonizing the targets in terms of units (GWh or MW) and time schedule (2020 and 2030) and by computing these targets together with the WAPP basic capacity forecast, an aggregated regional summation for the RE penetration can be calculated for 2020 and 2030.

Table 33: National RE penetration targets (% of total installed capacity)

	2020	2030
10 countries	7%	12%
10 countries minus Nigeria	13%	12%

The level of ambition is deemed moderate with 7% by 2020 and 12% by 2030 for a sample covering 95% of the demand. Without the influence of Nigeria that generally biases the regional results, the consolidated target for the nine countries is more ambitious for 2020. No solid vision was able to sustain this target for 2030 that falls back with 1%.

12.2.3 RE targets of the WAPP Master Plan Project Pipeline

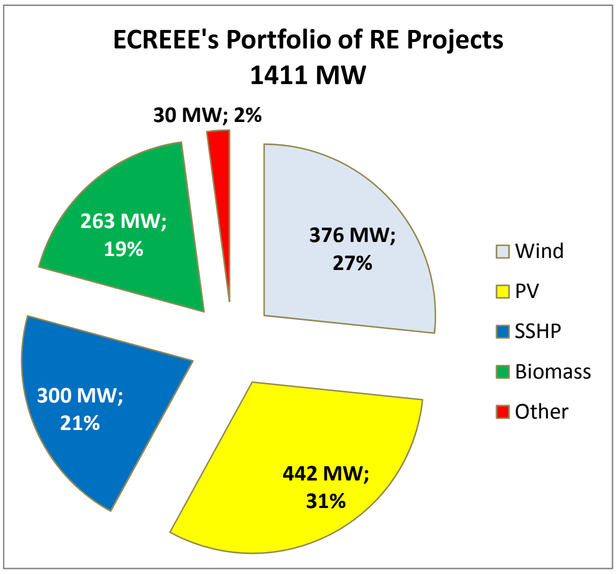
The WAPP 2011 Master Plan foresees already an increase of RE capacity of 7,893 MW (mainly large hydro with 7,093 MW) by 2030 in addition to the actually installed large hydro capacity of 3,447 MW. However, the WAPP scenario either did not consider other RE options very well or left them completely out (e.g. SSHP). According to the WAPP Master Plan scenario, large hydro would contribute 29% to the overall WAPP load.

Table 34: RE contribution in the WAPP Master Plan

in MW	2010 MW	2020 MW	2030 MW
ECOWAS load forecast	10.659	25.128	39.131
Existing LSHP capacities in the WAPP in MW	3.447	3.447	3.447
Additional RE capacity to be added by the WAPP Master Plan (mainly LSHP) in MW		2.825	7.893
Total RE capacity in the WAPP in MW	3.447	6.272	11.340
RE penetration of the total load in % (mainly LSHP)	**32%**	**25%**	**29%**

The figure below shows the portfolio of RE projects identified by the National Focal Institutions (NFIs) of the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE).The project pipeline is promoted by the ECOWAS Renewable Energy Investment Initiative which is managed by ECREEE. The ECREEE project portfolio foresees the installation of an electric capacity of 1,411 MW. However, most of the projects did not pass the stage of development so far, and their feasibility waits to be proven. The identified projects represent 5.6% of the 2020 demand forecast. In terms of distribution, the wind projects are better represented in ECREEE's portfolio compared to the more theoretical estimations (see above). On the other hand, the SSHP options seem to be underestimated.

Figure 58 : Porto folio of RE projects at national level



12.3 Proposed EREP grid-connected RE targets

Based on these assumptions the following on-grid RE targets for the EREP were identified:

- **10% of the WAPP peak load in 2020**, a level below the average figure calculated on the basis of the national targets; 2,425 MW RE capacity for a total investment of 7.9 billion € are the central figures related to the 10% penetration target.
- **19% of the WAPP peak load in 2030**, a level that is quite more visionary than the average corporate national target. Additional 5,181 MW will be installed as RE capacity by 2030, corresponding to an investment of 15 billion €.

Table 35: EREP Targets for grid-connected renewable energy

Installed electric capacity (in MW)	2010	2020	2030
Additional RE electric capacity in MW	0	2,425	7,606
RE penetration in % of peak load	0%	10%	19%
Total RE penetration (incl. medium and large hydro) in % of peak load	32%	35%	48%
Electricity generation (in GWh)	**2010**	**2020**	**2030**
Additional RE generation in GWh	0	8,350	29,229
RE generation in % of electricity demand	0%	5%	12%
Total RE generation (incl. medium large hydro) in % of electricity demand	26%	23%	31%

The EREP investments together with the planned WAPP investments are able to satisfy the projected load demand in the ECOWAS region by 2030. The shares of the EREP scenario are indicated below:

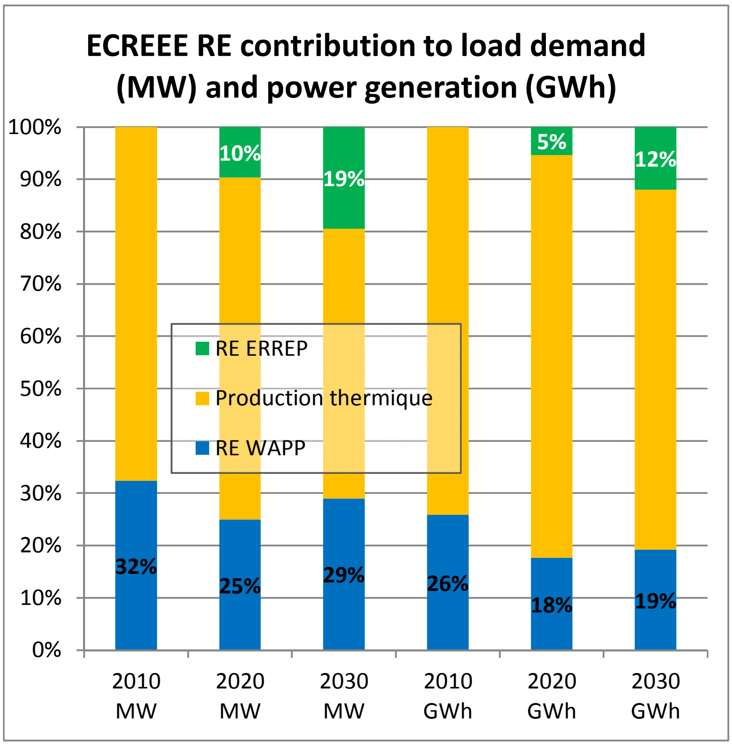
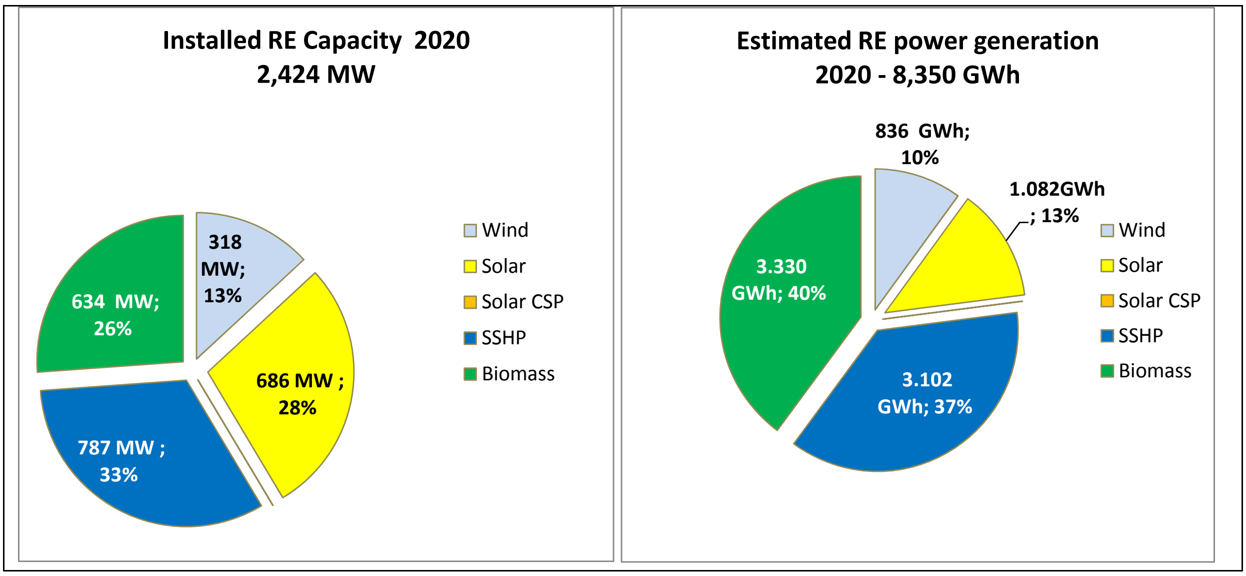


Figure 59: Targets for RE grid connected options (MW and GWh)

The shares of different RE technologies in the EREP scenario would be as follows:



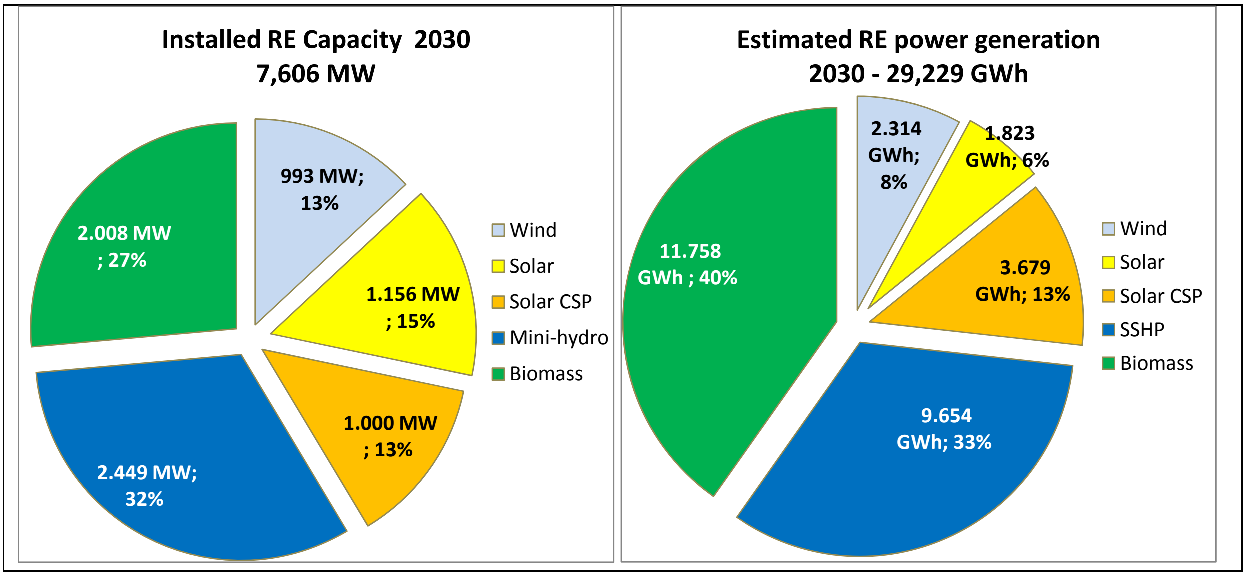


Figure 60: Grid-connected EREP scenarios

12.3.1 Investment requirements of the EREP scenario

The table below shows the level of needed investment to reach the grid-connected targets per technology:

Table 36 Details of the 10% and 20% RE penetration targets for 2020 and 2030

	Wind	Solar PV	Solar CSP	Small-scale hydro	Biomass	Total
Installed capacity in MW						
By 2020	318	686	-	787	634	**2,425**
By 2030	993	1,156	1,000	2,449	2,008	**7,606**
Production in GWh						
By 2020	836	1,082	-	3,102	3,330	**8,350**
By 2030	2,314	1,823	3,679	9,654	11,758	**29,229**
Investments in millions €						
Up to 2020	541	1,166	-	2,872	1,901	**6,479**
Total investments 2030	1,540	1,773	3,980	8,357	4,959	**20,609**

The investment costs were estimated on the basis of the following cost assumptions:

Table 37 Level of investment for RE technology

en M€/MW	2010-2020	2020-2030
Wind	1,90	1,65
Solar PV	2,50	1,82
CSP		4,24
Small-scale hydro Small-scale hydro	3,65	3,30
Biomass	3,00	2,23

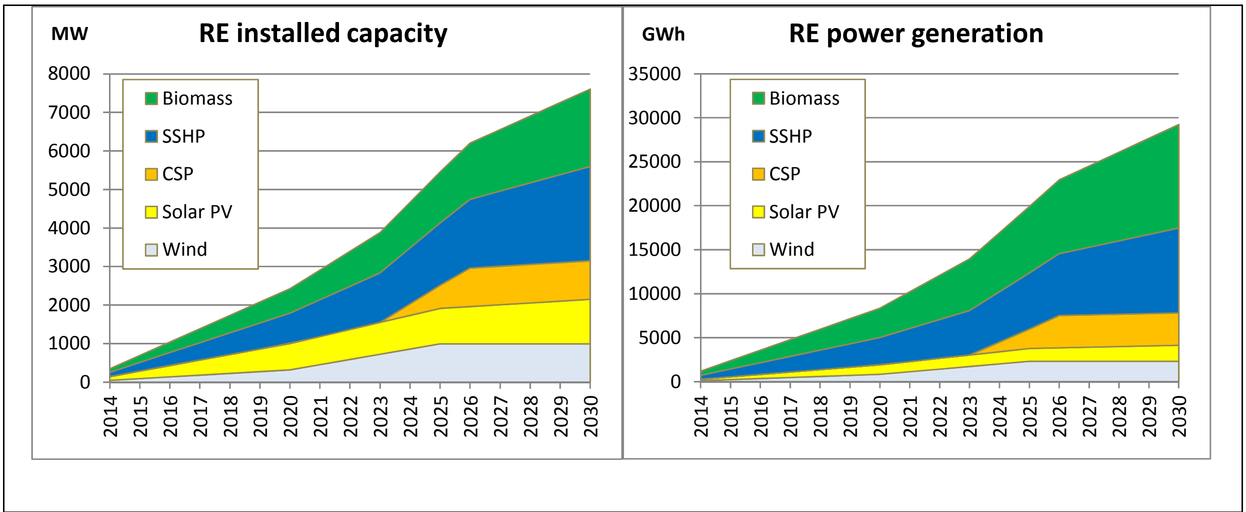
The prices are an average for the period.

As illustrated by the table above, the cheapest technologies in terms of the initial investment are the large wind turbines and the solar PV (not in terms of generation costs).

The price for wind in West Africa remains presently high as the largest turbines (several MW) cannot yet be installed due to the lack of appropriated cranes. But for both technologies, it is expected that their investment cost will reduce by 2030.

Until 2020, the solar technology will be restricted to the use of PV that is less expensive than CSP technology. The average price for PV solar remains higher than the price known for Europe. A real price reduction is expected after 2020. As CSP should be fully commercialized from 2020, it is assumed that unit investment for CSP will reach a level between 4 and 5 M€/MW. As of 2020, 1,000 MW CSP with energy storage is proposed as the investment cost is decreasing, thanks to its larger energy production and its better flexibility for regulation on the grid.

Price evolution for biomass and Small-scale hydro reflects an increase in installed capacity. For Biomass, it is expected that the size of the biomass plants will grow over time with the modernization of agriculture, reducing considerably the investment costs. Stating a cost for small-scale hydropower is often difficult as the cost of civil works will depend on the specific condition of the selected location. Both technologies are the cheapest in the view of their life-time costs and generation costs.



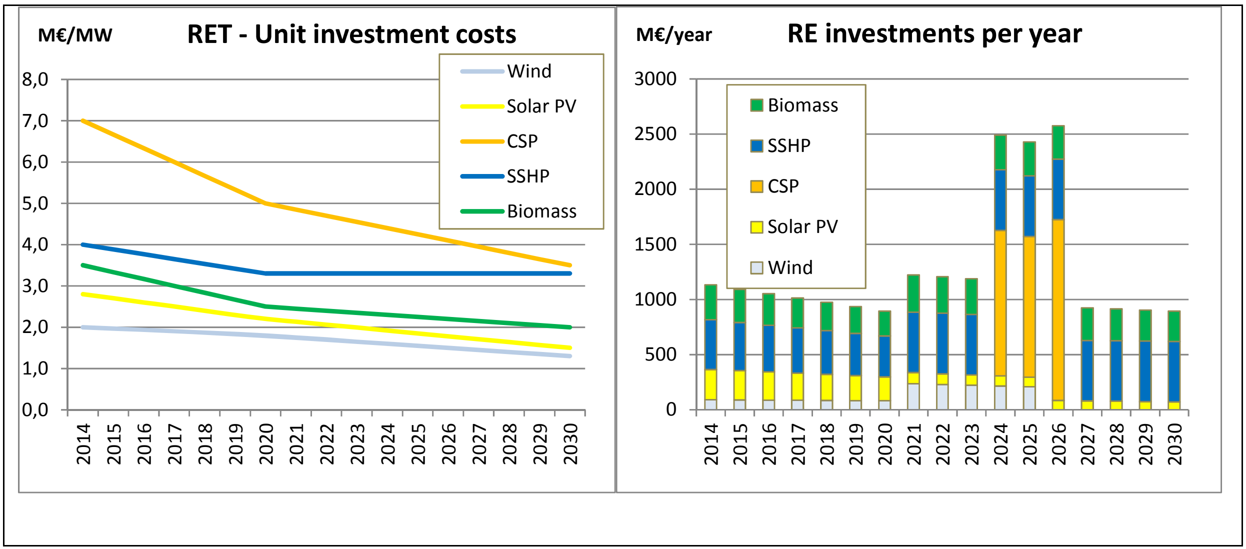


Figure 61: RE installed capacity and production 2014-2030, RE unit cost and investment needs 2014-2030

12.3.2 Economic viability of the RE targets

A least-cost option assessment calculated as levelized cost of energy (LCOE) shows the position of the technologies applied in the EREP scenario compared to the WAPP marginal costs proposed to the countries as of 2018 and the LCOE for diesel production. The calculation is carried out for both commercial conditions and ODA conditions (Long repayment period 25 to 40 years, low interest rate typically 1.5 to 2% and 5 to 10 years grace period).

Under commercial conditions, all the EREP renewable energy options are competitive with regard to diesel thermal generation. However, only biomass and small hydro can fully compete with the WAPP marginal costs. In average, the EREP consolidated RE options are 2c€/kWh more expensive than the WAPP option, but half of the diesel production cost. However, it should also be noted that the WAPP scenario shows an ideal case and it might be that, in the end, the marginal generation costs of the scenario are higher than projected or some of the projects are not implemented as planned.

Under soft loan ODA conditions, the EREP consolidated RE options would be fully competitive with the WAPP options. Biomass and Small-scale hydro technologies are cheaper than the WAPP options. The wind technology is fully competitive and only the solar option remains more expensive.

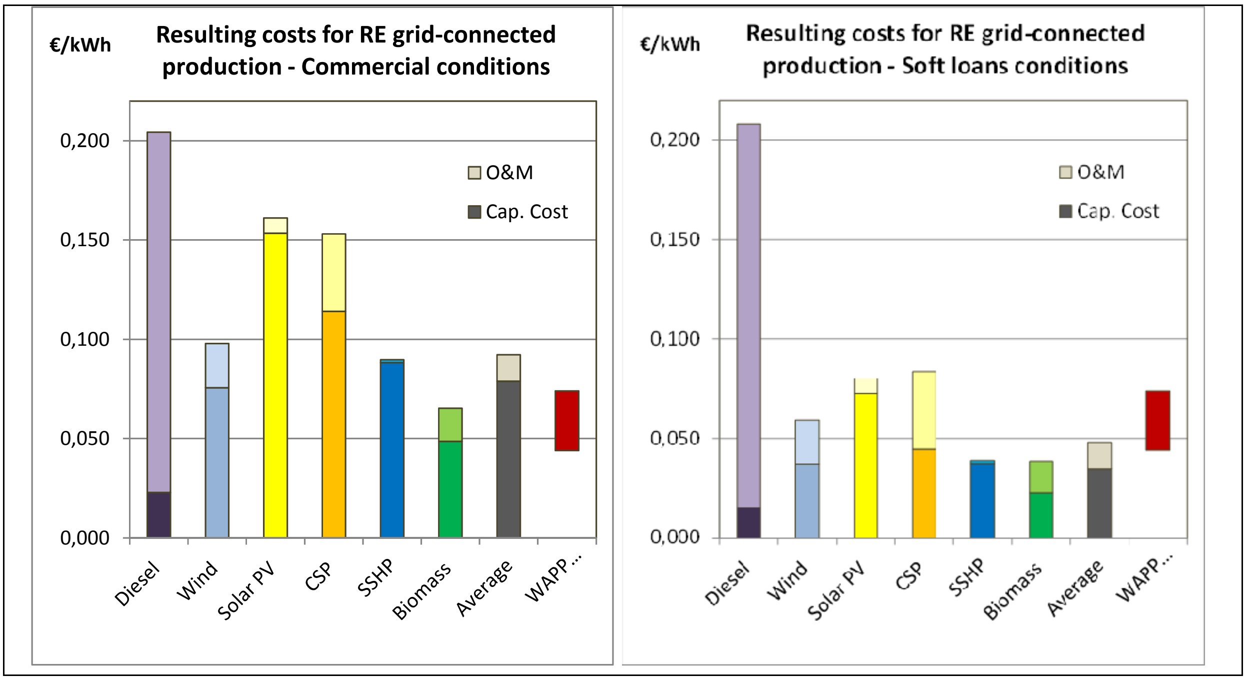


Figure 62: Generation costs of RETs under commercial (left) and soft loan ODA (right) financial conditions

In the graph above the low part of the bars represents the capital costs and the top the O&M costs. The figure below shows the viability of the EREP scenario in comparison with different alternative scenario such as the WAPP scenario.

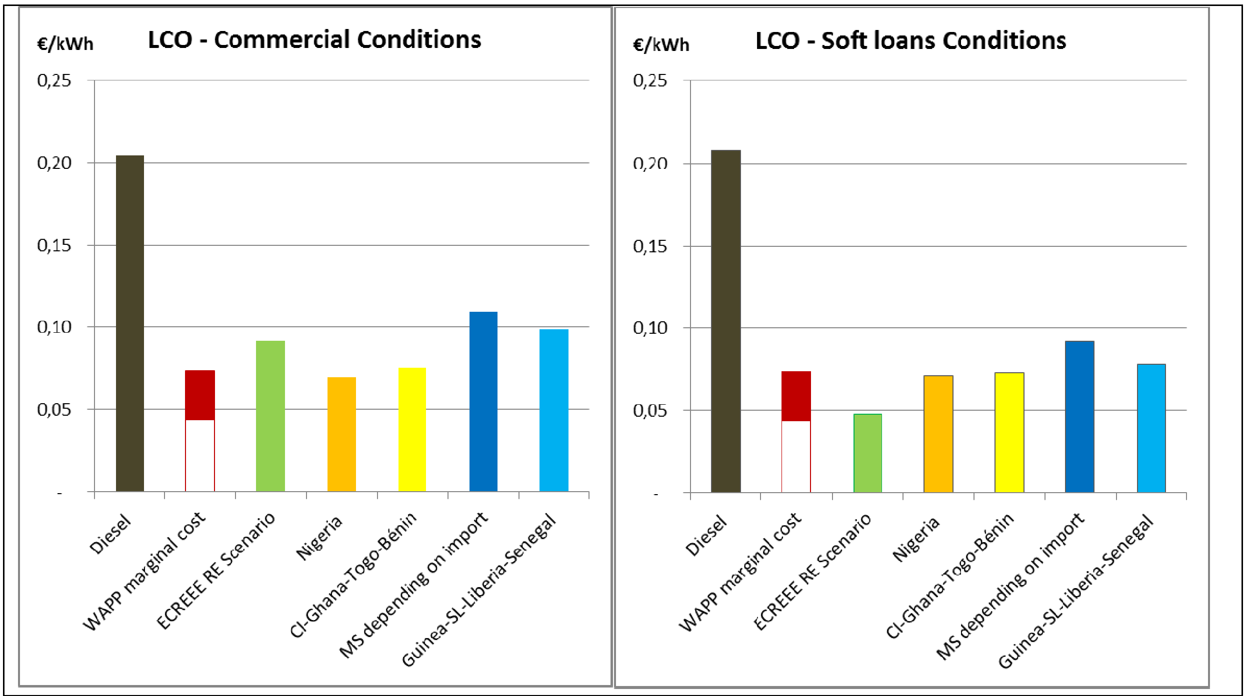


Figure 63: LCOE of the EREP scenario in comparison with other scenarios

The two first columns show the LCOE (levelised cost over a 25 year period) for diesel generation and the range of marginal costs for the WAPP options to the countries. The green columns represent the LCOE for the EREP provisional investment plan for all ECOWAS countries calculated over a 25 year period. The orange colour is the LCOE for Nigeria, while yellow is the LCOE for Cote d'Ivoire, Ghana, Togo and Benin. Dark blue is the LCOE for Burkina, Guinea Bissau, Mali, Gambia and Niger, and in light blue the LCOE for Guinea, Sierra Leone, Liberia and Senegal.

Under commercial financial conditions with the private sector investing in EREP renewable energy options, the EREP scenario constitutes on average a financially better option for all new capacities that can substitute oil-based thermal production up to 2018 or later on when they have access to the WAPP supply and price options. The average benefit is 0.7 c€/kWh for the countries that will have the cheapest WAPP options due to their hydro potentials or a large coal production; and 1.7 c€/kWh for the countries relying on future WAPP interconnection. Due to the digressing investment cost for all EREP renewable energy options during all the periods, some technologies will become gradually competitive with the WAPP options.

Under ODAs' conditions, the EREP scenario is a financially better solution for all the ECOWAS countries. However, it cannot be recommended as the solution to finance the implementation of EREP, since private investments are sought both with the power generation sector and the renewable energy industrial sector.

Nevertheless, by targeting a possible limited financial support, the EREP scenario could avoid to be a financial burden for countries like Nigeria, Ghana, Cote d'Ivoire, Togo, and Benin. A sensibility analysis shows that a 3.6% reduction on the commercial conditions will be sufficient to bring the LCOE for EREP scenario in line with the WAPP marginal costs from Nigeria, Côte d'Ivoire, Ghana, Togo and Benin.

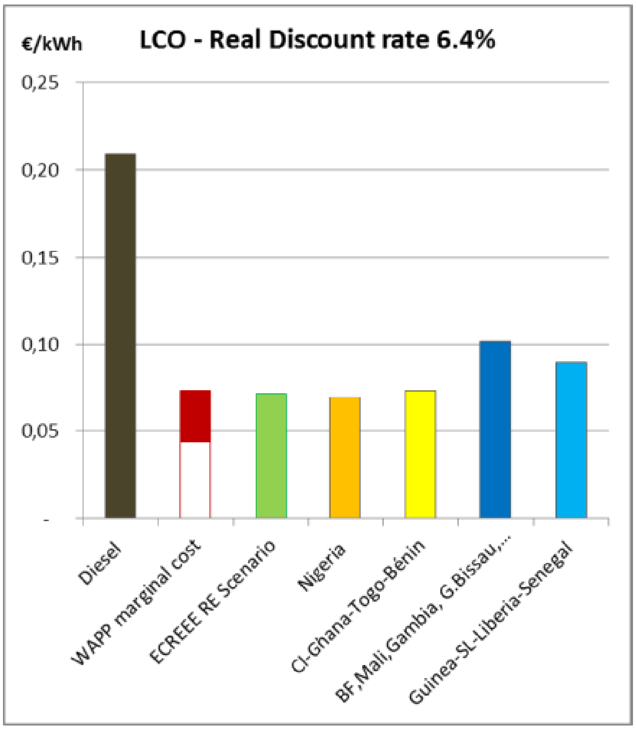


Figure 64: LCOE of the EREP scenario in comparison with other options

By taking into account the costs of negative environmental externalities of conventional power production (e.g. pollution, carbon emission costs), the EREP scenario becomes even more competitive (see calculations in the annex). Under these conditions, the EREP scenario becomes competitive with the LCOE for Nigeria, Côte d'Ivoire, Ghana, Togo and Benin, and is quite lower for the other countries.

Therefore, the following conclusions for Grid-connected EREP options:

- EREP renewable energy scenario is fully competitive under commercial conditions for countries relying today on diesel generation, as over a 25 year period, the EREP levelised cost will be from 0,7 c€/kWh to 1.7 c€/kWh, lower than a reference cost associating diesel generation up to 2018-2021 and WAPP options for the remaining period. This conclusion concerns the following countries: Burkina, Guinea Bissau, Mali, Gambia, Niger, Guinea, Sierra Leone, Liberia, and Senegal.
- For the other countries like Nigeria, Côte d'Ivoire, Ghana, Togo and Benin, EREP renewable energy options remain an interesting solution:
  - By selecting the cheapest options for the specific countries ;
  - By getting some financial support to mitigate the cost difference during a period where the Renewable Energy technologies' investment costs are remaining high
  - or by applying the externalities costs on the options

Renewable Energies will need some financial support during the first years of the learning process to initiate the development of a regional market for renewable energy which is a key weakness and one of the major barriers to cost reduction.

12.3.3 Robustness of set targets by considering energy efficiency improvements

These targets are established on the basis of the baseline demand forecast carried out by the WAPP's revised master plan. The ECOWAS Energy Efficiency Policy (EEEP) plans, a reduction of the regional power demand of 30% equally distributed among savings in the domestic sector, and a reduction of power system losses and other energy efficiency measures.

2030	Baseline demand forecast	EE demand forecast
Capacity demand in MW	39,131	27,392
Energy production in GWh	243,901	170,730
EREPEREP options in MW	19%	28%
EREP RE production in GWh	12%	17%

If the targets are maintained, the contribution of EREP in terms of electricity produced will grow from 12% to 17%.

If the WAPP master plan is also fully implemented, the overall share of renewable energy production will grow from 31% to 44%.

In terms of capacity penetration, the volume of regional solar and wind production planned in the WAPP and the EREP will be of 4,918 MW by 2030 (800 MW for the WAPP and 3,118 MW from EREP), corresponding to 18% of the total capacity demand by 2030. This proportion would remain fully compatible with the requirement of grid and voltage stability.

12.3.4 Impact of RE capacity factors on RE targets

The penetration targets are given as a percentage of the installed capacity. The targets indicating the annual volume of power produced depend on the capacity factors of the various RE technologies:

- For small-scale hydropower, the average capacity factor in the region is around 50% and the penetration target will be practically the same in GWh or in MW as the average capacity factor for the whole power system is fluctuating from 40 to 60% depending on the countries' level of industrial activities. In some cases, the capacity factors might be much higher than 50%. An analysis of various SSHP CDM projects has shown capacity factors between 20 and 95% (average 52%).

- For biomass, provided that the plant capacity is properly designed with regard to the resources, the penetration rate related to energy can be higher, as a biomass capacity can operate fullest at almost 90-95% of the time.
- For solar PV, the penetration rate related to the capacity (MW) will be less than half of the penetration rate when related to energy (GWh). For CSP technology, the difference is smaller as the yield of CSP is higher.
- For wind, it will depend on the wind regime. For good wind regime, there will not be major difference between the two ways to express the penetration rate. For less propitious wind regimes, the penetration rate in MW will generate less energy than the same target related to energy.

12.3.5 Availability of RE resources to fulfil the policy targets

This issue won't constitute a technical barrier as the resource is deemed sufficient. The resources are generous and well distributed among the ECOWAS countries:

- **Wind potential** is concentrated on costal zones (Cape Verde, Senegal, Gambia, and possibly Ghana, Mali and Nigeria). The overall wind assessments provide only general information on the potential that need to be refined locally with a survey and a measurement campaign to verify the strength and the seasonal variation of wind regimes in order to state the financial viability of the potential.
- **Small-scale hydro potential** is located mainly in the southern part of the region while solar resource is abundant in the northern regions (Niger, Burkina Faso, Niger and the northern part of Ghana and Nigeria). Except for Cape Verde and the Sahelean areas of Mali, Burkina Faso, and Niger, biomass resources are well distributed among the region, with a propitious potential in the Southern regions according to the pluviometry.
- When considering **biomass resources**, it is important to distinguish: (i) the diffused biomass resources from agricultural by-products, which is generally costly to collect and transport in large quantities, and for that reason can be used locally, and (ii) the concentrated resources at the agro-industries sites like rice husks, cotton seed shells, ground nuts and cashew shell, saw dust, manures and dongs at dairies or slaughterhouses, which can constitute proper resources for cogeneration. Under the same category are the urban wastes.

  Finally, **solar resource** is especially favourable in the northern desert areas of the ECOWAS region in Mali and Niger and in the North-Eastern part of Nigeria with a potential of 1700 kWh/installed kWp/year. The coastal areas from Liberia, Côte d'Ivoire, Ghana and Nigeria do not benefit to the same extent from this resource with an average potential of 1200 kWh/installed kWp/year. For the remaining areas, the average potential is about 1500 kWh/kWp/year.

12.3.6 Technical feasibility of RE grid integration

This will depend on the extent and the quality of the various national grids at different voltage levels, the regulating firm capacity available on the regional and the national grid and the quality and the experience of the regional and national dispatching centres. Only wind energy and PV solar plants to a less extent need regulating capacity to compensate for the intermittency of their production. It is expected that the WAPP programme, upon full realisation by 2017/21, will bring the sufficient grid and voltage stability at regional level, as the major sources of power generation will be larger hydro plants and thermal gas plants. Meanwhile, the member states have to rely on their own hydro and thermal capacity, and on the share of energy import, to create the sufficient grid stability required for additional renewable energy generation. Therefore, the EREP should include as preliminary activity, the carrying out of a technical diagnosis of national grids and dispatching facilities, in order to identify and access the areas of improvements enabling a better penetration of renewable energy capacity.

12.3.7 Economic and financial feasibility of RE

As stated in the financial assessment of renewable energy solutions, most of the grid-connected technologies have lower production costs than diesel based production. For some technologies such as wind, SSHP and bioelectricity, the production costs will be comparable to the envisaged generation costs by the WAPP Master Plan. It is also expected that the renewable energy options will propose lower cost as they have been going through their learning phase and a general price reduction. To be economically acceptable, the additional renewable energy options 'levelised cost should be lower than the national grid parity for the reference scenario calculated for the renewable energy options' life period. For off-grid systems, the question is purely economic as the number of mini-grids is already based on assumptions optimizing the demarcation between grid and off-grid supply. The question will be to assess whether hybrid or 100% renewable energy options are less expensive than traditional diesel based generation.

12.3.8 Delays in the WAPP Master Plan implementation

In case of a 3 year delay of the WAPP priority projects, the deficit of capacity in 2020 and 2030 will be respectively 4,172 MW and 4,025 MW corresponding to 18% and 11% of the required capacity. This deficit could be met by similar or slightly higher targets for additional renewable energy penetration related to capacity increase, depending on the level of wind and solar penetration having a capacity factor lower than the load factor.

12.3.9 Smart grid opportunities

The main problems with some RE sources are availability: wind and solar power are not always available where and when needed. Unlike conventional sources of electric power, these renewable sources are not "dispatchable"—the power output cannot be controlled. Daily and seasonal effects and limited predictability result in intermittent generation. Nowadays, the following rule of thumb is to say that intermittent RE production should not exceed a level of 20% on stable grid. Presently, the stability of the national HV grid is at the limit to be acceptable but need important improvement to cope with regional standards for grid integration. At that time, the WAPP integration policy will be possible. Therefore, one cannot except to have reliable HV grids at disposal within a period of 5 years. For example, the Nigerian grid cannot be presently synchronized with the Ghana-CI-BF due to the poor quality of its frequency control.

Smart grids promise to facilitate the integration of renewable energy and will provide other benefits as well. Industry must overcome a number of technical issues to deliver renewable energy in significant quantities. Control is one of the key enabling technologies for the deployment of renewable energy systems. Solar and wind power requires effective use of advanced control techniques.

Therefore, smart grid technologies work at the present time to secure a penetration rate of intermittent RE power generation to at least of 20% of the actual load on the grid. Smart grids are also developed to manage distributed RE power production (PV roof top).

12.4 Setting the targets for off-grid rural electrification

Based on the previous analysis the following off-grid targets were determined for the EREP:

Table 38 : Targets for RE Off-Grid Applications

Least-cost option	2010	2020	2030
Share of rural population served by RE off-grid solutions (mini-grids and stand-alone systems)		**22%**	**25%**

To reach the White Paper's targets in 2020 and universal access in 2030, the number of electricity supply systems to be installed was determined as follows:

- Grid connected rural electrification 32,000 (2012-2020) and 32,100 (2020-2030)
- Off-grid RE supply systems: 60,000 (2012-2020) and 68 (2020-2030)
- Stand-alone individual RE system 210,000 (2012-2020) and 262,000 (2020-2030) based on an assumptions of 10 people per rural households.

For grid-connected rural electrification, no additional targets for renewable energy are set as they are included in the targets for grid connected renewable energy options. For the off-grid applications, each mini-grid's power generation is in itself a candidate to include a renewable energy option - as PV solar, biomass as biogas plant or gasifier or biofuel, SSHP, and possibly small wind turbines. The most relevant options will consist in developing hybrid systems combining a diesel generation to a renewable energy option in order to limit the cost of the expensive power storage capacity.

Table 39 : Target for Domestic applications and biofuels

Least-cost option	2010	2020	2030
Biofuels (1st generation) Ethanol as share of Gasoline consumption Biodiesel as share of Diesel and Fuel-Oil consumption		 5% 5%	 15% 10%
Improved cook-stoves - % of population	11%	100%	100%
Efficient charcoal production share-%		60%	100%
Use of modern fuel alternatives for cooking (e.g. LPG) - % of population	17%	36%	41%
Solar water heater technologies for sanitary hot water and preheating of industrial process hot water: ▪ Residential sector (new detached house price higher than €75,000) ▪ District health centres, maternities, school kitchen and boarding schools ▪ Agro-food industries (preheating of process water)		 At least 1 system installed 25% 10%	 At least 1 system installed 50% 25%

▪ Hotels for hot sanitary water		10%	25%

12.4.1 Off-grid and stand alone or micro systems

The **market for mini-grids and decentralized supply systems** will typically address the need of rural populations living in rural centres and villages with population comprised between 200 and 2,500 inhabitants. Some larger cities can be included in this market segment according to their peripheral geographical situation vis-a-vis the national grid. This market will supply 71.4 million inhabitants living in 60,000 localities by 2020 and 104 million living in 96,000 localities by 2030. Some of the off-grid localities supplied before 2020 (estimated to 32,000) might be included in the grid extension as they will have grown up and their EREP renewable energy options connected to the grid. Therefore, the number of mini-grids to be established after 2020 is of 68,000.

12.4.2 Diesel generation cost as reference

With an average unit consumption of 350 g/kWh and a levelised price for DDO of 0,94€/kg taking into account a constant price escalation of the barrel price of 1.84% up to 2020 and 1.19% after 2020 (IRENA assumptions), the fuel cost per kWh produced is about 33 c€/kWh. The capital cost can be estimated to 2-3 c€/KWh. Including operation and maintenance costs, the production cost for a diesel production reference can be roughly estimated at 40 c€/kWh

12.4.3 Grid-connected rural electrification cost

The reference cost for energy supplied by grid connected rural electrification comprises the line capital cost and its maintenance as well as the energy bought from the national grid.

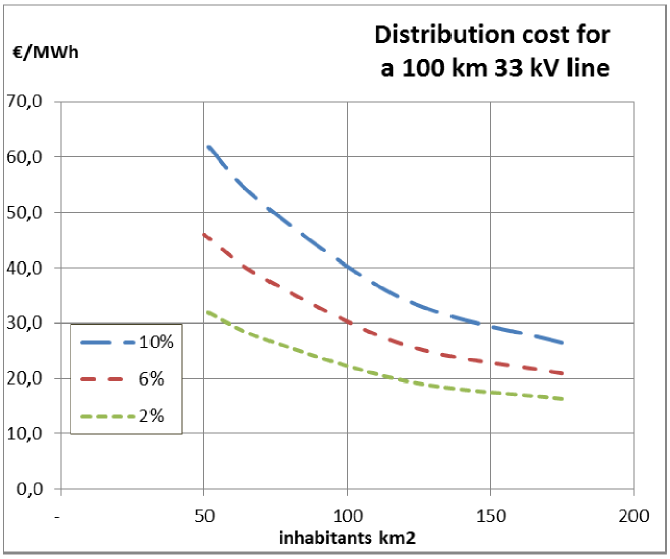


Figure 65: Optimized rural distribution cost for a 33 kV line

Figure 45 illustrates the distribution cost for a 100 km rural distribution line (54.4 mm^2 Almelec) as a function of the population density served by the line in a 30 year period. For commercial conditions (10% on the chart), the cost of distribution is about 6.2 c€/kWh in an optimized configuration (all the localities under and in the vicinity of the line are connected and the capacity of the line is optimized). Generally, this does not occur as the cost of transformers to serve small settlements are too expensive compared to the electricity sales. In the case of non-optimized use of the line, the distribution cost can be multiplied by two or three to a value of 12/18 c€/kWh.

The minimum and maximum LCOE for a WAPP option are calculated to respectively 8 and 13 c€/kWh. This cost includes 15% losses up to the consumer. The resulting on-grid rural electrification cost can be assessed to be comprised between 20 and 31 c/kWh.

Compared to the fuel cost for diesel thermal production, the capital cost of the renewable energy production per kWh (18 to 24 c$/kWh for a PV hybrid system) is lower than the DDO cost of 33 c€/kWh. A simple return on investment shows that fuel expenses can pay back the RE option investment in 7.2 years for the investments made during the period 2014-2020 and 5.2 years for the other investments.

Compared to a 'fictive' on-grid rural electrification tariff, since these localities will not be connected to the grid, the mini-grid is equivalent to a grid-connected solution over the period 2014-2020 and slightly more economic for the following period.

Table 40: Example of Mini-grid dimensioning and costing (PV hybrid with limited storage capacity)

Assumptions

Locality average size:	1,200	inhabitants		
No of inhabitants/household	8			
No of household	150			
No of connections/km LV line	30			
Length of the LV grid	5	km		
Unit price in €/km	9,000	€	Grid investment cost	
			45,000	€
Average cost for generation			Investment in generation	
2014-2020	3,500	€/kW	238,000	€
2021-2030	2,500	€/kW	170,000	€
Load demand - 1.5 A @ 220 V	50	kW		
RE capacity	68	kW		

Total investment costs in M€	No of mini-grid	Invest per mini-grid	Total investment	
2014-2020	60,000	0.283	16,980	M€
2021-2030	68,000	0.215	14,620	M€
2014-2030			31,600	M€

Financial assessment

Energy production /unit	100	MWh	
Diesel consumption	35,000	kg	
DDO price /kg (Levelised)	0.94	€/kg	
Fuel expense	32,905	€/year	
Return on invest/fuel expenses	7.2	years	2014-2020
Return on invest/fuel expenses	5.2	years	2021-2030

Capital cost - 2014-2020	26	c€/kWh
Capital cost - 2021-2030	18	c€/kWh

Fuel cost for diesel generation	33	c€/kWh

WAPP LCO max 15% losses	8	c€/kWh
WAPP LCO min 15% losses	13	c€/kWh
Distribution cost	>12	c€/kWh
Resulting on-grid supply	20< <25	c€/kWh

12.4.4 Stand-alone applications

The stand-alone system's cost is calibrated on a 30/40 Wp solar home system which actually can be estimated at 120 €. With an economic life time of 15 years and a maintenance cost of 60 € (1/2 of the investment) equally distributed in this period, the monthly fee to this service with a real discount rate of 10% is 1.42 € or 17 €/year.

The financial assessment for off-grid solutions indicates that hybrid systems with a renewable energy power generation option at a unit cost comprised between 2.5 and 3.5 million €/MW, can be competitive with a 100% diesel generation option (0.6 million €/MW). For stand-alone system, modern modular PV option will be able to provide in few years an AC 220 volt service for domestic needs as lighting, refrigeration, ventilation and leisure.

12.5 Setting targets for improved cook-stoves, charcoal burning and modern domestic fuel

In the reference scenario, the penetration of modern cooking fuel and cooking equipment is kept at their 2010 level while the assumption of the consumption shift from fuel wood to charcoal is applied.

In this case, the total demand for tons of wood to meet the demand for firewood and charcoal grows from 103.4 million tons in 2010 to 155.6 million tons in 2020 and 254.8 million in 2030.

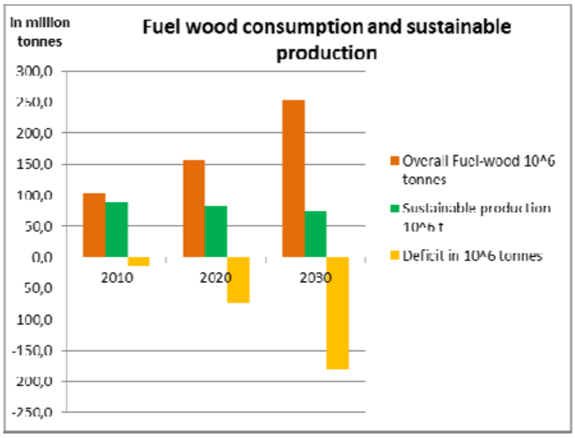


Figure 66: Reference scenario

Already in 2010, the sustainable ECOWAS woodland's fuel wood potential is less than the actual demand which means an overexploitation of the resource that can be assessed at an 'over-exploitation' index of 16%, corresponding to the gap between demand and sustainable resource over this sustainable resource. If nothing is done, this index will increase rapidly to reach a value of 91% in 2020 and 241% in 2030, with rapid potentially irreversible afforestation as consequence.

Besides the development of sustainable forestry that is of the competence of the environmental authorities, three energy related measures are analysed in order to identify energy related targets for the domestic energy sector.

Impact assessment of the improved cook-stoves

The first measure tested on this model is the reduction in fuel wood demand by implementing a policy of energy efficiency through the promotion of improved stoves for fire wood charcoal and seeking a substantial energy efficiency gain. The objectives of this policy are summarized in the following table:

Table 41: Cook-stove efficiency

	2010	2020	2030
Efficient urban wood cook-stove	15%	23%	30%
Efficient charcoal cook-stove	20%	28%	35%
Efficient rural wood cook-stove	12%	18%	25%

The objective is to significantly improve over a period of twenty years the efficiency of the stoves using wood and charcoal. The development of regional standards and labels for quality efficient cook-stoves has to be carried out to have a common reference. The second action is to agree on a common regulatory framework by prohibiting manufacturing and sale of inefficient stoves by, for example 2020, in order to avoid inefficient use of the resource as of 2020.

In terms of actions, it is necessary first to promote the know-how needed to secure the efficient production of good quality cook-stoves. This knowledge exists already. However, it has to be compiled and disseminated. The craftsmen manufacturing these stoves need to be informed about the coming ban, and a support to the entrepreneurial approach in order to adopt models similar to the Malian one should be considered. In a short transition period, micro-credit schemes for low-income households should be available to support the behaviour shift in purchasing cooking stoves at a value from 4 to 6 Euros. Nevertheless, it is essential to achieve a regional consensus on the obligation to manufacture and sell only improved stoves and to ban the inefficient ones. The longevity and efficiency of the improved stoves will in the long term generate a profit for the user. It is also necessary to avoid any idea of subsidizing this activity which should develop on commercial basis. In terms of results, this scenario has significant effects on the forest resources over-exploitation index as shown in following figure.

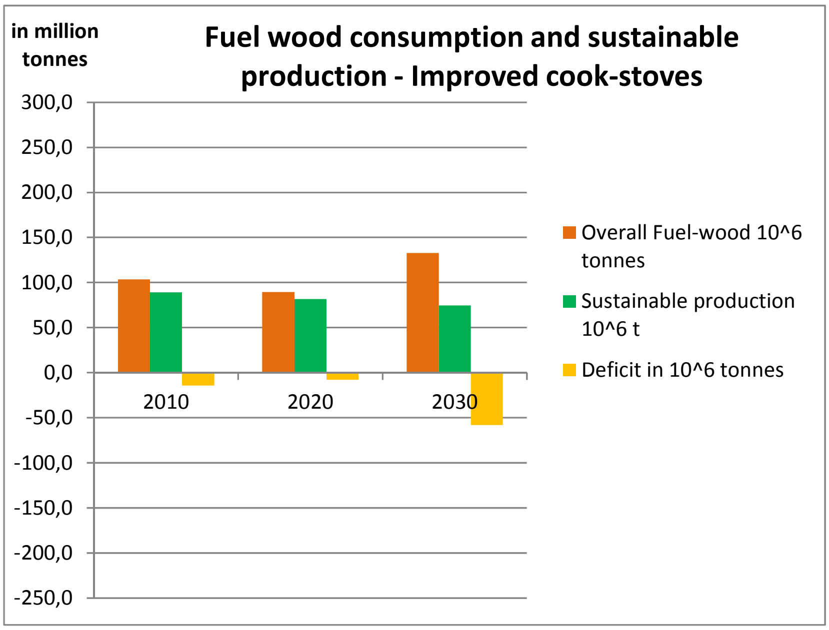


Figure 67: Efficient cook-stoves measures

The 2030 index that was of 241 % in the reference scenario is reduced to 86 %. Following the decision of banning the inefficient products from the market by 2020, the demand is dramatically diminished, reducing the pressure on the natural resources.

12.5.1 Efficient charcoal burning

The second measure tested is the performance improvement of carbonization which could increase from 12% today to 25% by 2030. A yield of 12% means that it takes 7 kilos of wood for a kilo of charcoal while a yield of 25% reduces the need for wood to 4 kg per kg of charcoal.

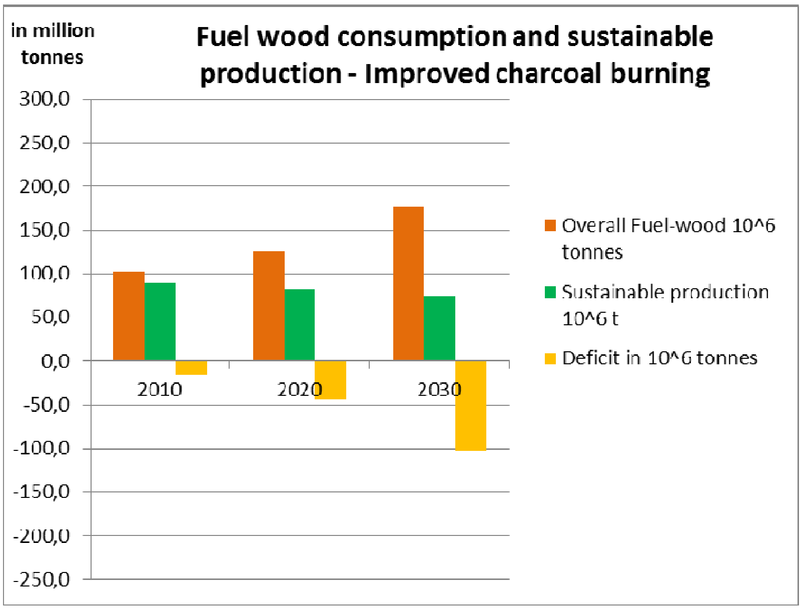


Figure 68: Efficient charcoal burning

This measure is also effective, and helps to shift the forest overexploitation index of 241% to 136% in 2030. The implementation of this measure is more complicated than the previous one since it requires both a training component of charcoal burners to more efficient techniques, and at the same time a monitoring to ensure that these new skills are being effectively applied by charcoal burners. Illegal charcoal production has to be controlled and eradicated. Since part of the production of charcoal is actually not controlled, this measure should be integrated as part of a policy for sustainable management of forest resources involving more directly the responsibility of the local population.

12.5.2 Combining both efficient cook-stove and efficient charcoal burning

By combining both identified measures (banishment of inefficient cook-stoves in 2020 and efficient carbonization in 2030), the index for overexploitation is reducing strongly. From 11% in 2010, it reverts in 2020 and again showing a value of 15% in 2030. As the woodfuel resources are not equally distributed, the issue of severe deforestation remains for Nigeria, if massive use of modern cooking fuel was not promoted.

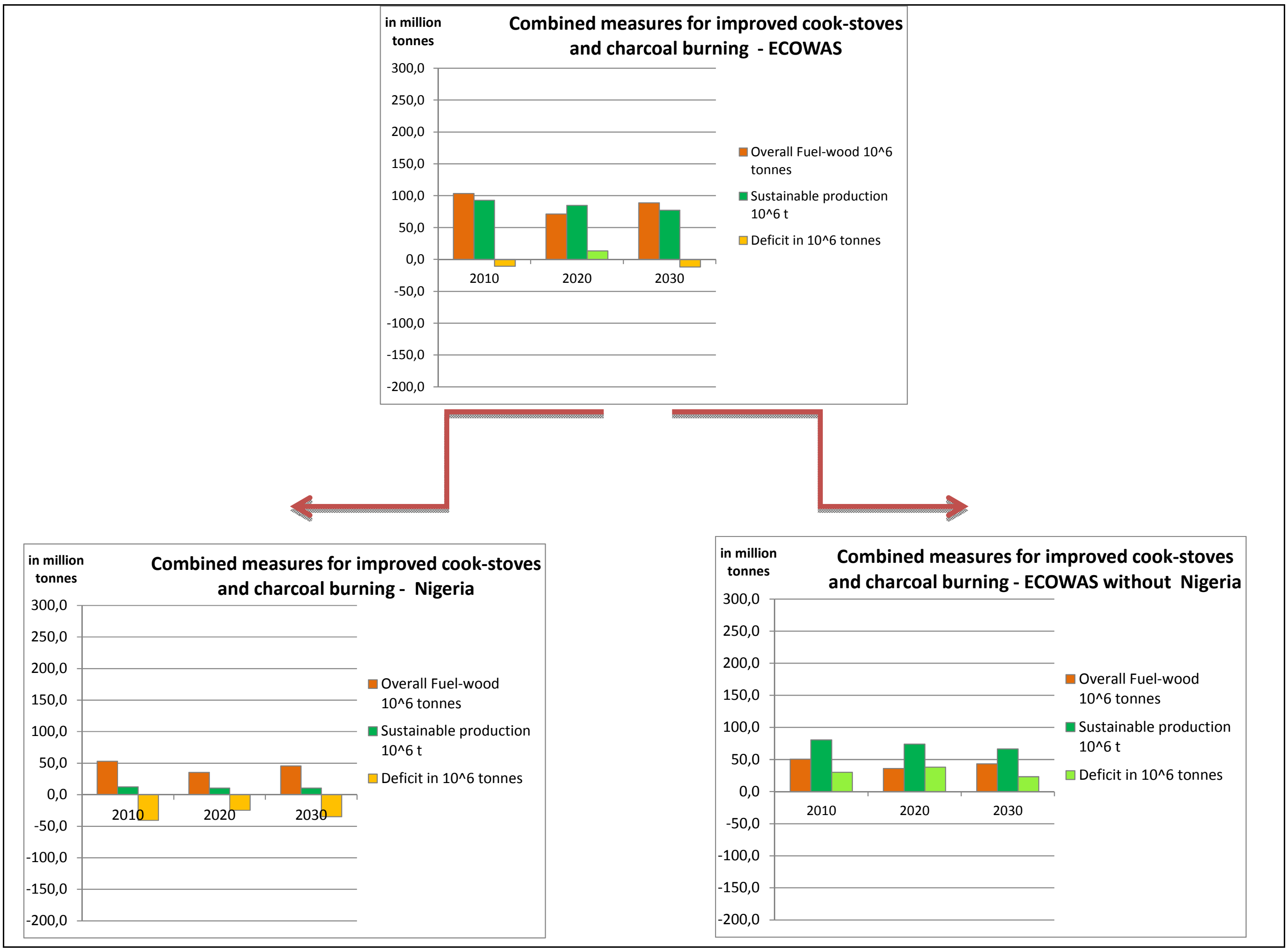


Figure 69 : Impacts of combining both previous measures

12.5.3 Substitution of fuel wood by modern fuels

The last practical measure that can be considered is to increase the share of modern energy in the mix of domestic energy in the ECOWAS. If utilized in a correct way, one of the benefits of modern energy is its high energy efficiency with a yield of 75%. Its drawback is the fact that they are petroleum products such as butane and kerosene; the prices of which are relatively high, if consumption is not subsidized. An alternative is to use biofuels produced locally, but prices are still not really competitive. Past policies have been subsidizing this type of energy. Increasingly, taking Senegal as example, governments are moving away from subsidies to pursue a policy of true prices. Burkina Faso, which still applies a large percentage of subsidies on the LPG cylinders under 12 kg, must pay on the finance law the subsidy amount to more than 10 million Euros per year for the sale of 30,000 tons covering only 5-6% of the national domestic energy.

The actual baseline for modern cooking fuel is a penetration rate of 17% due to the large use of kerosene in Nigeria accounting for 2/3 of the 17%. The penetration rate is 12% for LPG in the ECOWAS countries excluding Nigeria, and 22% for kerosene in Nigeria.

Maintaining the level of penetration for modern cooking fuel will not be sufficient in the case of Nigeria even if both previous measures are fully applied. For the other countries, the overexploitation of the woody resources will again speed up at the end of the period.

Therefore, the targets for modern cooking energy are set to restore the balance between sustainable fuel wood production and demand.

In that case the use for LPG in the ECOWAS countries (except Nigeria) should grow from 12% by 2010 to 20% by 2030 and the use of kerosene in Nigeria from 22% by 2010 to 60% by 2030.

The resulted aggregated targets are 17% by 2010, 36% by 2020 and 41% by 2030.

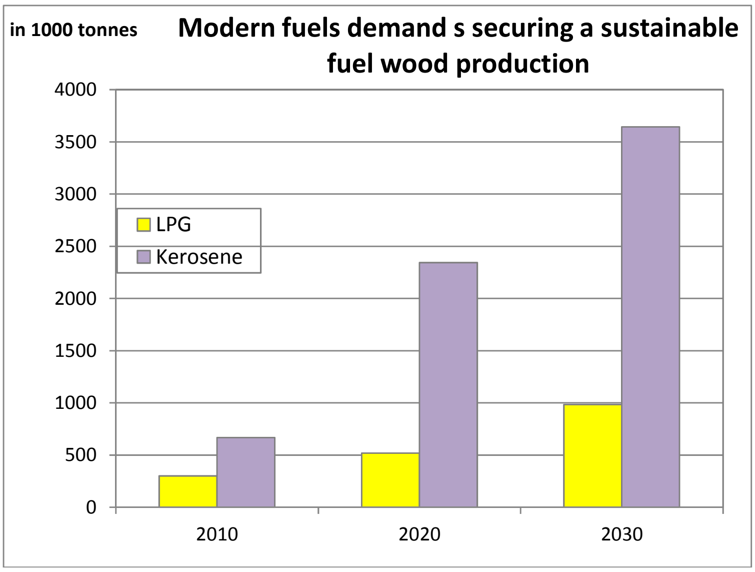


Figure 70: Resulting needs for modern cooking stoves

12.5.4 EREP Scenario for domestic energy

EREP scenario for domestic energy is to combine the three measures proposed. However, it must be noted that the second measure on improving yields of carbonization is part of a policy of natural resource management under the supervision of the Ministries in charge of environment and sustainable development; and that the third measure, can only be sustainable if the shift from wood energy to modern energy occurs on a basis of non-subsidized prices. The combination of the three measures does lead to a return of the balance between supply and sustainable forest cover energy demand of the people.

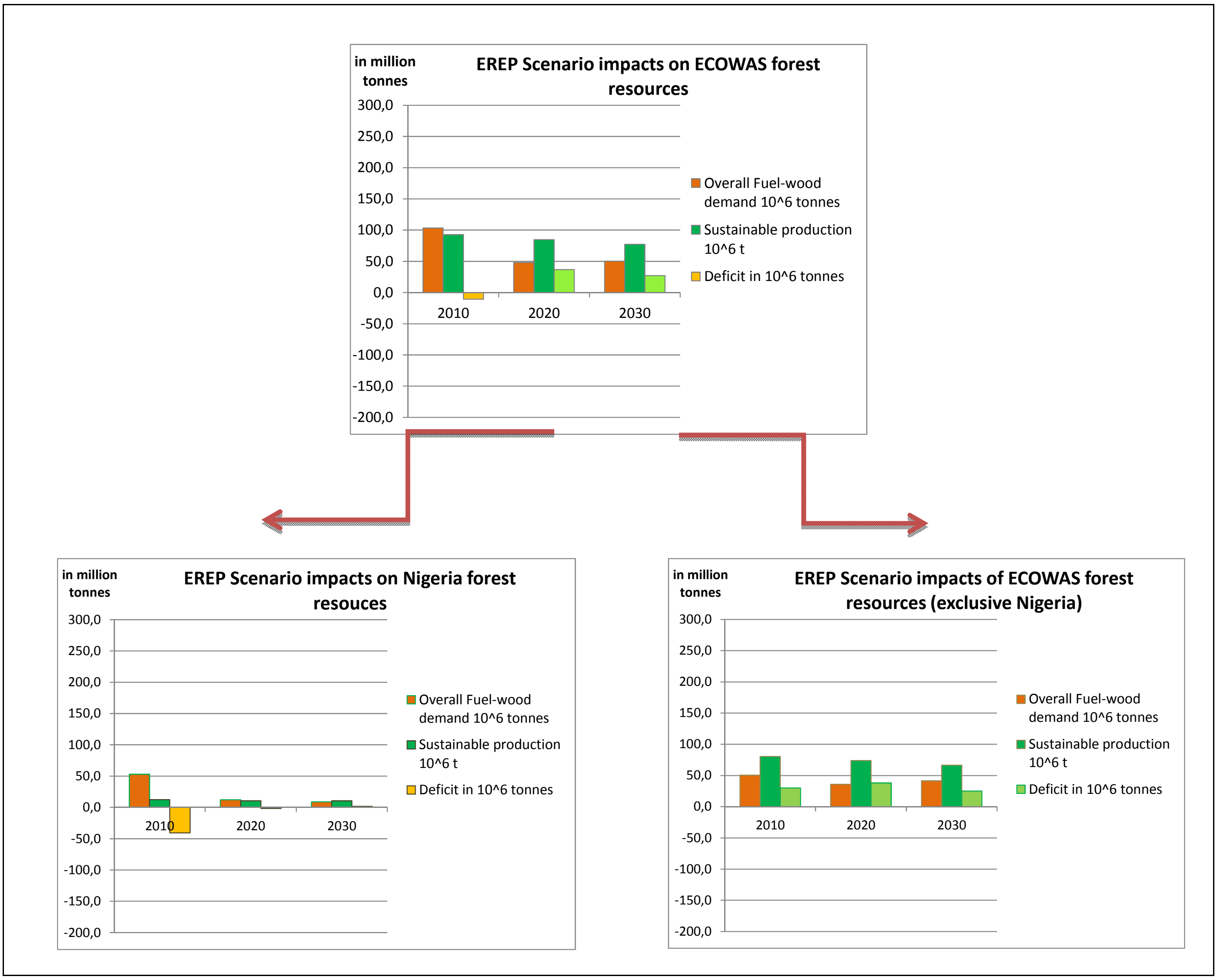


Figure 71: The ECREEE scenario for domestic energy

13 ANNEX I: WAPP List of Projects

Countries	RE Technologies and RE Capacities as decided or candidate projects	RET and RE Capacities proposed as additional investments (from 2016, from 2021)
Senegal	Biomass (30MW) Wind (125MW) Solar PV (7.5MW)	Wind (100MW, 100MW) Solar PV (100MW, 100MW)
Gambia	Wind (11MW) Solar PV (10MW)	Wind (40MW, 40MW) Solar PV (20MW, 20MW)
Guinea Bissau	No RE projects planned	Solar PV (20MW, 20MW)
Guinea	No RE projects planned	No additional RETs proposed due to comprehensive large hydro power investments
Sierra Leone	Biomass (115MW) Solar PV (5MW)	Biomass (125MW, 125MW)
Liberia	Biomass (35MW)	Biomass (35MW, 35MW) Solar PV (20MW, 20MW)
Mali	Biomass (18MW) Solar PV (80MW)	Solar PV (150MW,150MW) Thermal Solar (50MW,50MW) Biomass (20MW, 20MW)
Côte d'Ivoire	No RE projects planned	No additional RETs proposed due to comprehensive investments in large gas CC power plants and poor Wind and solar resources
Ghana	Wind (150MW) Solar PV (10MW)	Wind (100MW, 100MW) Solar PV (100MW, 100MW)
Togo	Wind (20MW) Solar PV (5MW)	Wind (50MW, 50MW) Solar PV (25MW, 25MW)
Benin	Solar PV (30MW)	Solar PV (70MW, 70MW)
Burkina Faso	Solar PV (43MW) Thermal solar (4MW)	Solar PV (150MW, 150MW) Thermal Solar (50MW, 50MW)
Niger	Wind (30MW) Thermal Solar (50MW)	Wind (30MW, 30MW) Solar PV (20MW, 20MW)
Nigeria	No RE projects planned	Wind (300MW, 300MW) Solar PV (250MW, 250MW) Biomass (200MW, 200MW)

With regards to the different regional projects progress, the situation is the following:

1. For the Coastal Backbone, the Ghanian part of the 330 kV system is operating since September 2010. For the following sections Riviera (IC)-Prestea (Ghana) and Volta (Gh)-Lomé C (Togo)- Sakété (Benin) their funding is secured and their commissioning is

respectively expected in 2015 and 2014. The last part of the Costal Backbone connecting the Zone A system to Nigerian system is not yet financed and the project is at the stage of preparation. Nevertheless, the commissioning of the section Saketé-Ikeja-West is expected in 2017.

2. The 330 kV line called North Core connecting Birnin Kebbi (Nigeria) - Bemberke (Benin). – Niamey (Niger) – Ouagadougou (Burkina Faso) is at a stage of pre-investment study and commissioning is expected in 2017.
3. For the Inter-zonal transmission hub, the line 225 kV connecting Ouagadougou to Bobo (BF) already connected to IC is in operation since 2010. The 225 kV line between Ouagadougou (BF) to Bolgatanga (Gh) will be commissioned in 2015. The financing is secured and practically acquired. The 225 kV connecting Ferkessedougou (IC) to Ségou (Mali) is under construction and its commissioning is expected in 2013. The 330 kV line Aboadze – Prestea – Kumasi – Bolgatanga (all Gh) is at level of pre-investment. It will enable the completion of the Coastal Backbone (Aboadze – Prestea) and links this Coastal Backbone to the Burkina, which is quite vital as the Ghanaian national grid south for Bolgatanga has a limited transfer capacity. It is expected that the commissioning will occur in 2015. The Han(Gh)-Bobo Dioulasso (BF)-Sikasso (Mali)-Bamako(Mali) 225 kV line is at pre-investment level and its financing is still required. However it is planned to be commissioned in 2016. And finally, the 225 kV Nzerekore (Guinea)-Fomi (Guinea)-Bamako(Mali) line connecting the potential hydro resource from Guinea to the Mali-Senegal and to the WAPP zone A system is at a pre-investment stage, but is foreseen to be commissioned in 2016.
4. Within the OMVS activities, the 60 MW Felou hydropower project should be commissioned in 2013-14. Funded by WB and AfDB, the project is under implementation.
5. The OMVG project should secure power supply to Senegal, the Gambia, Guinea-Bissau and Guinea. It comprises the construction of two Hydropower facilities at Sambangalou (128 MW) and at Kaleta (240 MW) and 1,677 km of a 225 kV transmission line interconnecting 4 countries. The Government of Guinea has launched construction of the Kaleta dam, and pledges made from Funding Agencies can now cover the construction of the interconnection line; the project is expected to be commissioned in 2016-17. However, the recent decision (August 2011) of Guinea Conakry to finance from the national budget the Kaleta dam (240 MW) raises many uncertainties. The financial partners are encouraged to redirect their funds towards the interconnection project and the dam of Sambagalou (128 MW) closed to the Senegal border. Currently, negotiations are focusing on the conditions for attributing shares of production capacity to other member states. A new financing plan must be prepared. There are efforts to develop the hydro potential of the HP Saltinho (18 MW) and Cusselinta (30 MW) in Guinea Bissau.
6. And finally, the CLSG sub-programme for the four countries: Ivory Coast, Liberia, Sierra Leone and Guinea. The project consists of the construction of a long interconnection HV line connecting the following substations: Man (Cote d'Ivoire) – Yekepa (Liberia) – Nzérékore (Guinea) – Buchanan (Liberia) – Monrovia (Liberia) – Bumbuna (Sierra Leone) – Linsan (Guinea), the reconstruction of Mt. Coffee / Development of St. Paul Hydro Plant in Liberia, and the construction of 515 MW and 118 MW hydropower capacities, respectively at Souapiti and Kassa 'B'. The design of the long transmission line in a mountainous terrain constitutes a technical challenge and has been subject to many changes. The overall estimated costs total US€ 330 million. Donor Consultation Meetings have already identified a pool of donors (WB, AfDB, EIB and KfW) ready to mobilize the necessary finances for project implementation. Bidding documents are being finalized and funding agencies and involved countries have to finalize the financing arrangements; the commissioning is expected for 2017.

Regarding the regional capacity development

1. ***147 MW WAPP Adjarala Hydropower Facility (Togo)***. This project is presently at a level of pre-investment and processing for financing. The funding is still required. The commissioning is expected at the end of 2017.

2. ***118 MW Kassa B Hydropower Facility (Guinea)***. This project is also at level of pre-investment, and will depend on the CLSG line to evacuate the produced electricity. Discussion on the trace of this line is still on-going. The commissioning is foreseen in 2016-17

3. ***515 MW Souapiti Hydropower Facility***. The project is at a pre-investment study level. The produced electricity is foreseen to be evacuated by the CLSG and OMVG transmission lines, which have to be built during the same period. Terms of Reference for update of the feasibility study are prepared and validated by EDG and the ministry in charge of energy in Guinea and its financing is requested; Expected Commissioning: 2018-19

4. ***64 MW WAPP Mount Coffee Hydropower Facility (Liberia)*** destroyed during the civil war. It seems that the financing is secured, as approximately US$182 million have being mobilized from EIB, WB, KfW and AfDB to implement the project. Preparatory studies will soon be launched - Expected Commissioning: 2015-16.

5. ***450 MW Maria Gleta Power Generation Facility***:

   The land is acquired in Benin and the Pre-Investment Studies is completed

6. ***400 MW Aboadze Power Generation Facility***:

   The land Acquisition in Ghana is in progress at the new site of Domunli/Bonyere

   The selection of a private company to develop in partnership with the WAPP the Maria Gleta and Aboadze plants is completed after successful competitive bidding process.

7. ***150 MW OMVS Power Generation Facility***:

   Government of Senegal has confirmed its willingness to incorporate WAPP requirements in its coal-fired generation program.

Décidés	Phase 1	Phase 2	Phase 3
Charbon 875 MW (Sénégal)			
Gouina (OMVS)	Interconnexion Kayes –Tambacounda		
	Eolien 200 MW (Sénégal-Gambie)		
Interconnexion Ghana-Burkina Faso Mali	Balassa- Badoumbé Interconnexion Linsan-Manantali (1er terne)	Koukoutamba-Interconnexion Linsan-Manantali (2nd terne)	Boureya
Kaléta (Guinée)			
Projet OMVG			Digan
			Grand-Kinkon
	Souapiti	Amaria	
Projet CLSG (+ Mount Coffee)	Bumbuna		
		Kassa	
		Projet Tiboto	
Félou (OMVS)			
		Solaire 150 MW (Mali)	

Décidés	Phase 1	Phase 2	Phase 3
Interconnexion Ségou-Ferkessedougou		Fomi-Boundiali	
	Projet Fomi		
	Projet Soubré		
Projet Dorsale Côtière			CC Togo
Aboadze (Ghana)			
Adjaralla (Togo)			
Maria Gleta (Bénin)			
Bolgatanga-Ougadougou	Axe 330kV Nord-Sud Ghana		
	Solaire 150 MW Burkina Faso		
	Projet Corridor Nord	Projet Salkadamna	
		Réseau 760kV	Mambilla
	Zungeru	Dorsale Médiane	
			Eolien 300 MW Nigeria Nord
			Renforcement Bénin Nigéria
6894 M$	**5726 M$**	**5724 M$**	**5887 M$**

14 ANNEX II: Incentive schemes for renewable energy

14.1 Feed-in-Tariffs (FIT)

14.1.1 Definition of the theoretical approach

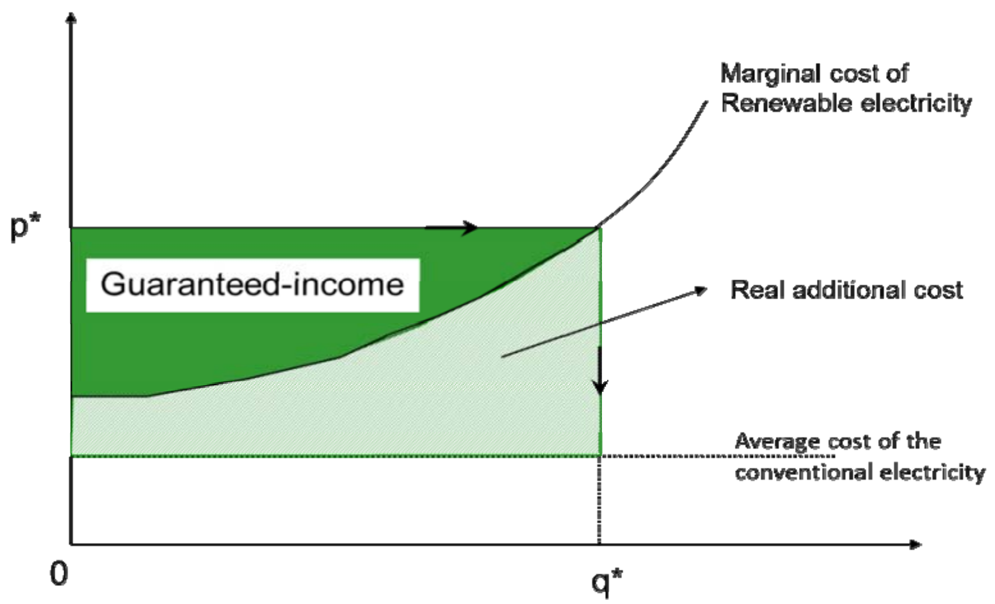
Feed-in-tariff (FIT) is a political mechanism seeking the emergence of private RE electricity generation through the fixation of incentive purchase tariff stimulating the private investments in this sub-sector.

FIT will secure a RE Independent power producers (RE-IPP) developing a power production based on solar PV, wind power, biomass, ... access to a guaranteed market as well as an acceptable return on investments. It includes generally three main measures:

- Guaranteed grid access,
- Long-term contracts for the generated electricity,
- Purchase prices which are calculated on RE generation cost.

This system makes obligation to the utility to buy renewable electricity produced by the RE- IPP on its grid, at a fixed price, decided by public authorities and guaranteed over a certain period. The purchase price calculated on the basis of the generation cost insures the investors their projects profitability and allows at the same time the development of the RE sector on an entrepreneurial basis. These incentive prices may represent generally an additional cost imputable to the consumer (or sometimes to the taxpayer via a solidarity fund or a contribution to the public service).

Figure 72 : Feed-in-Tariff system



The theoretical curve for RE marginal costs covers a panel of RE solutions from the cheapest solution to more expensive technologies (following the merit order principle). By fixing a price at p* level the planner or the regulator expects to mobilize through private investments an electricity quantity q*, that will be generated by the panel of RETs for the cheapest to a RET which marginal production cost is equal to the FIT p*. The total over cost to mobilize private investments corresponds to the cost difference between p*and the reference cost for conventional power generation multiplied by the RE electricity volume q*. The portion of the rectangle below the RE marginal costs curve expresses the real additional cost (light grey) and the remaining portion (shaded dark grey) is the guaranteed income paid to the investor. Therefore the fixation of the FIT has to be based on detailed marked analyses for both technologies and financial markets in order to avoid too generous FITs resulting into a quite bigger numbers of projects than planned with additional costs and consumer tariff increase as consequences.

This system is very incentive but does not manage the uncertainties on the quantity launched on the market. The fixation of FITs is a sensitive issue as a rent effect can be expected for producers whose marginal cost is appreciably lower than the guaranteed price. Therefore mechanisms to revise the FITs have be considered in relation the RETs market prices evolution.

14.1.2 Examples of implementation[26]

Among the policies employed by governments, feed-in tariffs (also called premium payments, advanced renewable tariffs, and minimum price standards) remain the most common. By early 2011, at least 61 countries and 26 states/provinces had FITs, more than half of which had been enacted since 2005. In Europe, this system has been firstly presented in the German law in year 2000, then followed by Denmark, Spain and France among others.

Additional costs generated by these purchase tariffs are financed, in the example of France, by a levy 'the Contribution to the Electricity Public Service (CSPE)': a tool for financing of the liberalized market of electricity. The CSPE was established by the law in year 2003.

There are many variations of FITs, and no single definition can be applied. In one variation of a new FIT, the U.S. State of Louisiana's Public Utility Commission announced in 2010 that electric utilities would be required to implement a limited "standard offer tariff" that is undifferentiated by project size, technology, or resource intensity. This type of tariff represents the utility's "avoided cost" of generation plus an "environment" premium fixed at U.S. 3 cents/kWh. The tariff also sets total floor and ceiling prices of 6 cents/kWh and 12 cents/kWh, caps total capacity at 30 MW per utility, and applies to projects between 25 kW and 5 MW. The additional costs are passed on to ratepayers through a fuel adjustment clause, an approach normally used to cover increases in the cost of fossil fuels.

Several of the existing FIT policies around the world are presently under review. In particular, many countries are revising solar PV FITs to dampen the booming rate of installations, which in many cases are far exceeding expectations due to the unprecedented price reductions in solar PV that occurred in 2009 and 2010. In late 2010, the Czech Republic passed new legislation to slow the rate of PV installations as total capacity increased from 65 MW at the end of 2008 to nearly 2 GW by the end of 2010 – in part out of concern for the impact of the FIT on average electricity prices. Effective from March 2011, the country cut all FIT rates for ground-mounted PV installations that were not yet interconnected with the grid. In May 2011, Italy cut tariffs for solar PV by 22–30% for 2011, by 23–45% for 2012, and by 10–45% for 2013 (ranges apply to different scales of installation). A project ceiling of 1 MW on rooftops and 0.2 MW for ground mounted systems was also imposed to limit the total cost to EUR 6–7 billion by the end of 2016, when roughly 23 GW are expected to be installed.

Many other FIT changes took place in 2010. In Spain, the EUR 0.42/kWh FIT level for solar PV, as set in 2007, still remains, but new legislation now caps the annual hours rewarded by the FIT, and some uncertainty arose regarding retroactive cuts to existing systems.

Greece's financial problems led to the government blocking a backlog of project applications for support incentives worth over EUR 2 billion, but the restriction was lifted in September 2010 and new projects continued.

[26] Exemples majoritairement tirés de la publication Renewables 2011 Global Status Report (REN21)

The United Kingdom decided in 2010 to replace its existing quota policy with a FIT, starting in 2013, for "low carbon generation."

Table 42: FEED-IN Tariff (FIT) for the UK and Scotland

System size etc	FIT rate
Solar Photovoltaic with total installed capacity of 4kW or less, where installed on a building which is already occupied	21 pence per kilowatt hour
Solar Photovoltaic with total installed capacity of 4kW or less, where installed on a new building before first occupation	21 pence per kilowatt hour
Solar Photovoltaic with total installed capacity greater than 4kW but not exceeding 10kW	16.8 pence per kilowatt hour
Solar Photovoltaic with total installed capacity greater than 10kW but not exceeding 50kW	15.2 pence per kilowatt hour
Solar Photovoltaic with total installed capacity greater than 50kW but not exceeding 250kW	12.9 pence per kilowatt hour
Solar Photovoltaic with total installed capacity greater than 250kW but not exceeding 5MW	8.9 pence per kilowatt hour
Stand-alone (autonomous) solar photovoltaic (not attached to a building and not wired to provide electricity to an occupied building)	8.9 pence per kilowatt hour

Bulgaria, through its new Renewable Energy Act of June 2011, put an annual cap on new projects receiving the FIT prices by applying a quota.

And Turkey enacted a long-awaited renewable energy law that replaces the existing single-rate FIT with technology-specific FIT rates over a 10-year term for wind, geothermal, biomass, biogas, and solar, with bonus payments if hardware components are made in Turkey.

In Africa, Kenya's FIT policy[27] has as its objectives to:

a) facilitate resource mobilization by providing investment security and market stability for investors in Renewable Energy Sources (RES) electricity generation
b) reduce transaction and administrative costs by eliminating the conventional bidding processes, and
c) encourage private investors to operate the power plant securely and efficiently so as to maximize its returns.

By taking a long-term commitment to the development of renewable sources of energy and stipulating a long-term power purchase agreements of a minimum of 20 years, the Kenya Government has taken a critically important step in the development of the country's significant potential for renewable energy generation, while pursuing equally important economic, environmental and social policy objectives.

In January 2010, Kenya revised the FIT policy, which resulted in the addition of three renewable energy sources: geothermal, biogas, and solar energy resource generated electricity. In addition, the revised policy extended the period of the power purchase agreements from 15 to 20 years and increased the fixed tariffs per kilowatt-hour for pre-existing wind and biomass under the FIT. It is expected that the FIT policy in Kenya could stimulate about 1300 MW of electricity generation capacity.

[27] UNEP www.unep.org > Green Economy > Success Stories > Feed-in tariffs in Kenya

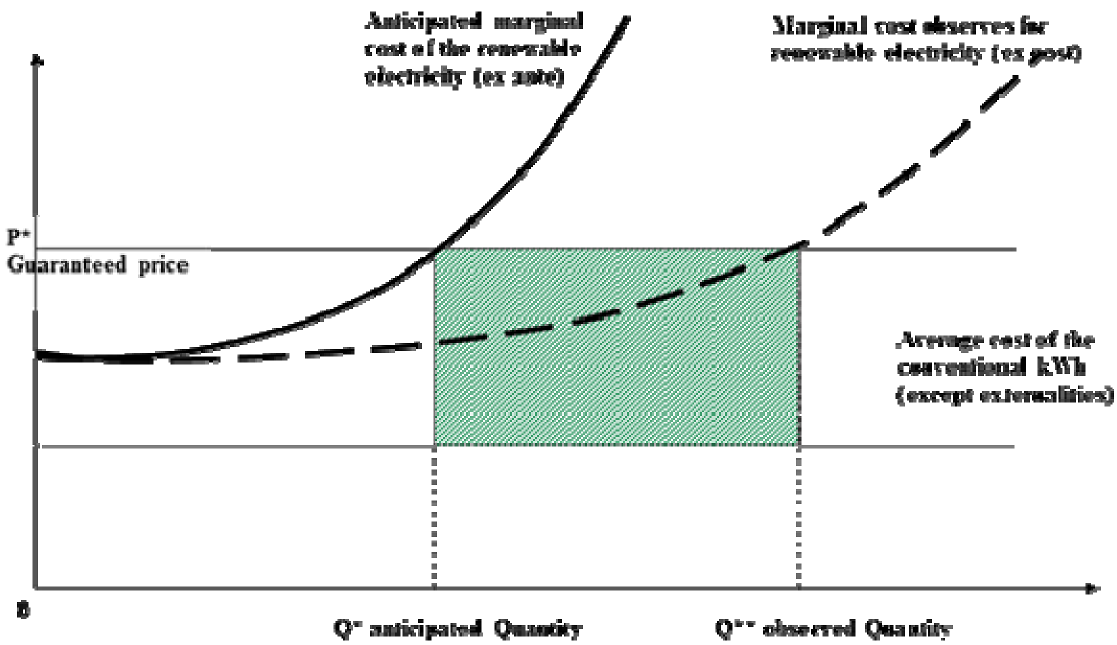
14.1.3 SWOT Analysis

Table 43 : Strengths and Weaknesses of Feed-in-Tariffs

Strengths	Weaknesses
For producers: Stable and secure income independently from fluctuations in the conventional electricity price	For public authorities: no guarantee on the quantities produced by renewable energies (risks of assessment/assumptions errors on calculation of marginal cost curves leading to unexpected impacts in terms of quantity and overall cost for the utility/consumers
Existence of a differential rent incites the producers to invest in the R&D (research) for innovative technologies to reduce generation costs	Guaranteed income in the form of "Windfall Profits" or 'Free Rides' for the producers whose marginal cost is low: can require to programme a FIT's diminution over time or a price cap principle and a differentiate FIT by technology
No transaction costs (due to a Stable and transparent regulatory framework)	For consumers: expensive system (if the electricity from conventional source is more competitive). The additional cost will be reduced over time if the price of conventional electricity increases.
	The guaranteed price does not take into account the default cost resulting from the irregularity of certain renewable energies (wind energy)

The FIT system is at present the system dominating in Europe but it is expensive for the consumer. The total cost increases with the increase of the renewable energy share in the energy mix unless the price of conventional electricity increases strongly, as during the sharp rise of oil prices.

Figure 73 : Guaranteed price and error of anticipation on the slope of the marginal cost



Additional cost with regard to the anticipations of public authorities

14.2 Quota system with competitive bidding

14.2.1 Definition of the theoretical approach

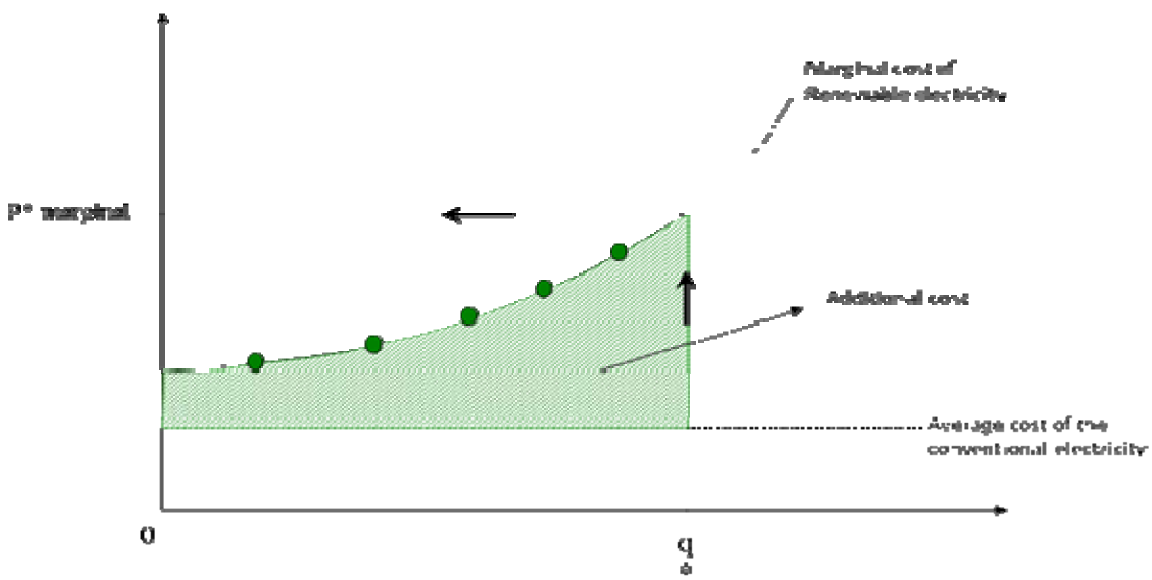
In order to generate a given quantum of green electricity the public authority sets a quantified target for green electricity bulk production to be injected into the grid and proceeds through competitive biddings.

Producers that are successful in the tender (merit order) get through their contract with the utility the guarantee to sale their green energy production to a given price. The contract price for green electricity for each awarded producer is:

- Either the same price-limit fixed on the basis on the last successful offer (the price proposed by the last awarded bidders) if the bidding system is "at the marginal price bid" or "French auctions" (In that case the price is uniform)

- Or the price charged by each awarded producer if within the system "pay as bid" or "Dutch auction" (in that case there is a price discrimination)

Figure 74 : Quota system with « *paid as bid* » auctions *(Dutch auction)*



The regulator sets a quota (q*) and proceeds through competitive biddings to the selection of projects. The bids are ranked in order of increasing price (merit order) and each bid receives the demanded price (Price) if the rule is 'paid as a bid' or the same price corresponding to the highest awarded bids if the rule is 'paid as marginal price'.

14.2.2 Examples of implementation

This system was used in England from 1991 to 2001 (Non Fossil Fuel Obligation) and in France between 1996 and 2000 (program "Eole 2005"), but both abandoned in favour of guaranteed prices in France and green certificates in England. This system remained in force in Ireland.

Quotas with competitive bidding are nevertheless still used case by case in France for offshore wind (see Agde and Fos-sur-Mer).

14.2.3 SWOT Analysis

Table 44 : Strengths and Weaknesses of the quota system with competitive bidding

Strengths	Weaknesses
The government keeps control of the volume of green electricity fed into the grid (but not of the cost)	Responses to tenders are uncertain and the price of each bidder is not known ex ante
Governments can choose in the tender documents the areas where the facilities will be implemented (Land-use policy planning)	Transaction costs (related to the organization of the auction)
Differential income observed with the system of guaranteed prices disappears. Bids prices follow the marginal costs (with a "reasonable" rate of profit)	A priori system that is less remunerative to producers and thus less incentive for RE clusters development
	The cost of failure remains for wind projects
	The "Dutch auctions" bring perverse effects: - The producers have an incentive to overstate their offer price as they anticipate the "winner's curse", whoses price is below the marginal cost. [28] - Producers are seeking to acquire information about competing bids (expensive) - The producers have an incentive to agree (collusion)

14.3 Decentralized quota system backed by a green certificate market

14.3.1 Definition of the theoretical approach

An alternative to the previous quotas system with competitive bidding is the fixation of mandatory production quotas for green electricity supply. These quotas are imposed on power generating utilities and / or electricity distribution utilities (calculated as a percentage of production/sales). Operators can meet these obligations in three ways:

- by producing their own green electricity,
- by buying the electricity under long term contracts,
- by acquiring on the financial market the "Green Certificates" corresponding to the amount of electricity required.

The green electricity producers receive for each green MWh produced a green certificate and they sell the two separate commodities (electricity on one hand and certificate on the other hand) in two markets:

- green electricity is sold on the wholesale electricity market, at the price of conventional electricity,
- the green certificate, which represents the " added value" of this electricity, is traded in the market for green certificates.

The certificate price is equal to the difference between the marginal cost of green electricity and the price of conventional electricity. This system allows an optimal allocation of effort (equalization of marginal costs).

[28] Cf Chari et Weber (1992)

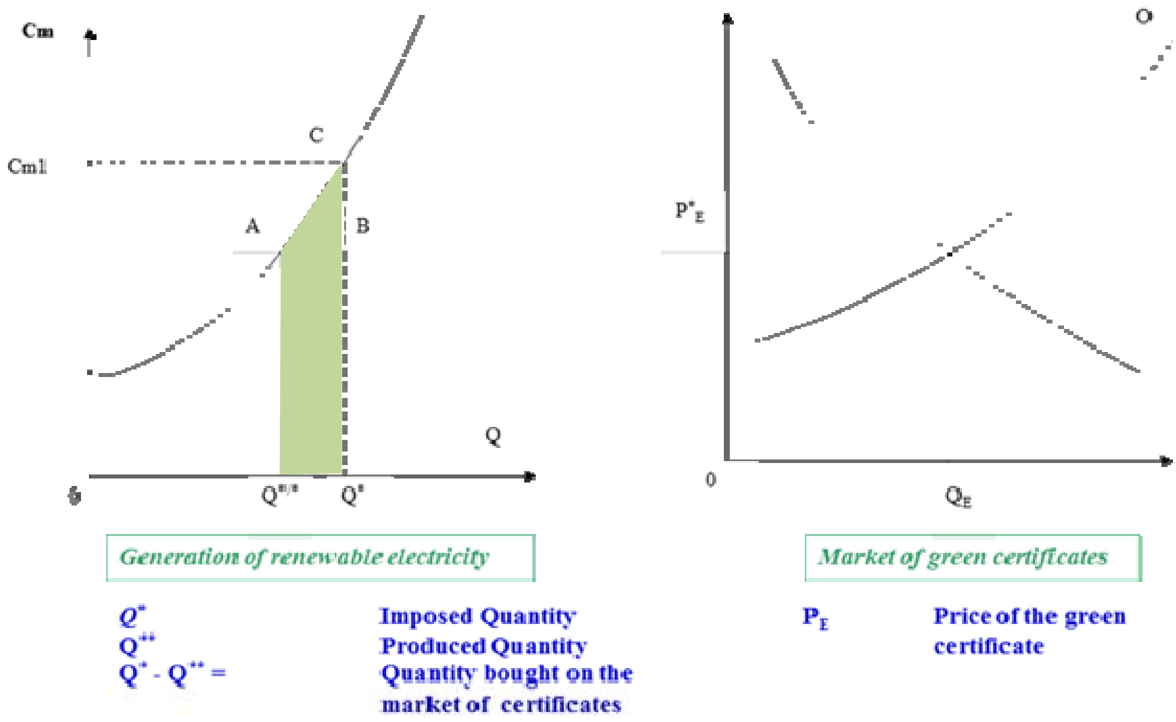


Figure 75 : Decentralized quota system backed by a green certificate market

Both graphs show the dynamics of the green certificates and mandatory quotas. Imposing a quotas for green electricity will increase the demand of green certificate on the financial market and lead to readjustment of the value of the green certificates. At the same time, producers or developers in the real world will build new capacity as the market is giving a clear signal

The new additional capacity will lead to an increase of the production marginal cost (from A→B on the left inside graph. The product of the green certificates on the financial market has to cover the extra costs for RE generation (the top of the romble ACQ*Q**) and a reasonable profit for the producer. The market regulates the quantities of RE electricity produced.

14.3.2 Examples of implementation

There are currently more than 6 million green power consumers in Europe, the United States, Australia, Japan, and Canada. Green power purchasing and utility green pricing programs are growing, aided by a combination of supporting policies, private initiatives, utility programs, and government purchases. The three main vehicles for green power purchases are:

1. utility green pricing programs,
2. competitive retail sales by third-party producers enabled through electricity deregulation/liberalization (also called "green marketing"),
3. and voluntary trading of renewable energy certificates.

Germany has become the world's green power leader, with a market that grew from 0.8 million residential customers in 2006 to 2.6 million in 2009. These consumers purchased 7 TWh of green electricity in 2009 (6% of the nation's total electricity consumption). In addition to residential consumers, 150,000 business and other customers purchased over 10 TWh in 2009 (9.5% of total electricity consumption). Other major European green power markets are Austria, Finland, Italy, Sweden, Switzerland, and the United Kingdom, although the market share of green power in these countries is less than 5%. Australia's 900,000 residential and 34,000 business consumers collectively purchased 1.8 TWh of green power in 2008. In Japan, the green power certificate market grew to 227 GWh in 2009 with more than 50 sellers. The Green Heat Certificate Program began in 2010 for solar thermal, with biomass joining in 2011. In South Africa, at least one company offers green power to retail customers using renewable electricity produced from bagasse combustion in sugar mills.

Some governments require that utilities offer green energy options to their consumers. In the United States, where green pricing programs are offered by more than 850 utilities, regulations in several states require utilities or electricity suppliers to offer green power products. More than 1.4 million U.S. consumers purchased 30 TWh of green power in 2009, up from 18 TWh in 2007.

The U.S. Environmental Protection Agency's Green Power Partnership grew to more than 1,300 corporate and institutional partners that purchased more than 19 TWh of electricity by the end of 2010. The largest consumer, Intel, nearly doubled its purchases in 2010, to 2.5 TWh. Other innovative green power purchasing models are emerging in the United States. For example, some utilities enable customers to purchase shares in a community solar project and then obtain a credit on their utility bill equivalent to their share of the project output.

The European Energy Certificate System (EECS) framework has 18 member countries and allows the issue, transfer, and redemption of voluntary renewable energy certificates (RECs). It also provides "guarantee-of-origin" certificates in combination with RECs to enable renewable electricity generators to confirm origin. During 2009, 209 TWh of certificates were issued, more than triple the number in 2006.

Norway, a major hydropower producer, issued 62% of all certificates under the EECS, virtually all of which were hydropower. In other European countries, green power labels such as "Grüner Strom" and "Ok-power" in Germany and "Nature made star" in Switzerland have been introduced to strengthen consumer confidence.[29]

14.3.3 SWOT Analyses

Table 45: Strengths and Weaknesses of a decentralized quota system backed by a green certificate market

Strengths	Weaknesses
Optimal allocation of efforts encourages the most efficient producers to expand its production; flexible and scalable system	High transaction costs
Incentive to locate production in most appropriated areas and allow a regional market for certificates	Market sometimes narrow, with low degree of liquidity and high price volatility of the certificates
Inexpensive system for the consumer; the overhead is proportional to electricity consumption, whereas with the guaranteed prices the extra cost is fixed $S = \alpha.C$ with green certificates S= pV (V amount injected independent of C) with guaranteed prices Incentive Certificate system to reduce electricity consumption C	Conceivable market in the EU but need to standardize the certificates and to improve the convergence of wholesale prices of conventional electricity
	Risk of assigning green certificates to depreciated facilities ("windfall profits"); difficult to control in practice

29 Renewables 2011 Global Status Report (REN21)

Later, the settlement of a green certificates market backed by a system of compulsory quota could become the standard. The green certificates system can be coupled with that of the CO^2 certificates ("black certificate") and that of the "white" certificates (energy savings).

This approach which gives the confidence into the liberalized market mechanisms to reach the optimal allocation of the resources was chosen by the EU. Moreover, it allows trade and crossed investment of industrialized countries towards developing countries.

14.4 Worldwide review of the policy landscape

Policies to support renewable energy investments continued to increase in number during 2010 and early 2011. Only a few countries had renewable energy support policies in the 1980s and early 1990s, but many more countries, states, provinces, and cities began to adopt such policies during the period 1998–2005, and especially during the period 2005–2011. The number of countries with some type of policy target and/or support policy related to renewable energy more than doubled during this latter period, from an estimated 55 in early 2005 to 118 by early 2011.

14.4.1 Summary of UE member states' progress

The following table provides an overview of the renewable electricity support instruments that are in place in the EU Member States. We differentiate six categories of support instruments:

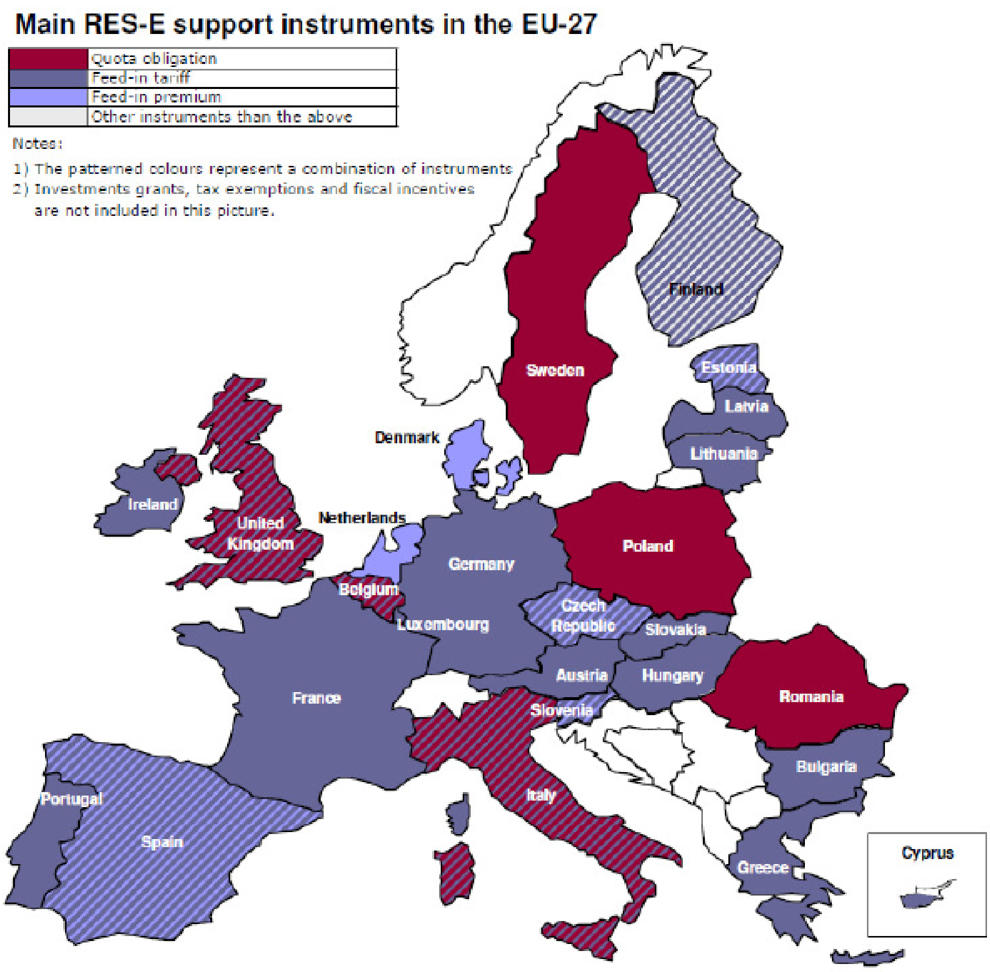
1) feed-in tariff,
2) premium,
3) quota obligation,
4) investment grants,
5) tax exemptions, and
6) fiscal incentives.

Table 46: Incentive Instruments used in EU member countries

	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE
FIT	X	X	X	x	x	X		X	x		X	x	x	x
Premium					x		x	X	x					
Quota obligation		X												
Investment grants		X		x	x					x		x	x	
Tax exemptions		X							x	x		x		
Fiscal incentives			X			X		X						

	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
FIT	x	x	X	x	X			x			X	x	x
Premium						x					X		
Quota obligation	x						X		x	x			x
Investment grants		X	X	x	X								
Tax exemptions				x		x	X			x		x	x
Fiscal incentives					X	x	X				X		

Source : Ecofys for the DG Energy of the European Commission[30]



Source : Ecofys for the DG Energy of the European Commission

[30] European Commission DG Energy : "Financing Renewable Energy in the European Energy Market" (2011)

14.4.2 Summary of developing countries progress

Table 47 Incentive Instruments used by developing countries

	REGULATORY POLICIES						FISCAL INCENTIVES				PUBLIC FINANCING	
	Feed-in tariff (incl. premium payment)	Electric utility quota obligation/ RPS	Net metering	Biofuels obligation/ mandate	Heat obligation/ mandate	Tradable REC	Capital subsidy, grant, or rebate	Investment or production tax credits	Reductions in sales, energy, CO_2, VAT, or other taxes	Energy production payment	Public investment, loans, or grants	Public competitive bidding
LOWER-MIDDLE INCOME COUNTRIES												
Armenia	●											
Bolivia									●			
China	●	●		●	●		●			●	●	●
Ecuador	●											
Egypt							●		●		●	●
El Salvador								●	●	●	●	●
Guatemala			●					●	●			●
Honduras	●							●	●			●
India	●	●		●		●	●	●	●		●	●
Indonesia	●						●	●	●		●	●
Jordan			●						●			
Marshall Islands									●			
Moldova	●								●		●	
Mongolia	●											●
Morocco											●	
Nicaragua	●							●	●			
Pakistan			●				▲				●	
Palestinian Ter.*									●			
Philippines	●	●	●	●			●	●	●	●	●	●
Sri Lanka	●											
Thailand	●			●							●	
Tunisia							●		●		●	
Ukraine	●											
Vietnam							●	●	●			

LOW INCOME COUNTRIES

Bangladesh							●				●	
Ethiopia				●					●		●	
Gambia									●			
Ghana						●			●			
Kenya	●								●			
Kyrgyzstan		●					●		●			
Mali									●			
Mozambique[3]				●							●	
Nepal							●	●	●		●	●
Rwanda									●		●	
Tanzania	●						●		●			
Uganda	●						●		●			
Zambia									●			

Source : Renewables 2011 Global Status Report (REN21)

14.4.3 Comparison of diverse incentives dedicated to the PV sector

Table 48: Performance criteria for PV incentives

Performance criterion	**Name / type of system**	**Attractiveness (feed-in-tariff + decrease)**	**Safety (guarantee period)**	**Specific energy yield + payback time of investments**
Performance indicator	Mix of instruments (max. cap in MW_p)	€/kWh (%)	years	kWh/kW_p + years
Austria	Feed-in-tariff + investment subsidies + fiscal incentives (cap currently 15 MW_p)	60 €ct/kWh (< 20 kW_p); 47 €ct/kWh (> 20 kW_p); no decrease	13	700–900 13 years
France	Feed-in-tariff + investment subsidies + fiscal incentives (cap currently 50 MW_p)	14,17 €ct/kWh (mainland France); 28,34 € ct/kWh (overseas); no decrease	20	900–1.200 (mainland France) + 15–30 (together with different regional grants)
Germany (2005)	**Feed-in-tariff (no cap anymore);**	**54,53 €ct/kWh (< 30 kW_p); 51,87 €ct/kWh (30–100 kW_p); 51,30 €ct/kWh (> 100 kW_p); bonus of + 5 €ct/kWh for BIPV; 43,42 €ct for ground-based PV; decrease 5 % p.a.**	**20**	**750–950 + 8–12 years**
Greece	Feed-in-tariff (amendment due in 2005!) + investment subsidies; (no cap)	8,17 €ct/kWh (for IPP); no decrease	10	1.300–1.500 + approx. 25–30 years for grid-connected systems
Italy	Feed-in-tariff incl. net metering & tendering system (launch in 2005!) + investment subsidies + fiscal incentives (cap currently 100 MW_p)	approx. 61 €ct/kWh (< 20 kW_p); 50 €ct/kWh (20–50 kW_p); competitive procedure (> 50 kW_p); decrease 2 % p.a.	20	1.100–1.500
Japan	Subsidies + fiscal incentives + Quota obligation	–	–	–
Netherlands	Feed-in-tariff + net metering system + fiscal incentives (no cap)	30–40 €ct/kWh (volatile)	10	700–800
Portugal	Feed-in-tariff + investment subsidies + fiscal incentives	52 €ct/kWh (< 5 kW_p); 35 €ct/kWh (> 5 kW_p); no decrease	valid for the first 21 GWh produced by each MW of installed capacity or for 15 years	n.k.
Slovenia	Feed-in-tariff + subsidy + soft loans	37 €ct/kWh (< 36 kW_p), 6,5 €ct/kWh (> 36 kW_p)	FIT too low, to complicated	1.000–1.100 12–15 years
Spain	**Feed-in-tariff + investment subsidies (cap currently 400 MW_p)**	**41,44 €ct/kWh (< 100 kW_p) 21,99 €ct/kWh (> 100 kW_p) decrease after 25 years**	**infinite (maximum security for all investors)**	**1.000–1.500 +**
Sweden	Quota obligation	–	–	–
UK	Subsidies + fiscal incentives + Quota obligation	–	–	–

Source : PV Policy Group – European Best practice report (2006)

14.5 Power Purchase Agreements (PPA)

Among the major tools at the disposal of the regulator and the public authorities, a standardized contract type of Power Purchase Agreement must be available in the country to facilitate involvement of private bodies. PPAs are helpful for projects dealing with national grid as well as mini-grids.

14.5.1 Definition of the theoretical approach

Power Purchase Agreements are contracts between two parties, one who generates electricity for the purpose of sale (**the seller**) and one who is looking to purchase electricity (**the buyer**). There are various forms of Power Purchase Agreements; these are differentiated by the source of energy harnessed (solar, wind, etc.). Financing for the project is delineated in the contract, which also specifies relevant dates of the project coming into effect, when the project will begin commercial operation, and a termination date for which the contract may be renewed or abandoned. All sales of electricity are metered to provide both seller and buyer with the most accurate information about the amount of electricity generated and bought. Rates for electricity are agreed upon in the contract between both parties to provide an economic incentive to being a Power Purchase Agreement.

Under a PPA, the buyer is often a utility company that purchases the electricity generated from the seller. In some circumstances, a company may be trying to meet renewable-energy portfolio standards and would be considered a retail purchaser. Under this condition, the retail purchaser may resell the electricity to another entity under a new PPA. Typically, a PPA is established between the primary seller and a utility company who is regulated to buy the electricity.

The PPA is often regarded as the central document in the development of independent electricity generating assets (power plants), and is a key to obtaining project financing for the project. Under the PPA model, the PPA provider would secure funding for the project, maintain and monitor the energy production, and sell the electricity to the host at a contractual price for the term of the contract. The term of a PPA generally lasts between 5 and 25 years. In some renewable energy contracts, the host has the option to purchase the generating equipment from the PPA provider at the end of the term, may renew the contract with different terms, or can request that the equipment be removed. One of the key benefits of the PPA is that by clearly defining the output of the generating assets (such as a solar electric system) and the credit of its associated revenue streams, a PPA can be used by the PPA provider to raise non-recourse financing from a bank or other financing counterparty.

14.5.2 Examples of implementation [31]

Five innovative nations in Asia have been among the first in developing ECOWAS (SPP) programs to promote renewable energy development in-country (Thailand, Indonesia, India, Sri Lanka and Viet Nam). These programs have been very successful in some of these nations in promoting during just a few years a substantial contribution of renewable small power projects to the national energy supply. Some of the most successful program features, innovative elements, and PPA design that have achieved notable success and could be the basis of programs in other nations. Each of these programs involves standardized PPAs or standardized tariffs, or both, which are a material element of program design. Most of these countries advanced their programs with technical and/or financial assistance from international donors and agencies, although the Thailand program proceeded without such assistance.

The Thai program operates in tranches of formal solicitation by the state utility. Eligible projects mirror the requirements of those of the “PURPA program” in the United States, with size limitations up to 60 MW, and in some cases, 90 MW. State subsidies are provided for some renewable SPPs

[31] cf Ferrey S. : Small Power Purchase Agreement Application for Renewable Energy Development: Lessons from Five Asian Countries (2004)

competitively selected. As in the U.S. experience, the majority of projects are natural gas-fired cogeneration projects.

Both firm and non-firm PPAs are available. The contract was designed to be indexed, but instead is adjusted periodically for foreign exchange risk for capacity and energy payments. For intermittent renewable projects, the capacity factor[32] must be greater than 0.5, without a reduction in capacity payments. Thailand was the first of the Asian SPP programs, and it set a standard for successful program development. A noteworthy feature is its competitively determined renewable SPP subsidy program.

The Indonesian began to develop a program in 1993. It came to involve a standardized PPA and tariff. The SPP program was designed to supply up to one-third of national new power supply from small, renewable sources, organized into four tiers of priority for projects of up to 30 MW in size on the primary island, and half of that size on smaller island grids. Since Indonesia comprises several separate and not interconnected island grid systems and isolated diesel systems, this program design was nuanced and disaggregated to address avoided cost and power requirements on a regional basis.

The standardized PPA in its original design contemplated either a firm[33] or non-firm power sale. The incentives for firm power delivery were embodied in the tariff, with indexation of capacity payments for foreign exchange risk, on the theory that most of the value added of generating capacity would be foreign production (this program included cogeneration utilizing fossil fuels as a lower-priority generation source). This provided an innovative approach to structuring the performance obligation, whereby no legal sanctions were imposed for performance failure of the SPP, but rather a substantial economic disincentive for the SPP from such non-performance was in place. Some innovative fuel price hedging was provided for renewable power projects.

In India, each state makes its own determinations about SPP programs. Two representative Indian states are described below. Although some Indian states provided formal SPP solicitations or allowed direct retail third-party sales, or both, neither of the two states evaluated here now allow direct third-party sales or conduct a formal project solicitation.

In the **state of Andhra Pradesh**, no formally standardized contract is in place, although de facto a set contract form is used by the utility, leaving some case-by-case discretion with the utility. The tariff is escalated at 5 per cent annually from a base year. Moreover, the tariff can be reset mid-contract after three years by the government. This undercuts long-term certainty. Energy wheeling is allowed, but discouraged economically by a high wheeling charge. No third-party retail sales are allowed.

In **Tamil Nadu state**, a similar de facto set PPA is employed. An SPP is defined as any project up to 25 MW. Many wind power projects have been developed and grid connected. Wheeling of power to an affiliated location—not to a third-party—is permitted with a 2 % charge. No third-party retail sales are allowed.

The Sri Lankan program does not utilize a simultaneous solicitation for SPP bids as was deployed in Indonesia and Thailand. Ad hoc offers are entertained by the state utility. Fifteen-year PPAs are available for projects up to 10 MW in size. All but one of the successful SPPs to date are Small-scale hydroelectric projects. The PPA is standardized, as it is the tariff. The tariff development was assisted by consultants provided by the World Bank. The tariff is revised annually based on a three-year fuel average, with a tariff floor of 90 % of the original tariff underneath renewable projects.

These Asian nations offer different forms of government and have different predominant fuel sources in their generation base (hydro, coal, gas, oil). Some of the national electric systems have an integrated high-voltage transmission system, whereas others have a disintegrated or island system, but there are key similarities:

[32] Total production/installed capacity/8760 h. A capacity factor >0.5 only for biomass and mini-hydro

[33] Firm power sale as defined in the contract (when and how many MW fully available)

- All are in need of long-term increases in power generation capacity (although Thailand has a short term current surplus).
- All have the potential of small-scale renewable energy options which is quite relevant for the WA region.
- Each country is being approached by private developers who seek to develop renewable SPP projects.
- Each system employs either deliberately or de facto a standardized PPA, although it is not necessarily a neutral or consensual document in all cases.
- Although **avoided cost** concepts for establishing the SPP tariff are recognized in each nation, avoided cost concepts are applied differently in these nations' SPP programs.

Table 49: Examples of Small Power Purchase Agreements

	Thailand	Indonesia	Sri Lanka
Capacity Limit	60 MW	Java/Bali: 30 MW, other: 15 MW	5 MW, but could be used for up to 10 MW
Power purchase agreement period	5-25 years	Non-firm: 2 yr Firm: 3-20 yrs	~10-15 years
Tariff	Non-negotiable, avoided cost based: Energy+capacity or Energy only	Non-negotiable, avoided cost based: Energy+capacity	Non-negotiable, avoided energy cost
Payment	Time-of-day Reduction if CF target not met	Time of day Firm/non-firm Facility location HV/MV Facility type	Wet/dry season
Tariff adjustment	Annual according change in avoided cost		

14.5.3 SWOT Analysis

Table 50 : Strengths and Weaknesses of PPA

Strengths	Weaknesses
Renewable developer (or partner) eligible for tax incentives, accelerated depreciation	Some utilities may find that the PPA option does not provide them with sufficient control over or certainty with regard to the operation and management of renewable resources
Minimal risk to public authorities : minimizes the capital demands on traditional utilities	Many renewable developers are having difficulty attracting the necessary capital to complete their projects (especially individuals or SME involved in small mini-grid projects)
No up-front capital from public required	
Renewable developer provides O&M	
Known long term electricity price for portion of site load	

Buying renewable energy through a PPA also minimizes development and construction risk for the utility. This may be particularly appealing to those utilities that divested their generation fleet in response to restructuring mandates, many of whom lack direct experience with renewable energy development and consider this function to be outside of their core business of energy delivery.

Accordingly, pursuit of and diligence regarding renewable PPAs may provide valuable experience for traditional utilities in renewable development, particularly if utility personnel work closely with renewable energy developers in developing the PPA and operational/ dispatch protocols for the facility.

The PPA option also leaves technology risk with the renewable developer. Given the speed of technological change in the renewable sector, utilities and their state commissions may be reluctant to take on actual or perceived technology risk.

14.6 Mini-grid concessions

14.6.1 Definition of the theoretical approach

Mini-grids involve a centrally located generating system that serves generally tens or hundreds of users. A mini-grid is an attractive option when customers are concentrated enough to be economically interconnected but the connection to the main grid is not feasible. It is typically the case of many isolated communities in African countries.

The outputs on which subsidies are disbursed in mini-grid systems are diverse and can range from construction milestone to installed capacity to connection of new customers. Most projects identified include a mix of these outputs, but most of the subsidies target the access to energy for rural population. In terms of market model, public-private partnerships in the form of concession contracts are the most common. Under concession, the service provider has exclusive rights to generate, distribute, and sell electricity in the concession area.

The concept of a "**concession**" was first developed in France. As with leasing, the framework for the concession is set out in the country law and the contract contains specific provisions to the project. Emphasis is placed in the law on the public nature of the agreement (because the operator has a direct relationship with the consumer) and safeguards are enshrined in the law to protect the consumer. Similar legal frameworks have been incorporated into civil law systems elsewhere.

Within the context of common law systems, the closest comparable legal structure is the BOT (Build-Operate-Transfer), which is typically for the purpose of constructing a facility or system.

The "**Concession**" and "**BOT**" contracts are almost similar: The main difference between concession and BOT contracts is that investment charges, operation and maintenance, commercial risk, and asset ownership for the duration of the contract are fully born by the private contractor in the case of the concession, while they can be shared between public and private entities as part of a mixed enterprise corporation for the BOT. Both systems were developed to attract private investments to the new infrastructure construction phase. Concession or BOT contracts allow the private sector to build a new infrastructure in compliance with standards established by the State, and to own exclusive operation rights for the concession area and for a sufficient period (generally ten to twenty years) to earn back the initial investment, plus a profit. The State becomes owner of the infrastructures at the contract expiration and then has the option to place them on a long-term lease contract, for example, with a private operator. The concession contract differs from other contracts, such as construction or public service contracts as follows:

- The assumption of the total or partial investment by the contractor as part of a long term contract, (duration of contract must be longer than the expected delay of return on investment);
- The transfer from the conceding entity to the contractor of public service obligations corresponding to a public responsibility and the sharing of the various risks between both parties;

Concession is defined by multiple criteria. Consequently, the national law must offer a distinct legal framework to concessions, different from that of public markets, and with assignment and execution rules specific to these contracts, in particular for those operating on mini-grid systems.

14.6.2 Examples of implementation

In most African countries, local communities do not (yet) have the technical and organizational capacities required to directly manage their rural electrification program: Therefore, the most common public service execution mode is public service management delegation. It is also the best system to financially involve the private sector in the investment phase.

The Madagascar implementation of concession model for mini-grid systems

In Madagascar, mini-grids are operated by private bodies under concession contract or authorization depending on the size of the generation and/or distribution system.

Table 51 : Differences between concession and authorization

Concession	Authorization
Generation : > Thermal power plant / Genset : > 500 kW > Hydro power plant : > 150 kW	Generation : > Thermal power plant / Genset : < = 500 kW > Hydro power plant : < = 150 kW
Distribution : Peak load exceeding 500 kW	Distribution : Peak load under 500 kW

The process to award concession and authorization is basically based on **call for tenders**. However, authorization can also be awarded after **unsolicited application.**

After technical acceptance by the National Agency for the Rural Electrification (ADER), tariff is negotiated between the contractor and the local community, and submitted for control and validation to the Regulator.

The ESCO model in Mali

Koraye Kurumba and Yeelen Kura are two Rural Energy Services Companies (RESCOs) created in 1999 and 2001 in two areas of rural Mali (Kayes and Koutiala). The companies were created by France's electricity company EDF, in partnership with the Dutch energy company NUON, the French TOTAL and with the support of the French Agency for the Environment and Energy Efficiency. The provision of low-cost electricity, based on solar home systems or small low-voltage village micro-networks supplied by diesel generators, resulted in undeniable development impacts, such as enhancing standards of living, favouring the development of income-generating activities, and improving quality of healthcare and education. Backed by a new institutional framework and international donors, the model– designed to ensure profitability, sustainability, reproducibility and local ownership– is to be expanded beyond the 24 villages and 2176 households/43,520 people were served at the end of 2006. The initial targets were 10,000 clients for a total population of 200,000 inhabitants.

Senegal: the concept of technological neutrality

In Senegal, the concept of technological neutrality is applied. For every concession, a Local Plan of Electrification is firstly drawn up, defining the appropriate technologies of electrification, the required investments, and the potential market. Actually, the technical-economic optimization favours the use of Renewable energies on mini-grids systems. As a result, from 2000 till 2007, looking at the solar energy only, the capacity installed in Senegal increased from 850kWc to about 2 000 kWc.

The system of attribution of the concessions is based on selection or call for tenders. Regarding the choice of the concession's operator, the determining criterion is the number of users to be supplied with a subsidy at the investment fixed by the ASER (Senegalese Agency of the Rural Electrification) in the call for tenders. The candidate who proposes the largest number of users' supplied with the granted level of subsidy is the winner.

To increase the chances of success, the choice of the most adapted technology and efforts in sizing are essential. The concession contract is obtained for duration of 25 years. The selected candidate to operate the concession proceeds to the realization of the works of electrification, the maintenance and the renewal of the installations present in its area during the duration of its contract. Within this framework, the integration of the local private sector in the creation of the project's company, which will have to operate the concession, is fundamental.

A particular but replicable electrification model in South Africa

The South African Energy Policy White Paper of 1998 required the integration of grid and non-grid technologies in a single National Electrification Programme. The South African Government encouraged private-sector participation in rural energy service provision. The approach being pursued, as in a number of other countries, was the award of geographical concessions to provide non-grid electricity supplies (primarily solar home systems) in remote areas.

The work conducted was particularly focused on the potential for isolated communities to benefit from emerging renewable technologies in the form of a renewable mini-grid. The interest in this particular form of rural electrification comes from the demographic profile of many sub-Saharan African countries, which have a high proportion of isolated communities. The development of an appropriate economic solution for isolated communities is a challenging aim. Yet, with rising in fuel prices and the mitigate success of a number of diesel based isolated systems throughout the region, there is an emerging interest in the use of renewable energy.

In 2003, the Global Sustainable Electricity Partnership (e7) began the development of a demonstration project in South Africa targeting off-grid mini-hybrid systems, with an emphasis on wind and solar power. The project objectives included: eligibility for CDM status, replicability, financial sustainability, and the practical principles associated with economic sustainability.

After identifying the sites, the e7 undertook a pre-feasibility study that yielded positive conclusions, leading to a decision to pursue the project at the feasibility stage. However, due to a faster growth in electrification plans in South Africa, the sites chosen for the feasibility study were no longer eligible for further implementation. Their conclusion not to proceed in South Africa was driven by the failure to identify a suitably remote site of reasonable density that was unlikely to be grid connected within the next five years. In discussions with government it also became obvious that providing rural communities with renewable energy solutions was likely to conflict with developing electrification policy in South Africa.

Nevertheless, the information and lessons learned from this study can greatly benefit similar electrification projects and programmes in other Sub-Saharan African countries. Among the main lessons learned from this South African experience we note the importance of a good coordination with government and electrification authorities, to avoid any conflict between mini-grids development and main grid deployment in the country that would result in a waste of financial resources.

14.6.3 SWOT analysis

The private company is responsible for infrastructure and daily operation financing. Pricing rules are discussed in the concession contract.

Table 52 : Strengths and Weaknesses of mini-grid concession

Strengths	Weaknesses
Substantial contribution of private capital	Implies a regulation capacity by the government
Combining private sector responsibilities in infrastructure development and daily management: Greater opportunities for innovation	Contract complexity : need to combine foresight and flexibility
Public sector get back the infrastructures and equipment upon expiration of the concession contract	Process not very competitive

14.7 Netmetering

14.7.1 Definition of the theoretical approach

Netmetering is a power supply arrangement that allows a two-way flow of electricity between the electricity distribution grid and customers that have their own generation system. The customer pays only for the net electricity delivered from the utility (total consumption minus self-production). A variation that employs two meters with differing tariffs for purchasing electricity or exporting excess electricity off-site is called “net billing.”

14.7.2 Examples of implementation

Net metering is an important policy for rooftop solar PV (as well as other renewables) that allows self-generated power to offset electricity purchases. Net metering laws now exist in at least 14 countries including Italy, Japan, Jordan, and Mexico, and almost all U.S. states. And finally, new forms of electric utility regulation and planning are emerging that target the integration of renewables into power grids at increasing levels of penetration.

15 Annex III: Costs of negative externalities of conventional plants

In 2004, the average external costs of electricity production in the EU-25 were between 1.8–6.0 Eurocent/kWh. Electricity production causes substantial environmental and human health damages, which vary widely depending on how and where the electricity is generated. The damages caused are for the most part not integrated into the current pricing system and thus represent an external cost. External costs for electricity are those that are not reflected in its price, but which society as a whole must bear.

The external costs are the sum of three components associated with the production of electricity:

I. Climate change damage costs associated with emissions of CO_2

II. Damage costs associated with other air pollutants (NOx, SO_2, NMVOCs, PM_{10}, NH_3), i.e. impacts on health, crops, etc.

III. And other non-environmental social costs for non-fossil electricity- generating technologies.

Marginal damage cost factors in the case of CO_2 are not country specific (i.e. all countries share the same marginal factors for CO_2, one for low, 19 Euro/ton and one for high 80 Euro/ton).

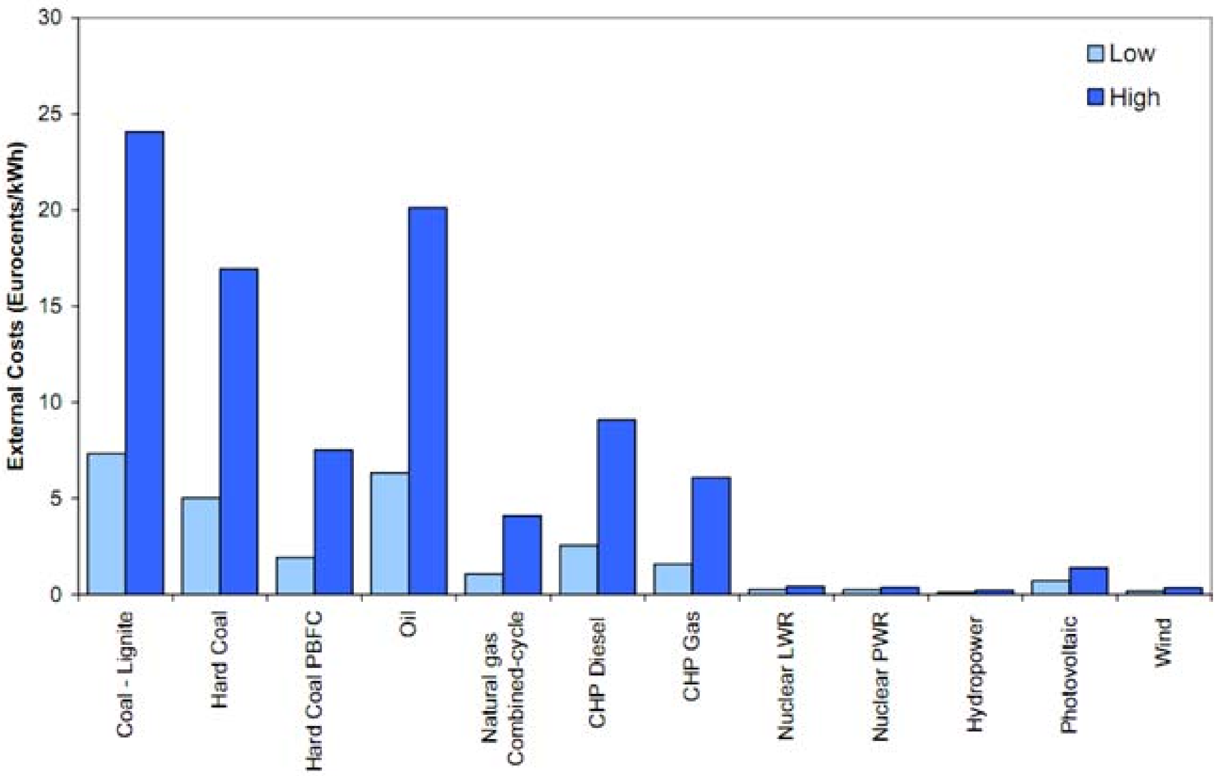


Figure 76 : Estimated average EU-25 external costs for electricity generation technologies

These external costs are not included in the conventional market prices for electricity, which contributes to inefficiencies in resource allocation decisions. By including external costs in market prices, such inefficiencies can be corrected.

For the purpose of the EREP the following marginal cost are considered

- Hard coal: 0,10 €/kWh
- Oil : 0,15 €/kWh
- CC and TAG natural gas 0,04 €/kWh
- Hydro: nil
- Wind: nil
- PV: 0,015 €/kWh

And for the WAPP with a mix of 3% RE, 5% coal, 55% gas, 37% hydro the resulting cost can be evaluated to = 0,0275 €/kWh

When considering the externalities, the ECREEE scenario LCOE is equivalent to the LCOE Nigeria and Côte d'Ivoire-Ghana-Togo-Bénin

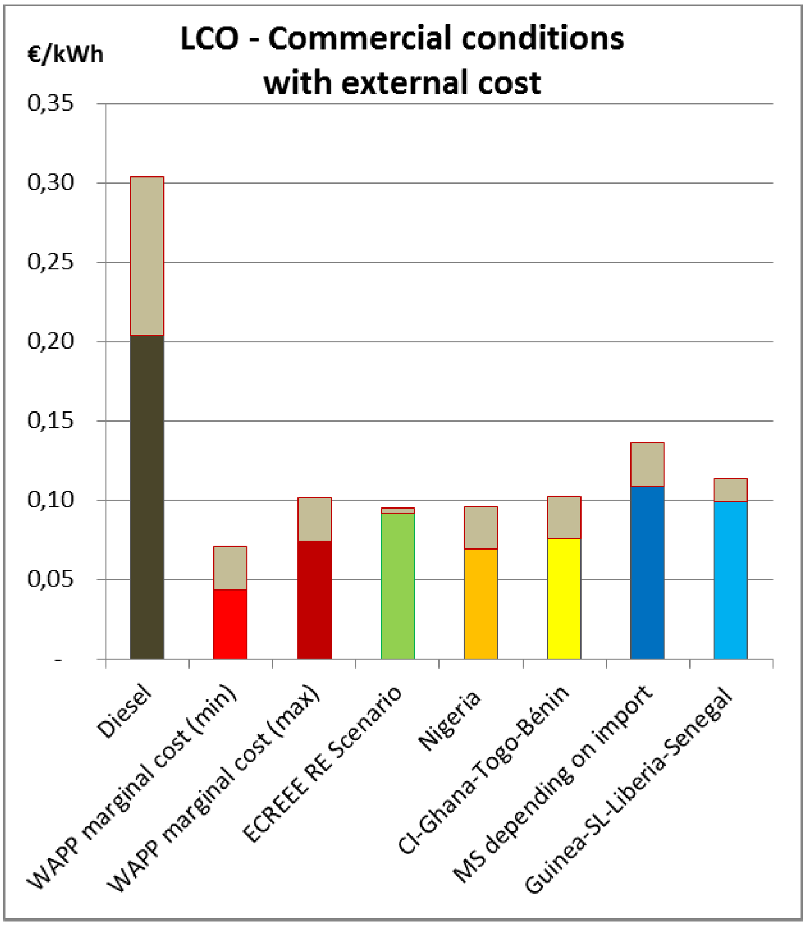


Figure 77: LCOE for different categories of MS (commercial conditions including negative externalities

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	Loi Code Electricité signé (Loi N° 2006-16 Mars 2007)	2007	Présidence de la République
	Arrêté Année 2004 N° 28 portant attributions, organisation et fonctionnement de la Direction Générale de l'Energie	2004	LE MINISTRE DES MINES, DE L'ENERGIE ET DE L'HYDRAULIQUE
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	Politique d'électrification rurale	2004?	DGE
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Burkina Faso			
	Renewable Energy in West Africa: BF	2010	GTZ
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	Décret 2003-089 portant création, attribution et fonctionnement du FDE	2003	Présidence
	ARRETE N° 07 -/MCE/SG/DGE portant Attributions, Organisation et Fonctionnement de la Direction Générale de l'Energie (DGE)	2007	MINISTERE DES MINES, DES CARRIERES ET DE L'ENERGIE
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	Arrêté conjoint n° 07-008 portant définition des critères de sélection et d'éligibilité des projets d'électrification rurale décentralisée au financement du Fonds de Développement de l'électrification	2007	MINISTERE DES MINES, DES CARRIERES ET DE L'ENERGIE

	Décret 2010-272 MEF portant sur la création du Fonds de Développement de l'Electrification en un établissement publique de l'Etat à caractère administratif	2010	Président du Conseil de Ministres
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Cape Verde			
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Côte d'Ivoire			
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	Politique énergétique de l' Côte d'Ivoire 2005-2020	2006	Direction de l'énergie
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	100 MW d'électricité à base des énergies renouvelables	2011	NOVIS
	Renewable Energy in West Africa: Côte d'Ivoire	2010	GTZ
The Gambia			
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Ghana			
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Guinée			
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Guinea Bissau			
	Renewable Energy in West Africa: Guinea	2010	GTZ
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	Note sur la Situation Socio-Economique de la GB	2006	UNDP
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Liberia			
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Mali			
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	Renewable Energy in West Africa: Mali	2010	GTZ
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	Energie et Ecodéveloppement en Mali	2005/2006	Observatoire de la viabilité énergétique, Direction Nationale de l'Energie
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	Textes Législatives Energie	n/a	Présidence de la République
Niger			
	Renewable Energy in West Africa: Niger	2010	GTZ

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	Stratégie Nationale et plan d'action sur les EnR	2003	PNUD et FAO
	Conclusions Forum sur la définition d'une politique de l'énergie électrique au Niger	2011	Présentation à la rencontre du CLUB ER www.club-er.org
Nigeria			
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Sénégal			
	Décret N° 2011-2014 portant application de la loi d'orientation sur les énergies renouvelables relatif aux conditions d'achat et de rémunération du surplus d'énergie électrique d'origine renouvelable résultant d'une production pour consommation propre	2011	République du Sénégal
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	Loi portant loi d'orientation sur les ENR	2010	République du Sénégal
	Projet de décret pour l'achat et vente l'électricité à partir des ENR	2010	République du Sénégal
	Projet de decret sue le Conditions d'achat et de rémunération du surplus d'énergie électrique d'origine renouvelable résultant d'une activité de production pour consommation propre	2010	République du Sénégal
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	Energy Policy Framework conditions for electricity market and renewable energies	2009	GTZ

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Sierra Leone			
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	SL first Renewable Energy Forum 15 Avr 10	2010	ENFO Energy for Opportunity

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Togo			
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	Compte Rendu Collecte de données	2011	IED
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