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Renewable energy in West Africa

STATUS, EXPERIENCES AND TRENDS

Elaborated by:

Regional Centre for Renewable Energy and Energy Efficiency
Centre Régional pour les Energies Renouvelables et l'Efficacité Energétique
Centro Regional para Energias Renováveis e Eficiência Energética
www.ecreee.org

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INSTITUTO TECNOLÓGICO DE CANARIAS

Gobierno de Canarias

CASA ÁFRICA

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CASA ÁFRICA

Prepared by:

With financing from:

PUBLISHERS:
ECOWAS CENTRE FOR RENEWABLE ENERGY AND ENERGY EFFICIENCY (ECREEE)
RENEWABLE ENERGY DEPARTMENT, CANARY ISLAND INSTITUTE OF TECHNOLOGY (ITC)
ECONOMY AND BUSINESS AREA, CASA ÁFRICA

THIS BOOK SHOULD BE CITED AS: "VILAR (ED) (2012) "RENEWABLE ENERGY IN WESTERN AFRICA: SITUATION, EXPERIENCES AND TENDENCIES"

TRANSLATION TEAM: AGNÈS LOUART (COORDINATOR), JORGE BARRIUSO, IAN THORPE, Mª JESÚS DÍAZ LÓPEZ DE VERGARA, EULOGIO BARRIO, LUISA PENA MONTERO, EVA MIRIAM SAMPAIO DE ANDRADE, MARÍA TERESA AMARAL, LAURA SANCHO ANDRÉS, MARÍA MAGDALENA FERNÁNDEZ PÉREZ

CANARY ISLANDS INSTITUTE OF TECHNOLOGY (ITC)
CASA ÁFRICA

RENEWABLE ENERGY IN WEST AFRICA. STATUS, EXPERIENCES AND TRENDS

NIPO: 502-12-033-7
ISBN: 978-84-8198-880-2
DEPÓSITO LEGAL: M-19.689-2013

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ACKNOWLEDGEMENTS

The Regional Centre for Renewable Energy and Energy Efficiency (ECREEE), the Canary Islands Institute of Technology (ITC) and Casa África would like to thank individuals and institutions for their immense contribution in preparing these articles. This publication was made possible through their selfless work.

We would also like to thank the Spanish Agency for International Development Cooperation (AECID), the RENOW project (MAC/3/C182), through the 2007-2013 Madeira-Azores-Canaries Transnational Cooperation Programme (PCT-MAC), and the European Regional Development Fund (FEDER), for their financial support and for agreeing to support this initiative.

FOREWORDS AND INTRODUCTION

FOREWORDS

INTRODUCTION FROM THE ECOWAS CENTRE FOR RENEWABLE ENERGY AND ENERGY EFFICIENCY (ECREEE)

MAHAMA KAPPIAH
EXECUTIVE DIRECTOR, ECREEE

As we journey together towards a cleaner and sustainable energy future, I am delighted to present this joint publication - "Renewable Energy in ECOWAS: Status, Experiences and Trends" - which provides an overview of the current situation and trends in the renewable energy sector in West Africa. The book aims to also contribute to the United Nations' Sustainable Energy for All (SE4ALL) Initiative.

The ECOWAS region is endowed with significant 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 based on renewable energy options. With the establishment of ECREEE, the ECOWAS Member States have demonstrated their resolve to improve access to modern, reliable and affordable energy services, energy security and reduction of energy related GHG emissions and climate change impacts on their energy systems. ECREEE therefore represents a carefully thought through and necessary regional response to international declarations, global climate change initiatives and to the specific needs of ECOWAS Member States as expressed in national and regional policies.

Since its establishment in July 2010, ECREEE has attained international recognition as a unique regional renewable energy and energy efficiency (RE&EE) promotion agency in Sub Saharan Africa. The Centre continues to serve as a catalyst for increasing energy access and the creation of favourable framework conditions for renewable energy and energy efficiency markets by supporting activities directed to mitigate existing barriers. These activities cover a range of areas: policy development, capacity building, resource assessment, knowledge management, and investment promotion.

A notable achievement was the adoption of the regional policies on renewable energy and energy efficiency by the ECOWAS Energy Ministers in October 2012. These regional policies will serve to guide the region's efforts to employ sustainable energy technologies and resources, notably in our efforts to attain universal energy access. It also means that the ECOWAS region is on track to become the second regional organization, after the European Union, to adopt regional green energy policies. The targets contained in these landmark policies are cost-effective, feasible and fully in line with the findings of the Global Energy Assessment, and the SE4ALL Initiative, which was presented at Rio+20 by the UN Secretary-General.

Other significant results include the approval of 41 projects with an overall volume of 2 million EUR through the first call for proposals of the ECOWAS Renewable Energy Facility (EREF); the establishment of the web-based ECOWAS Observatory for Renewable Energy and Energy Efficiency (ECOWREX), which provides targeted investment and business information for the private and public sectors; the commencement of the ECOWAS Renewable Energy Investment Initiative (EREI) which supports the development of a RE project pipeline for medium and large scale projects; the ECOWAS RE Capacity Building Programme; to mention a few.

This publication, which is jointly produced by ECREEE, the Canary Islands Institute of Technology (ITC) and Casa África, is a good example of international and institutional collaboration aimed at providing relevant information on the renewable energy situation in the West Africa region. In this book, we have tried to capture and present the current trends in the region's renewable energy sector, while striving to frame the discussions in the wider global and international context. It is our hope that the publication will assist the reader to broaden knowledge and understanding of the policy framework at regional and country levels, the state of renewable energy technologies, projects already implemented, future trends, and how the required financing for the development of renewable energy infrastructure can be effectively mobilised. In the final analysis, we hope that this book will further facilitate the ongoing process of increasing access to sustainable energy services for the attainment of the developmental aspirations of the ECOWAS region.

I take this opportunity to express my sincere appreciation to our strategic partners – the Governments of Austria (ADA), Spain (AECID) and the United Nations Industrial Development Organization (UNIDO) as well as the European Union (EU), the United States Agency for International Development (USAID) and other development partners for their continuous support and collaboration.

I hope this publication is useful, informative and stimulates interest in the ECOWAS region.

Thank you.

FOREWORD

SPAIN AND ECREEE – THE SUPPORT FOR RENEWABLE ENERGY IN WESTERN AFRICA

JUAN LÓPEZ-DÓRIGA
SPANISH INTERNATIONAL
DEVELOPMENT AGENCY (AECID)

For several years Spain has maintained a privileged relationship with the Economic Community of Western African States. For Spain, West Africa has been, and continues to be, a priority region at a bilateral level as well as from a regional perspective.

In this context, renewable energy is a key factor in the establishment of an efficient, equitable and sustainable energy development model in the region. In dealing with this decisive challenge, there can be no doubt that establishment of the ECOWAS Centre for Renewable Energy and Energy Efficiency has played a fundamental role. The main aim of this centre, from a regional perspective, is that of providing a response to the needs of the 15 ECOWAS member states with respect to the development and implementation of renewable energy and energy efficiency technology, while adapting itself to international political decisions on energy and climate change. This mandate has further been recently bolstered by the appointment of the centre as the focal point of the Sustainable Energy for All (SE4All) global initiative in West Africa, which is an acknowledgement at the highest level on the achievements so far.

Spain, the main technical and financial partner of the centre, and a member of its executive board, has actively accompanied ECREEE throughout its work, practically from its establishment.

As such, Spain is fully confident that its role during the coming years will be absolutely crucial for the inclusion of renewable energy and energy efficiency as a core part of the national agendas of ECOWAS Member States and in the region's international development agenda.

The fact that the involvement and support stemming from Spanish cooperation have been decisive for the foundation, launch and later strengthening of ECREEE, is a source of great satisfaction to AECID: Spain is the largest donor to the centre, and has contributed 7 million euros to its budget for the 2010-2014 period. Spanish commitment to the centre is derived from the convergence of various priorities that are fundamental for Spanish cooperation: the support for sustained and sustainable development in sub-Saharan Africa, with special emphasis on West Africa, with the conviction that this development must be led by Africans and their institutions, strengthened by recognising the relevance of initiatives for regional integration as a means to promote development and rapid growth.

Furthermore, although the energy sector has received a considerable amount of support in recent years, the contribution of Spanish cooperation to the renewable energy sector has not been limited to the financial contributions alone. Spain is recognised as one of the leading countries in the world in terms of renewable energy, and as such it made a commitment from the beginning, facilitating expertise and promoting the exchange of information and best practices in the area of renewable energy and energy efficiency. Spanish institutions of recognised prestige have therefore participated in these activities. These organisations include the Institute for Diversification and Energy Saving (IDAE), the Centre for Energy, Environment and Technological Studies (CIEMAT), the National Renewable Energy Centre (CENER), the Economic and Technological Development Distance Learning Centre Foundation (CEDDET) and the Higher Council for Scientific Research (CSIC), in addition to our finest universities.

In short, the commitment of Spanish cooperation in the region is firmly based on Spain's support for an energy development model where renewable energy and energy efficiency play an important role in the eradication of poverty and the fight against the adverse effects of climate change. As such, access to modern, reliable, clean, efficient and economically viable energy systems is being facilitated to the population so as to attain an energy security that will make a decisive contribution to sustainable social and economic development, as well as the achievement of the Millennium Development Goals.

FOREWORD

RENEWABLE ENERGY IN ECOWAS: STATUS, EXPERIENCES AND TRENDS

SANTIAGO MARTÍNEZ-CARO
DIRECTOR GENERAL OF CASA ÁFRICA

This publication presents several of the essential components of Casa África's mission as an instrument of public and economic diplomacy for Spain on the African continent.

First of all, this work is the result of a fruitful collaboration between public entities, working towards convergent goals from their respective positions. For Casa África it has also been a pleasure to work with two partner institutions which are benchmarks in their respective fields of work: the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE), and the Canary Islands Institute of Technology (ITC). This collaboration would not have been possible without the support of the Spanish Agency for International Development Cooperation (AECID), the United Nations Industrial Development Organization (UNIDO), and the Austrian Development Agency (ADA).

West Africa, the subject of this report, is a neighbouring region to Spain, and a priority in its foreign policy for Africa. Spain fosters close links with the Economic Community of West African States (ECOWAS), an inter-regional organization which includes amongst its members some of the emerging economic powers of the region, such as Ghana and Nigeria. Furthermore, in the last few years, ECOWAS has resolutely supported regional policies to develop clean energy and energy efficiency, with the strong support of Spain through AECID.

Spain, for its part, has been able to build and consolidate a considerable renewable energy industry, both at the national and international level. This highly specialized sector is already exporting its technology and investments to our neighbouring continent, as shown by the increasing presence of Spanish companies in the sector in South Africa, where 1,000 MW of the 2,459 MW of installed capacity bear the Spanish seal. Facts such as this undoubtedly help to strengthen the Spanish brand, demonstrating that we have much to offer Africa, and can be great exporters of knowledge, and know-how to the continent.

The goals of Spain and ECOWAS converge in this sector, since combining the participation of the private sector with government initiatives offers great potential, transferring the industrial capacities of our country and its capacity to create wealth and jobs in Africa and Spain.

Finally, this publication also clearly fulfils another of Casa África's strategic goals: disseminating and raising awareness in Spanish society of the reality in African countries, and the great opportunities they present.

Any example of economic and social development must be based on facts informed by the best sources of information, which reflect the reality on the ground. In Africa this information comes from Africans themselves, as well as specialized international organizations. We hope that this publication will be an example of this, and that it will provide readers with better knowledge of the present and future of the renewable energy sector in ECOWAS.

FOREWORD

CANARY ISLANDS INSTITUTE OF TECHNOLOGY (ITC) AND THE SEARCH FOR CLEAN AND EFFICIENT SOLUTIONS FOR THE SUSTAINABLE DEVELOPMENT OF THE ENERGY AND WATER SECTORS IN ECOWAS

GONZALO PIERNAVIEJA IZQUIERDO
R+D DIRECTOR
CANARY ISLANDS INSTITUTE OF TECHNOLOGY - ITC

1. THE CANARY ISLANDS: FOCUSING ON TECHNOLOGY TRANSFER TO AFRICA

The economic development experienced by the Canary Islands in the last twenty years has also led to significant technological development in emerging sectors. Within these new technological sectors are those in which the Canary Islands may provide additional value with respect to other areas in the world, due to its unique characteristics. Among these characteristics, as well as the 'island factor' is the important biodiversity of the archipelago (which is marking the way for the promising sector of biotechnology), the scarcity of water resources (that has resulted in the inhabitants of the islands becoming pioneers in different water production and treatment systems - such as the desalination of sea water) or the abundance of renewable endogenous energy resources (which are facilitating the implementation of innovative projects related to the use of renewable energy sources, even at a global level).

In the Canaries we see our archipelago as a natural laboratory for innovative and sustainable technologies. This view is already a reality, thanks to the launch of several unique projects in the fields of energy and water (e.g. the self-sufficient energy project for the island of El Hierro that uses only renewable energy sources and different initiatives for those water desalination systems that are operated solely by renewable energy sources).

Furthermore, the 'island factor' likens the Canaries in many ways to a multitude of neighbouring African regions (especially rural or isolated areas), that have serious shortcomings in basic services, such as access to energy and drinking water. If, in addition to this factor, we take the geostrategic position of the Canary Islands and its condition as an outermost region of the European Union into consideration, the view outlined above takes on a new dimension: the laboratory of new energy technologies also becomes a showcase for these technologies, which can almost be automatically replicated in neighbouring African countries, and so contribute to sustained and sustainable economic development in two key sectors: energy and water. ITC, which is working on cooperation projects in coordination with other regional and national institutions, such as companies, has been a driving force behind this philosophy of technology transfer to Western Africa, practically since its inception.

2. ITC: 15 YEARS OF EXPERIENCE IN COOPERATION PROJECTS WITH WEST AFRICA

ITC is a technological centre of the Canary Islands Regional Government that specialises in renewable energy sources, water technology and other emerging sectors, such as biotechnology, information technology and medical technology, and has been operative for twenty years. The first cooperation projects with African countries were first conceived and developed in 1997 with the aid of the AECID and the Canary Islands Regional Government. Since then ITC has undertaken numerous initiatives, mainly related to the development of systems and sustainable solutions for the supply of energy and water to rural areas using renewable energy resources. ITC has provided electricity to various isolated communities using solar and wind energy, it has provided drinking water to towns through the use of independent desalination plants (that are also fed by renewable energy resources and ITC technology), it has undertaken several awareness raising, advocacy and technical training initiatives (for people benefiting from the projects and technicians and public authorities from local counterparts) and has advised various public bodies in neighbouring regions and countries on hydraulic planning and sustainable energy sources. Over the last few years, these technological cooperation activities (undertaken by ITC in cooperation with other institutions and companies from the Canary Islands) have increased, thanks to the existence of new support programmes set up by the European Union. ITC has therefore contributed to the improvement of living conditions in various African communities, it has channelled technological transfer to the business community (in both the Canary Islands and in neighbouring areas), it has improved technical training and public policies in terms of energy and water (by advising governments on the development of regulatory and technical systems), and has promoted professional practices in the rational use of energy (energy efficiency and renewable energy sources) and water in neighbouring countries.

3. ITC, ECOWAS AND ECREEE

The coordination between the ITC, the AECID, the Directorate General of Relations with Africa of the Canary Islands Government, Casa África, and other Spanish institutions dedicated to the promotion of the rational use of energy and renewable energy sources, such as the IDAE and CIEMAT, fostered the start of institutional cooperation with ECOWAS in 2008. The willingness of these entities to show ECOWAS organisations and the leaders of member states the technological capacities of the Canary Islands in the areas of energy and water resulted in various visits to the ITC facilities in Pozo Izquierdo (in the southeast of the island of Gran Canaria), in 2008 and 2009. Both the then Executive Secretary of ECOWAS, Dr. Mohamed Ibn Chambas, and various leading figures from ECOWAS, including the current Executive Director of the Centre for Renewable Energy Sources and Energy Efficiency (ECREEE), Mr. Mahama Kappiah, who were able to verify on site the potential of the Canaries in terms of technology transfer in these sectors.

In July 2010, the President of the Canary Islands Regional Government, accompanied by a delegation in which the ITC participated, attended the inauguration of ECREEE in Praia (the Republic of Cape Verde). In March 2011 ITC and ECREEE signed a Memorandum of Understanding in Las Palmas de Gran Canaria, in which both institutions agreed to actively cooperate in the promotion of sustainable production technology for energy and water in ECOWAS. As a result of this agreement ITC, in coordination with ECREEE, organised two intensive seminars in 2011 for advanced training in renewable energy sources and water treatments for technicians and public officials from all member countries. These seminars were held in ITC facilities at Pozo Izquierdo and included visits to energy and water production plants and contact with organisations involved in the management of electrical energy, delegation from the Spanish Electrical Grid (REE) in the Canary Islands. This organisation has a powerful centre for the control and management of renewable energy systems connected to island grids. In 2011 the foundations were established for what is now an excellent cooperation initiative between ITC and ECOWAS by means of direct coordination with ECREEE. This work is already providing results through various specific projects being undertaken in Cape Verde by ITC and companies from the Canary Islands and these initiatives will soon extend to the mainland. Alongside these public initiatives, technology transfer opportunities are also emerging in the private sector in various ECOWAS countries, such as Guinea-Bissau, Ghana and The Gambia.

4. SUSTAINABLE GROWTH THROUGH ADAPTED TECHNOLOGY

As mentioned above, the prospects for technological cooperation with respect to energy (and water) between the Canary Islands (through ITC) and ECOWAS (through ECREEE) are highly promising.

The electrification levels of ECOWAS countries are the lowest in the world, especially in rural areas, where tens of millions of people have no access to 'modern' energy; a fact behind the rural exodus and the overcrowding of large cities. Furthermore, the lack of drinking water constitutes another emerging problem in these countries. ECOWAS needs sustainable solutions for the development of these basic sectors. However, these solutions are not the same as those of industrialised regions: they must be adapted to their needs and are different for each area (rural, suburban and urban). In its White Paper for a Regional Policy (2006), ECOWAS expressed its willingness to increase access to energy services for rural and suburban towns in order to fulfil the Millennium Development Goals. The specific aims of which are for at least 60% of those living in rural areas to have access to productive energy services in towns (especially electricity to promote productivity from economic activity). ECOWAS also aims to provide 66% of the population of its states (over 200 million inhabitants) with access to individual electrical supplies (100% in urban and suburban areas and 36% in rural towns).

Through technological centres like ITC and private companies, the Canary Islands, has the know-how and capacity to contribute to this development. ITC installations at Pozo Izquierdo have both the laboratories and the technology appropriate to ensure that this development is sustainable. The experience of ITC in decentralised generation and supply, as well as in the decentralised distribution of energy and water using endogenous and renewable sources, as well as our technical vision of sustainable energy development for ECOWAS is briefly described in one of the chapters of this book. ITC also possesses the technology and know-how for the deployment of innovative systems for the production and provision of electricity and water, which are based on small power stations known as micro or minigrids and which can operate either isolated from the main power grid or when connected or semi-connected to the grid - if the aim is to extend the electricity supply in a conventional manner to a specific area. The Canary Islands also has significant know-how in all types of water treatment technology (pumping, desalination, purification and production of drinking water).

Efforts have also been made to ensure that these techniques consume as little energy as possible and that they can be operated directly using renewable energy sources. At ITC we are convinced that the technological relationship between the Canary Islands and ECOWAS will help achieve the Millennium Development Goals and the sustainable growth of the ECOWAS states.

FOREWORD

BETTER TOGETHER

AMBASSADOR BRIGITTE ÖPPINGER-WALCHSHOFER
MANAGING DIRECTOR OF THE AUSTRIAN DEVELOPMENT AGENCY

Austrian Development Cooperation (ADC) has supported the establishment of the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) from the very beginning. At the ECOWAS Conference on Peace and Security held in November 2008 in Burkina Faso, the UNIDO Director General and the Austrian Foreign Minister together pledged support for such a Centre. In February 2010 the preparatory phase of the Centre commenced in cooperation with the ECOWAS Commission, with UNIDO as the leading technical partner and Austria as the first bilateral donor. At this point I would like to highlight the excellent cooperation with the ECOWAS Commission and UNIDO. The Austrian contribution had a high leverage effect and attracted other key donor partners such as AECID (Spain), the European Commission and others to join this initiative.

After three years of implementation, ECREEE has now become a regionally and internationally highly appreciated platform for the promotion of renewable energy and energy efficiency in West Africa. The Centre focuses on policy development, capacity building, awareness raising, technology transfer, pilot projects and the attraction of investment.

During the Forum on "Sustainable Energy For All in West Africa", held in Accra, Ghana, from 29 to 31 October 2012, the 15

ECOWAS Energy Ministers adopted regional policies on renewable energy and energy efficiency with strong targets and clear action plans for implementation. The Austrian Energy Agency led the process for the ECOWAS policy formation on energy efficiency funded by the European Commission. Austria, through the Global Forum on Sustainable Energy, also acted as a Co-organiser of the mentioned Forum.

Austrian Development Cooperation will continue to fulfill its commitment to the Centre through financial assistance and the provision of technical assistance of ECREEE's business plan adopted for the time period of 2011-2016.

Since its creation in 2004 the Austrian Development Agency, the operational unit of the Austrian Development Cooperation, has been focusing on the sector "sustainable energy" to promote affordable access to clean, safe and efficient sustainable energy services. Austria has a very long tradition in the use of renewable energy sources and energy efficiency solutions in buildings, SMEs and industrial processes. The Austrian Development Cooperation supports partner countries in Africa and other parts of the world by sharing Austrian experiences and lessons learned in the sector and in turn, learns from their achievements.

Our experience shows that regional cooperation becomes more effective by applying a mix of approaches at the same time: bottom up and top down. In this way, the Austrian Development Agency combines demand driven capacity building for local experts and institutions as well as technical know-how transfer with regional and national political engagement in policy formulation and implementation. We highly appreciate that the Centre´s model will now be replicated in other regions of Sub-Saharan Africa and will continue to contribute to these activities.

FOREWORD

CONTRIBUTION OF UNIDO TO THE PROMOTION OF SUSTAINABLE ENERGY IN WESTERN AFRICA

PRADEEP MONGA
DIRECTOR, ENERGY AND CLIMATE CHANGE, UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

In 2010, when UNIDO envisaged ECREEE to be a nodal organization for renewable energy and energy efficiency initiatives in the ECOWAS region, the level of intervention, its scope and political support that ECREEE would get from the national governments in the region was not clear. In 2012, ECREEE, in collaboration with UNIDO and its other partners oversaw the adoption of the regional RE and EE policies by the energy minister from all the ECOWAS countries. This publication in its initial chapters introduces the adopted policies and further looks at the intertwined relationship with gender. In chapter 3, several case studies and technology specific policy frameworks are outlined. In the final chapters 4 and 5, the financing and market development for renewable energy is highlighted.

The timeliness of this publication is critical, as not only does it outline the targets set out in the regional RE policy but also showcases best practices by citing examples from the region and explores the financing options and initiatives required to achieve these targets within the time frame stated.

UNIDO is implementing 8 renewable energy projects, 1 energy efficiency project and 1 regional project under the Strategic Programme for West Africa-Energy Component funded by the Global Environment Facility. The UNIDO portfolio in West Africa amounts to more than 80 million USD (including co-financing) and covers

Burkina Faso, Cape Verde, Chad, Côte d'Ivoire, Guinea, Liberia, Nigeria, Sierra Leone and The Gambia.

Furthermore it is evident that the roadmap of West Africa's energy future must include renewable energy as a prominent source of energy especially in the non grid connected areas through micro grids and in industrial grid connected areas through its vast hydro and solar potential. Rising industrial growth rates are accompanied by an increased energy demand. In the case of West Africa, this increased demand must be met by adopting innovative energy solutions that encompass the use of transformative renewable energy technologies, transitive forms of clean energy and increased energy efficient industrial and transport sector.

Financing the use of renewable energy poses certain unanswered questions. It remains to be seen if the policy frameworks supported by the financial mechanisms funded through donor organizations, will create an enabling environment in which the private sector for renewable energy will burgeon and and if the market forces will support the use of energy from renewables.

On behalf of the United Nations Industrial Development Organization and the international community, I would like to congratulate ECREEE and Casa África for their efforts in documenting the renewable energy policies, technologies, best practices and financing options prevalent in West Africa, as both global and national policy makers engage in the arduous journey to overcome the hurdles along the energy road map that impede growth in the region.

INTRODUCTION

DAVID VILAR FERRENBACH
ECREEE

In 2010 the Economic Community of West African States (ECOWAS) inaugurated the Regional Centre for Renewable Energy and Energy Efficiency (ECREEE). ECREEE's mandate was to promote renewable energy and energy efficiency in the region by integrating various complementary project strategies, garnering political support, knowledge transfer and encouraging investment.

The United Nations' mechanism for inter-agency collaboration in the field of energy, UN-Energy, declared in its *Looking to the Future* publication that: "There is an emerging consensus on the diversity and complex nature of key energy issues, and the requirement to look at them in a holistic manner".

West Africa is an asymmetrical group of states that includes big countries such as Nigeria, but also small ones such as The Gambia, Guinea-Bissau or Liberia, with quite diverse and complex situations. These states are distributed from the Sahel region in the north to the humid area in the south, which accounts for the diversity of environments found in the region. In addition, the majority of these states are among the least developed countries in the world, with high levels of poverty both in urban and rural areas. In this context, energy plays an essential role in improving living conditions. This is especially true in a region with abundant renewable energy resources, yet that continues to be highly dependent on fossil fuels.

The energy situation in West Africa, specifically in the area of renewable energy and human development, is highly diverse and complex. Therefore, any initiative in the sector must start with a strong understanding of the region and its dynamics and must also take into account different aspects of development, from the local to the regional level.

This publication, "*Renewable energy in West Africa: STATUS, EXPERIENCES AND TRENDS*", is the result of a coordinated effort between the ECREEE, the Technological Institute of the Canary Islands and Casa África to provide information on the current situation of renewable energy in West Africa, a region connected to a globalized world in permanent development. To do so, various aspects that fundamental to contextualize the sector are dealt with, such as technology and financing. In this sense, the publication is structured in three well-defined parts.

First of all, the plans and regulatory frameworks in the region are presented and compared to other international experiences. This section will emphasize the asymmetry, not just between the region and an international context, but also between the different countries within the region, while at the same time considering important transversal aspects such as a gender-based focus.

In the second part, after describing the current state and potential of some renewable energy technologies of interest to the region, other cases of real projects that have been carried out or that are in the process of being implemented are examined in order to present some of the specific activities in this sector in West Africa.

The last part presents the current situation of the financing mechanisms in place to implement projects in this region. In addition, some of the more relevant business models for this sector in rural areas are presented. Finally, the initiatives being developed by ECREEE to attract financing in this sector are explained. In this part we shall discuss that adapting a financing mechanism to the region's situation is necessary to convert the effort invested into the creation of a favourable legal context, improved capabilities and information, and to attract investment.

The structure of the publication allows the experiences of various experts and specialized institutions to be coherently grouped in a format that can be used for specific consultations. It also permits to acquire a broader vision of the opportunities in the region's renewable energy sector.

Although there are more topics that we would have liked to include, this publication offers a representative sample of the current situation of renewable energy in a region that has many development opportunities but that needs initiatives adapted to its context. We hope that this work will help to increase the understanding and interest in development in this region.

Praia, 22 December 2012

FIRST PART
GLOBAL OUTLOOK AND REGULATORY FRAMEWORK OF RENEWABLE ENERGIES

RENEWABLE ENERGY – INTERNATIONAL CONTEXT

JANET SAWIN, RANA ADIB Y KANIKA CHAWLA
REN21

ABSTRACT

This section, based on the REN21 Renewables 2012 Global Status Report, focuses on providing a comprehensive overview of the renewable energy market, industry, and policy developments all over the world; providing a sound basis for measuring global progress in renewable energy deployment. The year 2011 saw the reorientation of future energy policy in many countries in the wake of the tragic nuclear disaster in Fukushima, Japan. Despite the economic uncertainty of the present, global investment in renewable power and fuels increased 17% and the renewable energy continued to grow strongly in all end use sectors- power, heating and cooling, and transport. Renewable energy support policies continue to be a driving force behind the increasing shares of renewable energy. Renewables are also increasingly viewed as critical to creating jobs, providing energy access- particularly in rural areas - and for achieving energy autonomy. Today more people than ever before derive energy from renewables as capacity continues to grow, prices continue to fall and shares of global energy from renewables continue to increase.

Keywords: Renewable energy, REN21 Global Status Report, policy, investment, energy access, rural energy, industry trends, wind power, solar PV, Biomass, solar thermal heating and cooling, CSP, geothermal, hydropower, ocean energy, modern renewables, power generation, policy targets.

1. INTRODUCTION

Renewable energies represent a broad and diverse array of energy resources- biomass, hydro, geothermal, wind, solar and ocean energy- as well as a range of conversion processes and applications such as combustion, thermal, mechanical, photovoltaic processes, etc. Apart from obvious emission control advantages, renewable energy technologies can also make a significant contribution to domestic energy security and spur economic development.

Renewable energy markets and policy frameworks have evolved rapidly in recent years. This section is based on the findings of the REN21 *Renewables 2012 Global Status Report* and highlights recent developments, current status, and key trends in the field of renewable energy, worldwide.

The United Nations General Assembly declared 2012 the International Year of Sustainable Energy for All. UN Secretary-General Ban Ki-moon has supported the Year with his new global initiative – Sustainable Energy for All, which seeks to mobilize global action on three inter-linked objectives to be achieved by 2030: universal access to modern energy services, improved rates of energy efficiency, and expanded use of renewable energy sources.

Renewable energy support policies have been the driving force behind the increasing shares of renewable energy. As many as 118 countries, more than half of which are developing countries, have had renewable energy targets in place by early 2012, and 109 countries have had policies to support renewable in the power sector.

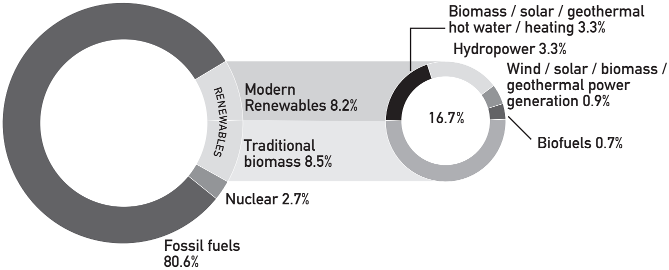
A main driver propelling policy forward is renewable energy's potential to create jobs. Globally, an estimated 5 million people work directly or indirectly with renewable energy industries. More and more governments around the world acknowledge the benefits of renewable energy along with energy efficiency as central elements of any green economy strategy.

Renewables are also increasingly viewed as critical for providing access to energy, particularly in rural areas of the developing world. Renewable energy is now seen as a viable option for providing millions of people with a better quality of life. Although there is a long way to go to provide energy access to all, today more people than ever before derive energy from renewables as capacity continues to grow, prices continue to fall, and shares of global energy from renewables continue to increase.

2. RENEWABLE ENERGY GROWTH IN ALL END-USE SECTORS

Renewable sources, including traditional biomass, have grown to supply 16.7% of global final energy consumption in 2011. Of this total, modern renewable energy accounted for an estimated 8.2%, a share that has increased in recent years, while the share of traditional biomass has declined slightly to an estimated 8.5%. During 2011, renewables continued to grow strongly in all end-use sectors: power, heating and cooling, and transport.

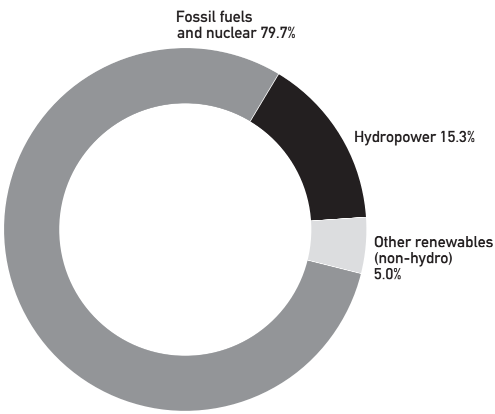
FIGURE 1
RENEWABLE ENERGY SHARE OF GLOBAL FINAL ENERGY CONSUMPTION, 2010



SOURCE: FIGURE 1 FROM REN21 RENEWABLES 2012 GLOBAL STATUS REPORT (PARIS: REN21 SECRETARIAT).

In the power sector, renewables accounted for almost half of the estimated 208 gigawatts (GW) of electric capacity added globally during the year. Wind and solar photovoltaic (PV) accounted for almost 40% and 30% of new renewable capacity, respectively, followed by hydropower (nearly 25%). By the end of 2011, total renewable power capacity worldwide exceeded 1,360 GW, up 8% over 2010; renewables comprised more than 25% of total global power-generating capacity (estimated at 5,360 GW in 2011) and supplied an estimated 20.3% of global electricity. Non-hydropower renewables exceeded 390 GW, a 24% capacity increase over 2010.

FIGURE 2
RENEWABLE ENERGIES SHARE



SOURCE: FROM REN21 RENEWABLES 2012 GLOBAL STATUS REPORT (PARIS: REN21 SECRETARIAT).

The heating and cooling sector offers an immense yet untapped potential for renewable energy deployment. Heat from biomass, solar and geothermal sources already represents a significant portion of the energy derived from renewables and is slowly evolving as countries (particularly in the European Union) are starting to enact supporting policies and to track the share of heat derived from renewable sources. Trends in the heating (and cooling) sector include an increase in system size, expanding use of combined heat and power (CHP), providing renewable heating and cooling into district networks, and the use of renewable heat for industrial purposes.

Renewable energy is used in the transport sector in the form of gaseous and liquid biofuels; liquid biofuels provided about 3% of global road transport fuels in 2011, more than any other renewable energy source in the transport sector. Electricity powers trains, subways, and a small but growing number of passenger cars and motorised cycles, and there are limited but increasing initiatives to link electric transport with renewable energy.

Solar PV grew the fastest of all renewable technologies during the period from end 2006 through 2011, with operating capacity increasing by an average of 58% annually, followed by concentrating solar thermal power (CSP), which increased almost 37% annually over this period from a small base, and wind power (26%). Demand is also growing rapidly for solar thermal heat systems, geothermal ground-source heat pumps, and some solid biomass fuels, such as wood pellets. The development of liquid biofuels has been mixed in recent years, with biodiesel production expanding in 2011 and ethanol production stable or down slightly compared with 2010. Hydropower and geothermal power are growing globally at rates averaging 2-3% per year. In several countries, however, the growth in these and other renewable technologies far exceeds the global average.

The top seven countries for non-hydro renewable electric capacity—China, the United States, Germany, Spain, Italy, India, and Japan—accounted for about 70% of total capacity worldwide. The ranking was quite different on a per person basis, with Germany in the lead followed by Spain, Italy, the United States, Japan, China, and India. By region, the EU was home to nearly 44% of global non-hydro renewable capacity at the end of 2011, and the BRICS[1] nations accounted for almost 26%. Their share has been increasing in recent years, but virtually all of this capacity is in China, India, and Brazil.

Even so, renewable technologies are expanding into new markets. In 2011, around 50 countries installed wind power capacity, and solar PV capacity is moving rapidly into new regions and countries. Interest in geothermal power has taken hold in East Africa's

Rift Valley and elsewhere, and solar hot water collectors are used by more than 200 million households, as well as in many public and commercial buildings the world over. Interest in geothermal heating and cooling is on the rise in countries around the world, and the use of modern biomass for energy purposes is expanding in all regions of the globe.

Across most technologies, renewable energy industries saw continued growth in equipment manufacturing, sales, and installation during 2011. Solar PV and onshore wind power experienced dramatic price reductions resulting from declining costs due to economies of scale and technology advances, but also due to reductions or uncertainties in policy support. At the same time, some renewable energy industries—particularly solar PV manufacturing—have been challenged by falling prices, declining policy support, the international financial crisis, and tensions in international trade. Continuing economic challenges (especially in traditional renewable energy markets) and changing policy environments in many countries contributed to some industry uncertainties or negative outlooks, and over the course of the year there was a steady decline in new projects proposed for development.

3. A DYNAMIC POLICY LANDSCAPE

Renewable energy targets and support policies continued to be a driving force behind increasing markets for renewable energy, despite some setbacks resulting from a lack of long-term policy certainty and stability in many countries. The number of official renewable energy targets and policies in place to support investments in renewable energy continued to increase in 2011 and early 2012, but at a slower adoption rate relative to previous years. Several countries undertook significant policy overhauls that have resulted in reduced support; some changes were intended to improve existing instruments and achieve more targeted results as renewable energy technologies mature, while others were part of the trend towards austerity measures.

FIGURE 3
COUNTRIES WITH POLICIES, EARLY 2012

SOURCE: 2012 POLICY MAPS; REN21 RENEWABLES 2012 GLOBAL STATUS REPORT; PAGE 79 (PARIS: REN21 SECRETARIAT).

FIGURE 4
COUNTRIES WITH POLICIES, 2005

SOURCE: 2012 POLICY MAPS; REN21 RENEWABLES 2012 GLOBAL STATUS REPORT; PAGE 79 (PARIS: REN21 SECRETARIAT).

Renewable power generation policies remain the most common type of support policy; at least 109 countries had some type of renewable power policy by early 2012, up from the 96 countries reported in the *GSR 2011*. Feed-in-tariffs (FIT) and renewable portfolio standards (RPS) are the most commonly used policies in this sector. FIT policies were in place in at least 65 countries and 27 states by early 2012. While a number of new FITs were enacted, most related policy activities involved revisions to existing laws, at times under controversy and involving legal disputes. Quotas or Renewable Portfolio Standards (RPS) were in use in 19 countries and at least 54 other jurisdictions, with two new countries having enacted such policies in 2011 and early 2012.

Policies to promote renewable heating and cooling continue to be enacted less aggressively than those in other sectors, but their use has expanded in recent years. By early 2012, at least 19 countries had specific renewable heating/cooling targets in place and at least 17 countries and states had obligations/mandates to promote renewable heat. Numerous local governments also support renewable heating systems through building codes and other measures. The focus of this sector is still primarily in Europe, but interest is expanding to other regions.

Biofuel blending and fuel share mandates existed in at least 46 countries at the national level and in 26 states and provinces by early 2012, with three countries enacting new mandates during 2011 and at least six increasing existing mandates. Transport fuel-tax exemptions and biofuel production subsidies also existed in at least 19 countries. At the same time, Brazil's mandated ethanol blend level was reduced, partly in response to low sugarcane yields, while long-term ethanol support policies in the United States were allowed to expire at year's end.

Thousands of cities and local governments around the world also have active policies, plans, or targets for renewable energy and climate mitigation. Almost two-thirds of the world's largest cities had adopted climate change action plans by the end of 2011, with more than half of them planning to increase their uptake of renewable energy. Many of the institutions encouraging co-operation among cities in local renewable energy deployment saw increased membership and activities in 2011, including the *EU Covenant of Mayors* (with over 3,000 member cities). Most activity has occurred in North American and European cities, although 100 demonstration cities exist in China, and cities in Argentina, Australia, Brazil, India, Mexico, South Africa, South Korea, and elsewhere undertook initiatives to support renewable energy deployment in 2011.

Policymakers are increasingly aware of renewable energy's wide range of benefits—including energy security, reduced import dependency, reduction of greenhouse gas (GHG) emissions, prevention of biodiversity loss, improved health, job creation, rural development, and energy access—leading to closer integration in some countries of renewable energy with policies in other economic sectors. Globally there are more than 5 million jobs in renewable energy industries, and the potential for job creation continues to be a main driver for renewable energy policies. During 2011, policy development and implementation were also stimulated in some countries by the Fukushima nuclear catastrophe in Japan and by the UN Secretary-General's announced goal to double the share of renewables in the energy mix by 2030.

There has been little systematic linking of energy efficiency and renewable energy in the policy arena to date, but countries are beginning to wake up to the importance of tapping their potential synergies. Efficiency and renewables can be considered the "twin pillars" of a sustainable energy future, with renewables reducing the emissions of pollutants per unit of energy produced, and energy efficiency improvements reducing energy consumption altogether. Improving the efficiency of energy services is advantageous irrespective of the primary energy source, but there is a special synergy between energy efficiency and renewable energy sources. In the EU, the United States, and elsewhere, countries are beginning to link the two through targets and policies. At the global level, the UN Secretary-General's initiative on Sustainable Energy for All highlights the interlinkages among energy access, energy efficiency improvements, and renewable energy deployment. Policies have also begun to address the efficiency of renewable energy systems themselves.

4. INVESTMENT TRENDS

Global new investment in renewables rose 17% to a record USD 257 billion in 2011. This was more than six times the figure for 2004 and almost twice the total investment in 2007, the last year before the acute phase of the recent global financial crisis. This increase took place at a time when the cost of renewable power equipment was falling rapidly and when there was uncertainty over economic growth and policy priorities in developed countries. Including large hydropower, net investment in renewable power capacity was some USD 40 billion higher than net investment in fossil fuel capacity.

One of the highlights of 2011 was the strong performance of solar power, which blew past wind power, the biggest single sector for investment in recent years. Another highlight was the performance of the United States, where investment increased by 57% relative to 2010, mainly as the result of developers rushing to take advantage of federal incentive programmes that were coming to an end.

The top five countries for total investment were China, which led the world for the third year running, followed by the United States, Germany, Italy, and India. India displayed the fastest expansion in investment of any large renewables market in the world, with 62% growth. Developing countries saw their relative share of total global investment slip back after several years of consistent increases; developing countries accounted for USD 117 billion of new investment in 2011, compared with USD 140 billion in developed countries.

5. RURAL RENEWABLE ENERGY: SPECIAL FOCUS

Significant technological innovation and cost reductions of renewable energy technologies, along with improved business and financing models, are increasingly creating clean and affordable renewable energy solutions for individuals and communities in developing countries. For a majority of very remote and dispersed users, decentralised off-grid renewable electricity is less expensive than extending the power grid. At the same time, developing countries have begun deploying more and more grid-connected renewable capacity, which is in turn expanding markets and further reducing prices, potentially improving the outlook for rural renewable energy developments.

Rural renewable energy markets in developing countries differ significantly across regions: for example, Africa has by far the lowest rates of access to modern energy services, while Asia presents significant gaps among countries, and Latin America's rate of electrification is quite high. In addition, active players in this sector are numerous, and participants differ from one region to the next. The rural renewable energy market is highly dynamic and constantly evolving; it is also challenged by the lack of structured frameworks and of consolidated data sets.

In addition to a focus on technologies and systems, most developing countries have started to identify and implement programmes and policies to improve the ongoing operational structures governing rural energy markets. Most countries are developing targets for electrification that include renewable off-grid options and/or renewably powered mini-grids; there is also some use of grid-connected renewable electricity. In the rural cooking and heating market, advanced cookstoves fueled by renewable sources are gaining impetus as reliable and sustainable alternatives to traditional biomass cookstoves. Such developments are increasing the attractiveness of rural energy markets and developing economies for potential investors.

After many years of relatively slow political, technical, financial, industrial, and related developments, the impressive deployment of all renewable energy technologies and the reduction of the cost represent an important opportunity that points to a brighter future. However, further efforts will be necessary to reach the outlined objectives: the International Energy Agency estimates that annual investment in the rural energy sector needs to increase more than fivefold to provide universal access to modern energy by 2030.

6. CONCLUSION

Recent years have seen significant growth of renewable energy in all parts of the world. In terms of energy production, installed capacities, and investment number, growth has been steady, positioning several renewable energy technologies as integral to the current energy mix.

These positive developments have made several renewable energy technologies cost-competitive under an increasing range of locations and conditions. Furthermore, they provide a sound basis for projections indicating that in the long run, the future world energy mix will rely heavily on renewable energy technologies. For example, the IPCC's special report on Renewable Energy Sources & Climate Change Mitigation estimates in one of its scenarios, that up to 77% of the world's energy supply could be met by renewables by mid-century if backed by the right enabling public policies such as rethinking of the energy system away from a centralized towards a decentralized one with corresponding implications on energy infrastructure will be imperative. Flexibility-driven design of energy markets will be needed to cope with system changes.

NOTES

1. Brazil, Russia, India, China and South Africa.

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[1] REN21 Renewables 2012 Global Status Report (Paris: REN21 Secretariat).

AUTHORS

Janet Sawin. Lead Author, REN21 Renewables 2012 Global Status Report; Partner, Sunna Research; and Senior Fellow, Worldwatch Institute.

Rana Adib. Project Manager, REN21 Renewables 2012 Global Status Report; Policy Advisor, REN21 Secretariat.

Kanika Chawla. Supplementary Author and Community Manager, REN21 Renewables 2012 Global Status Report; Junior Policy Consultant, REN21 Secretariat.

www.ren21.net

POWER SUPPLY SCENARIOS FOR THE ECOWAS REGION

DOLF GIELEN Y ASAMI MIKETA
IRENA

BRUNO MERVEN
UNIVERSIDAD DE CIUDAD DEL CABO

ABSTRACT

New ECOWAS power pool model analysis suggests that up to 54% of Western African power supply could be based on renewables by 2030. Results for 2030 do not vary widely depending on the policy framework or the technology optimism but the share of renewables beyond 2030 varies significantly between scenarios. The model assumptions for renewable energy and the results are summarized in this paper. Results depend on the input assumptions and further analysis is needed to identify key sensitivities and develop robust strategies. The tool is available for decision makers in the region for future scenario and strategy analysis.

Keywords: Energy planning, Renewable energy, energy technology, IRENA.

1. INTRODUCTION

In July 2011 the African leaders have asked the International Renewable Energy Agency (IRENA) at their summit in Abu Dhabi to assist in the accelerated deployment of renewable energy (IRENA; 2011a). This has resulted in an IRENA Africa initiative that has a number of activities. Development and use of tools for energy planning, including scenarios and strategies, is one of these. So far two reports have been released (IRENA, 2011b, 2012b). The planning toolbox for West Africa has been further refined since. This paper provides an update of the latest insights (status June 2012).

At present West Africa has a very low per capita electricity use. This situation is likely to change rapidly in the future. It is projected that demand may increase ten-fold in the coming two decades as the economic activity increases and universal access is achieved. This raises important questions regarding the optimal power supply mix. Worldwide the share of renewables in annual power capacity additions has reached more than 50%. Hydro, wind and solar PV have reached global capacity addition levels of 30, 42 and 28 GW, respectively, in 2011. This indicates that a power sector transition has started. It is a fact that West Africa has significant renewable energy potentials. The challenge is how to use these potentials to meet future electricity demand.

While the region is endowed with rich fossil fuel resources, this has not helped to alleviate the energy access situation. Nigeria is an example: massive amounts of oil and gas have been produced and exported for decades but their own population in Nigeria has even today only very limited access to electricity. Electricity grid supply cannot meet demand and blackouts abound. In combination with low price diesel fuel this has resulted in the widespread use of diesel power generators. But this diesel fuel is imported and subsidized by the government. The burden on the national budget has risen to a level that is not sustainable. Early 2012 efforts to curb subsidies for oil products resulted in widespread unrests. It shows that energy security is not a given for a fossil fuel based economy.

This situation can be resolved through increased use of renewable power. Diesel power generation is one of the most expensive power options, typically around 40 USD C per kWh at market prices.

Most renewable power options are considerably cheaper. Many renewable power technologies are decentralized and do not face the same planning challenges as fossil and nuclear plant that are only economic at a scale of hundreds of Mega Watts that require massive investments in a transmission grid. Communities, households and small scale entrepreneurs can carry the burden for such renewables investments where governments fail to do so.

Power sector planning is complex. Supply must meet demand at any point in time, or power system blackouts will occur. Energy systems models that cover the supply and demand chain have been used since several decades to help decision makers understand a complex reality. These tools help to identify the best mix of supply options for the coming decades. They account for existing capital stock characteristics, future energy demand projections, and the techno-economic characteristics of different supply options. The MESSAGE model is one such tool. It is a generic linear programming software tool that can be used to model energy systems. One such model has been used by IRENA for the analysis of the role of renewable power supply options in the ECOWAS power pool. The model was built on earlier work done by the International Atomic Energy Agency. This model was refined significantly in order to improve its use for renewable energy planning. The following enhancements make it much more suited to assess renewable power options:

- Demand projections were updated in line with the latest projections (ECOWAS, 2011).
- Demand has been split into rural, urban and industrial demand, to allow a better representation of decentralized power supply and improve the representation of the load curve.
- The latest data on planned and proposed transmission lines and interconnectors were included.
- Renewable energy potentials have been updated based on new resource assessment studies.
- The technology database has been expanded to reflect the range of renewable power generation options more comprehensively.

- Technology characteristics have been updated to reflect the latest cost reductions for renewable power technologies.
- The latest fossil fuel price projections have been included. Gas supply for Nigeria, Côte d'Ivoire, and Ghana was split into two types: domestic gas and associated gas. Associated gas is half the price of domestic gas and has an annual production limit estimated on limited information available in the master plan.
- The nuclear supply option was excluded from the analysis, as it requires further investigation into technical, legal, and economic challenges, and it is outside the scope of this study.

Two scenarios are compared:

- A business as usual scenario (BAU-T).
- A scenario more favourable for renewable energy and with increased electricity interconnections (RE).

The two scenarios differ in assumptions on future cost development of renewable technologies and in the amounts of trade allowed within the region and with Central Africa. The renewable energy scenario assumes active support policies. Higher shares of local content and more significant deployment levels result in accelerated cost reductions. The investment cost assumptions for the two scenarios are taken from IRENA (2011b).

These scenarios serve illustrative purposes. Demand projections, cost of financing, fossil fuel prices are typical examples of uncertain variables where further sensitivity and scenario analysis would be warranted before investment strategies are developed.

2. TECHNOLOGY CHARACTERISTICS

Table 1 shows the complete list of available technologies to the region and gives the overnight investment cost for the more optimistic (RE) scenario, as well as the construction duration and the expected lifetime. The reduction in investment cost is due to technology learning anticipated from increased global installed capacity in those technologies, in combination with policies promoting increased local content.

For fossil fuel based power generation the cost of fuel are critical. Diesel prices are projected to increase from 24 to 29 USD per GJ between 2010 and 2030. Gas supplied from transmission pipelines is projected to increase from 9 to 11 USD/GJ in the same period. Local associated gas is considerably cheaper, rising from 4.5 to 9 USD/GJ. Domestic coal increases from 2.5 to 4 USD/GJ while imported coal is about 30% more expensive.

TABLE 1

TECHNOLOGY OPTIONS AND INVESTMENT COSTS, RE SCENARIO

	OVERNIGHT 2010	OVERNIGHT 2015	OVERNIGHT 2020	OVERNIGHT 2030	CONST. DURATION	LIFE
	USD/KW	USD/KW	USD/KW	USD/KW	Years	Years
Diesel	1,070	1,070	1,070	1,070	2	25
HFO	1,350	1,350	1,350	1,350	2	25
OCGT	603	603	603	603	2	25
CCGT	1,069	1,069	1,069	1,069	3	30
Supercritical coal	2,403	2,403	2,403	2,403	4	30
Hydro	2,000	2,000	2,000	2,000	5	50
Small Hydro	4,000	3,804	3,618	3,272	2	50
Biomass	2,500	2,260	2,043	1,847	4	30
Bulk Wind (25% CF)	2,000	1,808	1,634	1,335	2	25
Bulk Wind (30% CF)	2,000	1,808	1,634	1,335	2	25
Solar PV (utility)	2,000	1,631	1,474	1,267	1	25
Solar PV (roof top)	2,500	2,038	1,843	1,584	1	25
PV with Battery	3,500	2,854	2,451	2,002	1	25
Solar thermal no storage	3,000	2,576	2,329	1,903	4	25
Solar thermal with storage	5,400	4,637	4,086	3,338	4	25
Solar thermal with gas co-firing	1,388	1,320	1,288	1,225	4	25

NOTE: CF CAPACITY FACTOR; CCGT COMBINED CYCLE GAS TURBINE; OCGT OPEN CYCLE GAS TURBINE.

Based on the above assumptions on the cost development, a levelized cost of electricity (LCOE) analysis was performed. The LCOE was computed for the two above-mentioned scenarios. Results for both scenarios are shown in Table 2 and Table 3 for the base year and 2020. The results are presented for the power plant LCOE with and without levelized transmission and distribution costs. Transmission and distribution costs need to be added to certain large scale power options that require transmission and distribution lines. They do not apply for decentralized power generation units, or they will be significantly reduced in such cases. Also decentralized power does not face the same transmission and distribution losses as centralized power generation.

Three classes of consumers are distinguished as they are assumed to require different degree of transmission and distribution infrastructures. Three classes of consumers are:

- Heavy industry (e.g. mining), which connects to generation at a high voltage and generally requires less transmission and no distribution infrastructure.
- Urban residential, commercial, and small industries, which are connected to generation via relatively more transmission and distribution infrastructure.
- Rural residential and commercial, which require even more transmission and distribution infrastructure.

Accordingly, transmission and distribution cost are assumed to vary by market segment. For industry, urban and rural consumers 1.5, 5 and 10 USD C/kWh was assumed. Losses were set at 7, 15 and 20%, respectively, and were kept constant over time. In comparison average losses in other countries are well below 8%. High losses favour decentralized solutions.

The levelized cost of electricity data in Table 2 shows that for industrial customers connecting at high voltage, hydropower is the cheapest option, closely followed by combined cycles using associated. However, this situation changes in 2020, with the escalation in fuel price. For countries that have domestic coal, coal generation is the next cheapest option but this is closely followed by wind with high capacity factors. Next is natural gas based on imported gas and power generation based on imported coal. This is followed by biomass. PV utility and solar thermal are the next options for countries without any other domestic resources.

The optimal mix is different for rural areas. For rural customers, mini hydro remains the best option, where it is available. Distributed/roof-top PV with and without battery are expected to become the next best option for these customers in the RE scenario.

TABLE 2

LCOE COMPARISONS FOR 2020

LCOE USD/MWH	GRID	BAU-T	RE	RE TND IND	RE TND URBAN	RE TND RURAL
Diesel	0	326	326	326	326	326
HFO	1	208	208	238	295	360
OCGT	1	154	154	180	231	292
CCGT	1	98	98	120	165	222
CCGT Associated Gas	1	69	69	89	131	187
Supercritical coal	1	104	104	127	173	231
Supercritical Domestic Coal	1	89	89	110	154	211
Hydro	1	62	62	82	123	178
Small Hydro	0	102	102	102	102	102
Biomass	1	104	104	127	173	231
Bulk Wind (25% CF)	1	111	111	134	181	239
Bulk Wind (30% CF)	1	94	94	116	160	217
Solar PV (utility)	1	107	107	130	175	233
Solar PV (roof top)	0	159	159	159	159	159
PV with Battery	0	201	201	201	201	201
Solar thermal no storage	1	125	125	149	196	256
Solar thermal with storage	1	149	149	176	226	287
Solar thermal with gas co-firing	1	112	112	136	182	240

3. SCENARIO RESULTS

Power supply is projected to grow from 51 TWh in 2010 to 247 TWh in 2030 (a five-fold increase) and to 600 TWh in 2050 (a twelve-fold increase). This huge demand increase creates great opportunities to deploy renewable energy technologies.

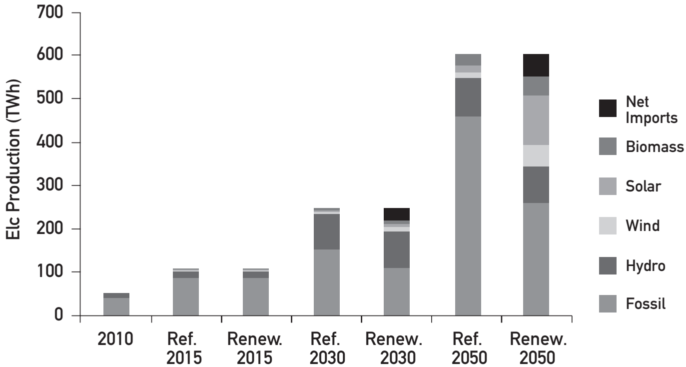
The fossil power generation mix in 2030 includes 94 TWh of gas and 18 TWh of coal. The gas is largely associated gas, a low-cost by-product from oil production. This gas supply is limited to those countries with significant oil production. Significant efforts are ongoing to increase the use of this gas, part of which is flared today. The associated gas production ceases a few years after oil production is stopped.

The share of renewables in power generation was 22% in 2010. In the RE scenario it rises to 54% in 2030. Three quarters of this renewable power supply in 2030 is regional hydropower, supplemented by imported hydropower from Central Africa. With more trade in the RE scenario, the share of hydro (within the region) and imported hydro from Central Africa increases relative to BAU-T. Solar and biomass start to emerge in 2030, but solar wind and import of hydro grow significantly after 2030. While fossil power plant additions dominate 2010-2020, the majority of power plant additions after 2020-2030 are based on renewables. This result can be explained by the fact that the best hydropower resources are exhausted past 2030.

It is a surprise that no more wind and solar is applied prior to 2030. The LCOE data in Table 2 explain this result. In rural electricity markets renewables constitute the favoured option. However, the size of this market is limited. Centralized renewable power options face the same high transmission and distribution cost as fossil fuels. Moreover in the largest markets, Nigeria and Côte d´Ivoire, low cost associated gas based power generation dominates. The availability of this gas in the coming decades needs to be assessed in more detail. It should also be noted that the scenarios do not assume any CO_2 pricing. Sensitivity analysis suggests that of a CO_2 price were considered the share of renewables would rise further at the expense of fossil fuels.

FIGURE 1

POWER SUPPLY PROJECTIONS, 2010-2050



REF.: REFERENCE. RENOW.: RENEWABLE.
POWER SUPPLY PROJECTIONS, 2010-2050

Figure 1 shows the breakdown of the power supply mix by country. The mix varies significantly. But also the level of power demand varies widely. Nigeria alone accounts for about 60% of total electricity use, followed by Ghana with about 10%. In Nigeria gas based power generation dominates, and this explains the high share of gas for the region as a whole.

In this set of model runs planned mining projects were included. Many of these mines are in remote regions and do not have grid access, therefore their power supply options are limited and renewables can play a role in this market. The results suggest also limited use of coal for power generation. Some coal is used in the coastal regions (imported coal) and in Niger (which has domestic coal).

The inland countries with no access to gas and coal (Burkina Faso and Mali) invest in various levels of solar thermal in all cases.

Guinea-Bissau is the only country that is a net exporter for hydropower. All other countries are net importers. Significant amounts of hydropower are imported from the Central Africa region.

FIGURE 2

COUNTRY POWER SUPPLY MIX, RE SCENARIO, 2030

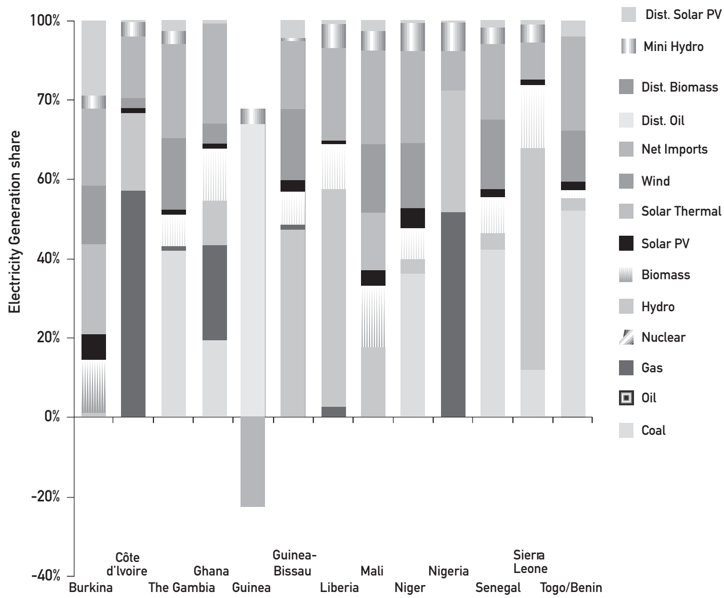


FIGURE 3

SHARE OF DECENTRALIZED POWER SUPPLY OPTIONS IN TOTAL ELECTRICITY SUPPLY, 2030

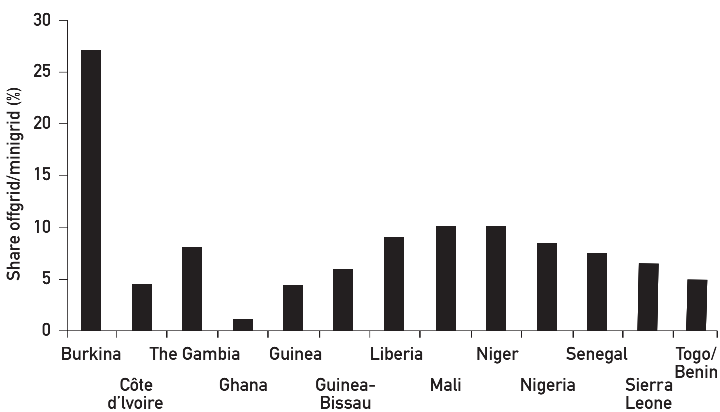


Figure 3 shows the share of distributed power supply options (representing off-grid and mini-grid systems) in total electricity supply. This share is generally low (below 10%), with the exception of Burkina Faso where it reaches 25%. In line with the low LCOE, most of the rural demand is met by mini hydro and PV (see also Figure 2). However, this demand remains in all cases quite small so the overall share remains quite low.

Results depend on the assumptions and further analysis is needed to identify key sensitivities and develop robust strategies. The tool is available for decision makers in the region for future scenario analysis. An outreach programme is planned with power sector decision makers in the region in order to refine the results further. This will be followed by outreach to deploy this model for energy planning in the region.

FIGURE 4

SYSTEM COST RE SCENARIO, 2010-2030

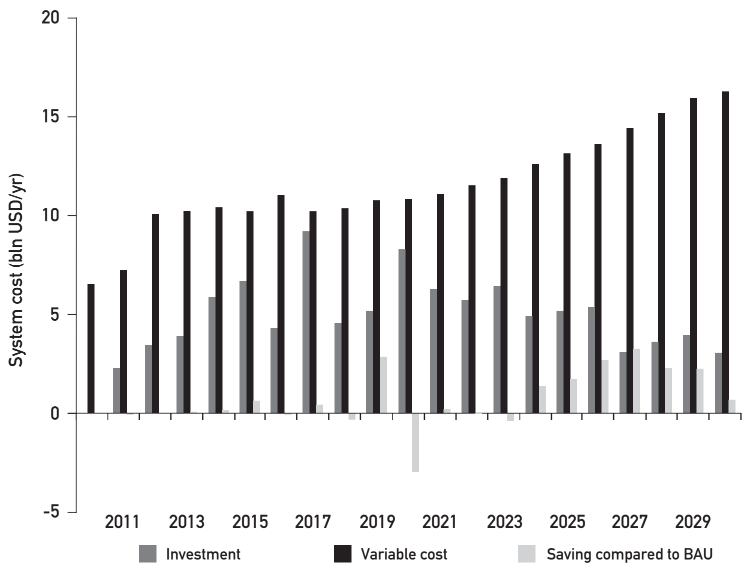


Figure 4 shows the undiscounted total system costs including investment, operation and maintenance, and fuel costs for the renewable scenario. The differences in total costs for the two scenarios can be interpreted as a cost saving brought due to the policy framework to enable more trade in the region and with Central Africa, as well as dramatic cost reductions in the renewable technology investment costs. The figure shows evolution of this cost saving. The main savings occur in the period 2020-2030. Total system cost reduction amounts to USD 15.1 bln without discounting and by USD 2.7 bln when a 10% discount rate is applied for future savings.

4. CONCLUSIONS

An updated version of a model of the ECOWAS power pool system in MESSAGE was developed. This tool has important additional features compared to earlier versions of the models of the region such as a better representation of urban and rural markets, the latest technology and cost data for renewable power, and a better representation of associated gas. Results of two modelled scenarios are presented: a Business As Usual scenario and an RE Scenario. With more trade in the RE scenario, the share of hydro (within the region) and imported hydro from Central Africa increases relative to BAU-T. With active support policies to encourage higher shares of local content and more significant deployment levels result in accelerated cost reductions. Solar, wind and biomass start to emerge by 2030, but solar and wind grow significantly after 2030. The results indicate that renewables can play an important role in the future energy supply of West Africa. By 2030 up to 54% of power supply is based on renewables. The optimal power mix varies by country. Grid expansion dominates but offgrid and minigrid solutions also play a role.

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AUTHORS

Dolf Gielen, Director IRENA Innovation and Technology Centre, Bonn, Germany.

Bruno Merven, Senior Researcher, Cape Town University, Cape Town, South Africa.

Asami Miketa, Senior Analyst IRENA Innovation and Technology Centre, Bonn, Germany.

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REGULATORY FRAMEWORK AND INCENTIVES FOR RENEWABLE ENERGY

SOFÍA MARTÍNEZ
IDAE

ABSTRACT

Renewable energy has the potential to play a key role in providing sustainable energy, including growing populations in developing countries who as yet have no access to energy. Technologies exist at competitive costs if the evaluation includes external costs and benefits, and subsidies to conventional energy are eliminated. Many countries are in the process of deregulating and restructuring their energy systems and industries. Renewable energy technology is developing rapidly around the world aided by a range of economic support mechanisms, but still far to realise its potential due to several barriers to its penetration. It is necessary a combination of efficient and effective policy and financial instruments, an appropriate technical and regulatory infrastructure, clear and efficient administrative procedures, public awareness and acceptance, research and development leading to innovation and new technologies entering the marketplace at competitive prices, and a cadre of professionals to design, build, operate and maintain the systems. The development of innovative regulatory, legal and economic frameworks to support the development and deployment of RES to better leverage private capital and expertise will change the future global energy mix towards cleaner, more sustainable and more secure sources.

Keywords: Renewable energy; Barriers; Incentives; Policies; Regulatory framework.

1. INTRODUCTION: THE NEED FOR RENEWABLE ENERGY SOURCES (RES) SUPPORT POLICY

Renewable energy technologies (RET) are still new entrants in the global energy system. They face an uphill struggle against the well-established conventional energy supply technologies (oil, coal, gas, nuclear…). Making the shift from fossil fuels to RES is leading governments to simulate the expansion of renewable energy via a range of subsidies and other financial support systems. This paper looks at the main regulatory framework and economic support mechanisms that have been used worldwide.

Despite the substantial decrease in RET's costs and the growth of RET over the past decades, renewables still face many barriers and will require more than just public and private finance to operate at scale. Experiences from numerous countries show that without the creation of a favourable legal and regulatory framework RES will be condemned to remain a small niche market. Studies suggest that further market development is highly sensitive to administrative barriers, grid access and the risk of policy change [1]. Even if well-designed renewables support programmes are in place, bureaucratic procedures and administrative hurdles or difficulties in accessing the electricity grid can prevent market development. Therefore, a key precondition for the development of renewable energies is the reduction of economic, technical, legal and administrative barriers [2].

The costs associated with RE integration, whether for electricity, heating, cooling, gaseous or liquid fuels, are contextual, site-specific and generally difficult to determine [3]. Renewables support policies aim to reduce barriers for its deployment, providing a level playing field, making renewables cost competitive, starting out a local industry development and a renewables market, protecting the environment and human health as well as diversifying the energy mix and increasing energy independency and global energy access. These policies should offer an initial support so that renewables may compete against conventional sources independently. The support for renewables can be done through the creation of a favourable regulatory framework and direct support programmes and incentives as well as by putting into place measures aimed at reducing the use of fossil fuels (e.g. reducing the support of conventional energy, often heavily subsidised, and internalising external costs that are currently being paid by the society).

Unfortunately, there is no one perfect regulatory framework or support scheme for all RET and for all countries. The issue of deciding which policies for RES development to choose depends upon many factors (e.g. current market prices, forecasted RET costs reduction, budget available, energy demand, local resources…). A mix of policy instruments needs to be tailored to the particular technology and the specific national situation. This policy mix needs to evolve with the technology. Even more important is the proper design and monitoring of the support system adopted. In this sense the functionality, stability and continuity of the chosen policy-support system are crucial features [4].

2. REGULATORY FRAMEWORK

In a very broad sense regulation seeks to ensure proper competition and economic efficiency as well as to address inequity or market failure, being appropriate where it is necessary to protect consumers and/or the environment. Regulatory challenges are diverse, including [1] [2]:

- Absence of long-term energy planning, with no RES targets.
- Inefficient administrative procedures (high number of relevant authorities, lack of coordination between relevant authorities, lack of transparency, long lead times…).

- Market structures not prepared for RES.
- Insufficient consideration of renewable energy in spatial planning.
- Complex permitting procedures and legal appeal process.
- Lack of stakeholder involvement in decision-making.
- Lack of experience among decision-makers.
- Complex grid access and connection procedures.

Thus, governments need to be involved with renewable energy deployment because markets alone are usually ineffective in mainstreaming RES. Energy markets comprise considerable institutional barriers and long-term subsidies for conventional fuels and equipment preventing the deployment of RES. Governments can enforce a broad range of policies that affect the price of both fossil and renewable energies through subsidies reforms and taxes for example, to support the market development of RES. Support for renewables is important not only to incorporate the external costs (environmental, social and security) of energy production and consumption, but to account for the numerous benefits associated with renewables (diversification of the energy mix, reduced external energy dependence, reduced risk of fuel price volatility, cleaner environment and better health, job creation, economic delete the dots). Well-designed incentive schemes will help to bridge the cost gap between renewables and conventional energy. Only a few countries had renewable energy support policies in the early 1990s, but in early 2011 around 118 countries had enacted some type of policy target and/or support policy related to renewable energy [5].

Renewables shall be an important part of the energy planning process if we want them to become an important part of the energy mix. And according to the International Energy Agency the policy design should reflect some key issues [6]:

- Removal of economic and non-economic barriers, including RES social acceptance issues.
- Design of predictable, stable and transparent support framework for RES to attract investments and reduce risks.

- In order to foster and monitor technological innovation RES incentives will decrease over time, accelerating RES market competitiveness. Incentives shall be technology specific, based on the degree of technology maturity.

It is important that RES are considered early in the design of energy sector reforms, and not after the reforms are done. Experience shows that deregulating the energy sector has the potential to attract private investment and Independent Power Producers (IPPs) to the market, essential for the deployment of RES. And it is also advisable to include mandatory RES targets in the policy planning rather than indicative so as to reinforce industry confidence and stimulate Government intervention (e.g. the European Union 20-20-20 targets set by the "climate and energy package"[1]).

Best practices around the world shows that an independent single entity known as the energy regulator, with authority in key areas such as tariff-setting, license issuance and monitoring, is critical to the development of a liberalized energy sector conducive to high RES deployment [7]. Regulation of RES must focus not only on traditional regulatory issues such as price and quality, but also at the larger context in which RE is being developed and promoted. Successful renewable regulatory framework usually:

- Is long-term and consistent, including a secure and predictable payment mechanism (stability).
- Provide fair and open RES access.
- Is transparent and simple, including low transaction costs.
- Includes R&D as well as capacity building (institutional and technical).
- Takes into account socioeconomic and longer-term development goals.
- Encourage small distributed generation and enact regulations to encourage consumer production of RES (net metering).
- Power purchase agreements (PPA) for RES.
- Grid codes to ensure access to the network.

3. INCENTIVES FOR RENEWABLE ENERGY

Governmental intervention typically includes incentives for RES producers and investors, as well as obligations and some non-mandatory policy measures. The literature indicates that long-term objectives for RES and flexibility to learn from experience are critical to achieve cost-effective and high penetrations of RES [4]. Support schemes are optimised based on best practice and lessons learned, thus continuously improving the policy design (more effective than a switch to a different policy). It is also advisable to keep the financing of the support scheme outside the Government budget (no effects of changes in policy design and/or allocation of budgets).

Besides attracting sufficient capital to RES projects, the challenge for policy makers is to minimize RES support policy costs. Incentives to encourage RES are multiple and varied and are directed to all end-use sectors and technologies (electricity, heating and transportation). However, most current RE deployment policies are focused on the electricity sector. These policies can include fiscal incentives such as investment subsidies and tax credits; government financing such as low-interest loans; regulations such as feed-in tariffs (FITs), quotas or net metering; direct R&D grants and funds; assistance in resource mapping; encouraging the voluntary sector, etc. These possible support mechanisms are not mutually exclusive, and their effectiveness varies greatly depending on the country/region as well as the type of RES to promote [2] [4] [7] [8].

3.1. INCENTIVES FOR RENEWABLE ELECTRICITY (RES-E)

As shown in Figure 1, incentives for RES-E can be classified according to four general categories resulting from cross-referencing the period in time where Government intervention may be applied and the concept regulated by the Government. In general, the types of support mechanisms most commonly applied for high-penetration of renewable electricity are feed-in-tariffs (FITs), tradable green certificates (TGCs) in conjunction with quota obligations and tenders (see figure 1). For all of the mechanisms to work properly, it is important that renewable electricity has guaranteed connection to the grid and preferential access. Otherwise, system operators may not connect or may curtail renewable generators [8]. The appropriate RES-E support mechanism depends on the maturity of the RES-E industry, thus, some schemes are more appropriate for less mature technologies than others.

FIGURE 1
OVERVIEW OF SUPPORT SCHEMES

	PRICE BASED SUPPORT	QUANTITY BASED SUPPORT
Investment focused	Investment subsidies Tax incentives Soft loans	Tender mechanisms
Generation focused	Feed-in tariffs and premiums Power Purchase Agreements Net metering	Tender mechanisms Quota obligation

3.1.1. Feed-in tariffs

Feed-in tariffs (FIT) guarantee a fixed financial payment per unit of electricity produced from RES. FIT must be high enough to ensure long-term recovery of costs for a given technology. This support can be fixed, and the generator do not participate in the electricity market (fixed FIT), selling the electricity through a purchase obligation, usually enforced on the system operator. Or the producer receives the rest of his income from selling the electricity on the regular electricity market plus a premium on top of this price (Feed-in Premium, FIP). FIP systems have improved compatibility with electricity market as compared to FIT, because RES generators react to market signals. FIP models can be introduced in combination with other systems, allowing for intervals to change between FIP and the alternative system. For example, in Spain, producers could choose every year which support system, FIT or FIP, they want to use [9]. In both cases, the extra-costs are passed on to the end-consumers of the electricity. Other features that can be incorporated into the FIT/FIP design include [10]:

- Tariff is set over a sufficiently long period of time, commonly between 10 to 30 years.

- Technology-specific tariffs, to avoid windfall profits for cheaper technologies.
- Tariffs can be stepped according to site conditions in order to avoid windfall profits for projects at the more favourable sites.
- A fixed or regularly determined degression of tariffs over time for new installations can be used in order to take technological learning into account and to avoid overcompensation.
- Type of premium: fixed, cap and floor (e.g. Spain), sliding (e.g. "breathing cap" in Germany).

So far FIT and FIP has been the most efficient and effective support schemes for promoting RES-E.

3.1.2. Quota obligations

Quota obligations, also called renewable obligations or renewable portfolio standards (RPS), impose a minimum share of renewables in the overall electricity mix to ensure that a portion of the electricity comes from renewables, establishing a separate market for these obligations. Tradable certificates are awarded for every unit produced from RES-E and bought by those required to comply with the RES-E quota. This obligation can be imposed on consumers, retailers or producers. If the quota obligation is set too low, or if the penalty is too low or not enforced, then the value of RES-E in the market will be low, generating insufficient stimulation to initiate new RES-E projects [10] [11].

3.1.3. Tendering schemes or competitive auctions

Through tenders, the government or other institution (e.g. regulator) set the RES capacity to be built during a specific period at the least-costly price (Tender winning). Tenders usually specify the capacity and/or production to be achieved, the maximum price per unit of energy and can be technology or project/site-specific or include shares of local manufacturing. Usually the parties sign a long-term contract (power purchasing agreement). Penalties for non-compliance can be implemented in order to avoid unreasonably low bids, or to projects exceeding deadlines. I order to avoid stop-and-go development of the RES industry it is desirable to ensure long-term continuity and predictability of calls [10].

3.1.4. Tax incentives and other instruments

Their aim is to promote renewable energy by investment subsidies, low-interest loans, and different tax measures like for instance tax deductions or flexible depreciation schemes. Although they can be used as a main support scheme, e.g. for biofuels, in most cases they are used as an additional policy tool or supplementary measure.

But we cannot forget that there are other issues that will have a significant impact in the effectiveness of the support scheme and crucial for RES-E deployment, like policies to reduce administrative and grid barriers, or to improve design of power markets to accommodate the characteristics of RES-E by a more flexible and integrated design. In most cases RES are geographically widespread and sometimes far away from consumption centres. The costs associated with the need of reinforcing the grid to accommodate the renewable power plants, especially intermittent sources like wind or solar PV, has become an important technical barrier for RES-E deployment. For example, according to the Renewable Energy Directive [12] EU countries must ensure that transmission system operators and distribution system operators guarantee the transmission and distribution of renewable electricity and provide for either priority access to the grid system (connected generators of renewable electricity are sure that they will be able to sell and transmit their electricity) or guaranteed access (ensuring that all electricity from renewable sources sold and supported gets access to the grid).

Introducing a priority purchase obligation is of most importance for RES-E support schemes so that electricity from renewable energy sources is purchased ahead of electricity from other sources. The usual wholesale purchaser of electricity should have an obligation to buy and transmit the electricity produced from the eligible renewable energy plants, assuring producers that each unit produced can be sold, increasing RES investment security and at coping with RES intermittency. Some other of the non-economic barriers needed to be addressed in order to enable support schemes to be effective can include:

- One-stop shop for authorisation.
- Response periods & approval rates.
- Lengthy processes increases risk and cost.
- Clear guidelines for authorisation procedures.
- Pre-planned areas for a targeted level of RES capacity.
- Increase grid capacity and improve manageability of intermittent sources.
- Transparent grid connection procedures and cost allocation.

3.2. INCENTIVES FOR RENEWABLE HEAT (RES-H)

The policy design for renewable heat is different from renewable electricity due to key differences between the delivery of heat and electricity. The heterogeneous nature of heating fuels means that a diverse group of companies supply the market. The demand side also is fragmented and difficult to target [13]. Support mechanisms for renewable heating have not developed to the same extent as those for electricity generation. The modest market development of RES-H production, which is in contrast with the development in the electricity as well as in the transport sector, can be explained by the absence of a stable support framework for the support of RES in the heating sector at the European and partially at national levels during the last decade [11].

A wide variety of different types of mechanisms has the potential to support the expansion of RES-H, and can be classified according to their different approach to the various existing barriers [13]:

- Financial or fiscal mechanisms. Ordinarily, the capital resources come from Governments' budgets:
  - Grant/investment mechanisms. To date, direct capital cost subsidies for the purchase of a renewable heating system are the

most widely adopted financial mechanism in the OECD for the support of renewable heat [8].

- Public procurement: encourages or compels the adoption of RES-H technologies in public buildings.
- Mechanisms similar to those used for RES-E: quota mechanism, tariff or bonus mechanism, tendering mechanism.
- Tax related instruments, levies and soft loans.
- Support for research, development and demonstration.

• Non-financial mechanisms:
  - Use obligations. This is the case of solar obligations, which have now been adopted by a number of countries, regions and municipalities all around the world. For example, in 2006 the Government of Spain adopted the Technical Building Code which obliged owners of all new buildings and those undergoing renovation, to provide 30% to 70% of their domestic hot water demand by solar thermal energy [14]. Municipal solar ordinances started well before, and as of 2006, more than 70 municipalities adopted similar ordinances. These municipal solar obligations will remain in force as long as they are stronger than the national obligation.
  - Skills, education and training.
  - Information, awareness and promotion.

3.3. INCENTIVES FOR RES-TRANSPORT

The principal policy tools that have been used to stimulate demand for biofuels are blending mandates, biofuel subsidies and tax exemptions. A mandate legally requires fuel retailers to add a certain percentage of biofuels to the conventional fuel. Blending mandates now exist in 31 countries at the national level and in 29 states/provinces around the world. Fuel-tax exemptions and production subsidies exist in at least 19 countries [5]. Recent years have also seen increased attention to biofuels sustainability and environmental standards, most notably under the EU Renewable Energy Directive [12].

Policies to support electric vehicle (EV) deployment are also starting, although such policies do not necessarily require that the electricity used by the EV will be renewable. Several countries have announced targets that together would result in over 20 million electric battery vehicles (EVs) operating by 2020 [5]. Their deployment is closely link to the Smart Grids development and initiatives like Smart Cities.

4. CONCLUSIONS

In recent years renewable energy sources have gained importance in the global energy systems, but we need to intensify our efforts to accelerate global renewable energy deployment. Fossil-fuel technologies are still heavily subsidized, distorting the market to the disadvantage of RE. Together with other challenges, like RES storage and dispatchability, it is been almost impossible for RES to compete with conventional technologies without regulatory intervention (removing risks by removing barriers). A necessary first step will be cutting down fossil-fuel subsidies where they exist, while respecting the social dimension of energy pricing. The support level required is strongly dependant on non-economic and non-static barriers to RES deployment, the design of the support system as well as the risks associated for private investors. Keep the financing of the support scheme outside the government budget and the removal of certain barriers will reduce the costs associated with the support schemes and will accelerate RES projects [11].

Experiences show that the development of the RE sector in different countries varies depending on their incentive policies. Only those countries with strong compulsory RES objectives integrated into the national energy planning, and with stable long-term commitment policies and incentives to support RES have achieved high levels of RES penetration and developed a strong local industry. The support scheme must remain active long enough to provide stable planning horizons and should not change during the project lifetime. Fine-tuning support schemes based on empirical evidence and improved design of existing policy support schemes may be more effective than switching to a different scheme.

When choosing and designing RES support schemes and incentives, it is important to differentiate among sources, use and technologies, ensuring that a balance is found between developing higher-cost technologies and deploying lower-cost technology potentials at an adequate speed. Successful incentive mechanisms and support levels should be aligned with generation and RES technology costs, based on realistic assumptions for investment costs. The deployment of each technology differs from country to country, but global market status has important implications for national policy making as well. Thus, learning from experience, best practice exchange and technology information sharing will benefit all the actors involved in RES promotion, choosing the means that best suit their national circumstances.

NOTE

1. In January 2008, the European Commission proposed binding legislation to meet the objectives established by the European Parliament and the Council for December 2008, which became law in June, 2009. The core of the integrated measures on energy and climate change included four norms: a reform and reinforcement of the Emission Trading System (ETS); a "Decision on shared effort" regulating emissions in sectors not covered by the EU- ETS; binding national objectives on renewable energy that, as a whole, would raise the average quota of renewable energy in the EU by 20% from here to 2020; a legal framework which would promote the development and safe use of extraction and storage of coal.

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AUTHOR

Sofía Martínez. International Relations Department, IDAE.

www.idae.es

ECOWAS RENEWABLE ENERGY POLICY (EREP)

HYACINTH ELAYO, MARTIN LUGMAYR,
DAVID VILAR AND MAHAMA KAPPIAH
ECREEE

ABSTRACT

The Economic Community of West African States (ECOWAS) region faces significant challenges in terms of energy delivery. Despite the vast energy resources of its 15 member states, the region's overall access rate to modern energy services is very low. This situation hinders socio-economic activities, the provision of basic social services and the reduction of poverty and the attainment of the Millennium Development Goals (MDGs). ECOWAS Member States recognise that achieving the goals for energy access and energy security will require increased use of renewable energy, as well as increased efficiency in the use of energy. This led to the adoption of regional policies for renewable energy and energy efficiency by the ECOWAS Energy Ministers in October 2012. These policies aim to guide the region's efforts to employ sustainable energy technologies and resources. They also contribute to the realisation of national and Millennium Development Objectives and the three targets defined under the Sustainable Energy for All Initiative - Ensuring universal access to modern energy services; doubling the rate of improvement in energy efficiency; and doubling the share of renewable energy in the global energy mix. This article presents the key elements of the ECOWAS RE policy (EREP).

Keywords: ECOWAS, Renewable energy, policy.

1. INTRODUCTION

At the background of the severe energy crisis in the Economic Community of West African States (ECOWAS), the fifteen Member States have expressed the need to mainstream renewable energy and energy efficiency into their national policies. In this context, the countries have agreed on a stronger regional cooperation and integration to accelerate this process. The renewable energy and energy efficiency directives of the European Union have shown that regional integration can be an effective tool to catalyse necessary actions at national level. As a consequence, the ECOWAS Member States created the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) in 2010. As part of its mandate, the Centre has been leading the process of developing and implementing the ECOWAS Renewable Energy Policy (EREP), prepared by ECREEE with the technical assistance of Innovation Energie Developpement (IED). The policy document, which was prepared on the basis of a comprehensive baseline study on renewable energy in the ECOWAS region, was adopted by the ECOWAS Energy Ministers in October 2012.

2. THE ENERGY CHALLENGES IN WEST AFRICA

The current status of the energy system hampers the social, economic and industrial development of the whole region. The countries face the interrelated challenges of energy access, energy security and climate change mitigation simultaneously. Electricity shortages in urban areas and lack of access to modern, affordable and reliable energy services in rural areas are interrelated with a variety of economic, social, environmental and political problems.

2.1. ENERGY POVERTY

In "business as usual" scenarios – without considerable additional investments – energy poverty and its consequences for the 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. There are significant energy pricing and income inequalities between urban and rural areas and among different social groups, a phenomenon common to many developing countries. The urban and rural poor in West Africa spend proportionately more of their income for poor quality energy services than the better-off for better quality services. Whereas urban areas tend to use energy higher up the energy ladder (e.g. electricity, charcoal, kerosene, etc.), rural areas continue to rely on traditional biomass for meeting their energy requirements for cooking and lighting.

In 2009-10, it was estimated that nearly 175 million people had no access to electricity. Amongst them, 25% are living in urban and 75% in rural areas. In some countries, less than 10% of the rural population has access. In the most optimistic scenarios it is estimated that 75% of the population will have access to grid electricity by 2030. This would still leave almost 150 million inhabitants and 58% of the localities in the ECOWAS region without access. If this trend continues, the region would be far from achieving universal energy access.

The private sector has not been attracted to invest in electricity in rural areas due to the low consumption of electricity, limited ability and willingness to pay, and the high costs of diesel generation. Therefore, most governments have set up Rural Electrification Agencies (REAs) and/or Rural Electrification Funds (REFs) to promote decentralised rural electrification. However, due to inadequate financial and technical expertise, they have been unable to make much impact so far.

Meanwhile, if the total energy situation is considered, traditional biomass (firewood and charcoal) represents the bulk of the final energy consumption, reaching up to 70-85% in some of the countries. Although there are efforts to promote the use of LPG in urban areas, charcoal has remained the basic fuel used in these areas; charcoal is preferred to firewood because of its better combustion and its lower transportation costs compared to firewood, but its conversion from firewood is inefficient. The rural population use firewood in traditional stoves. Increasing population and urbanisation are, therefore, severely impacting the forest and savannah woodland environment, calling for stringent ameliorative measures. The use of woodfuels is also severely impacting the health and quality of life of rural and urban people, particularly women and infants.

2.1.1. Current Access Rate in the ECOWAS region

The actual status of the energy access situation is summarised in the charts below. It relies on data from UNDP report on General Energy Access in ECOWAS Region - UNDP Dakar – Regional Energy Poverty Project – 2011, corrected for some factual and compilation errors; for example, Mali's national access rate is 28% instead of 17% and the regional electricity access rate is 42% instead of 27%.

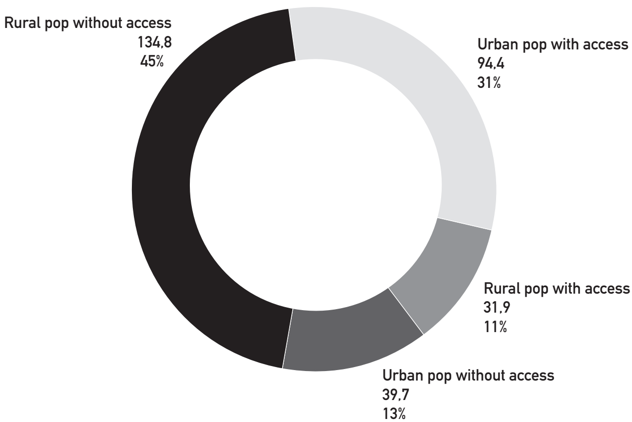
For the ECOWAS region, 19% of the rural population have access, mainly the major rural centres and some localities under the lines. And 81% of their rural population are left without access. Six countries already have a significant national electricity access rate in 2009, greater than 30%. These are Cape Verde (87%), Ghana (66.7%), Nigeria (50%), Côte d'Ivoire (47.3%), and Senegal (42%). For these countries, 25.1 million urban people and 78.8 million rural populations had no access to electricity in 2009. For the remaining 10 countries, only 18% of the population in average had access to electricity with most of them in urban areas (83%). 82% of the total population are without access with 80% living in the rural areas.

FIGURE 1

ANALYSIS OF THE ELECTRICITY ACCESS SITUATION IN THE ECOWAS

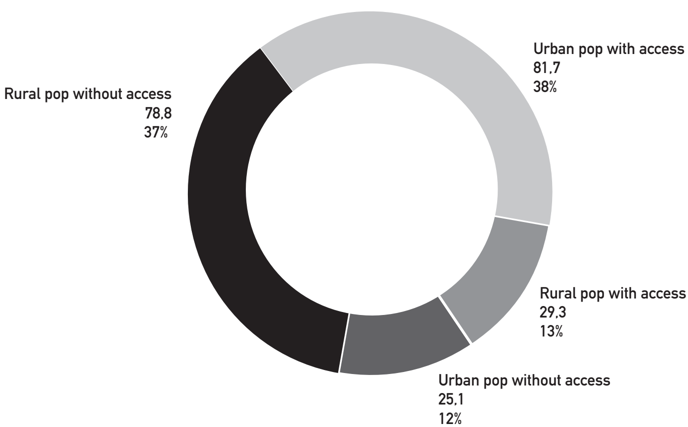
1.1. ACCESS SITUATION IN THE ECOWAS, 2009

300,7 million inhabitants

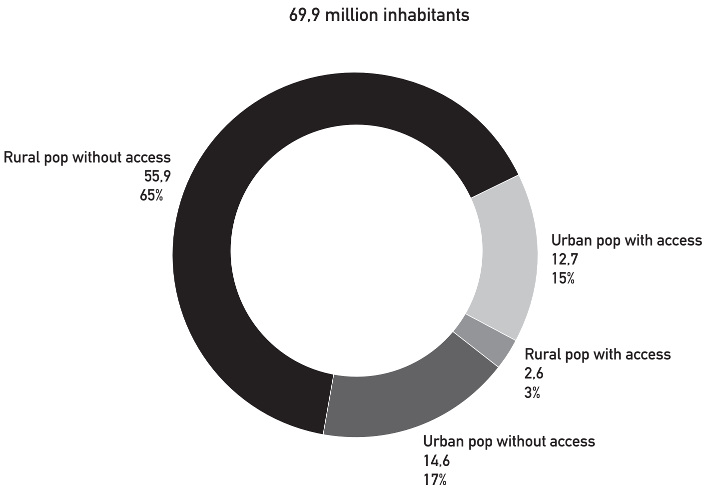


1.2. ACCESS SITUATION IN NIGERIA, GHANA, CÔTE D'IVOIRE, SENEGAL AND CAPE VERDE (>30%)

2009-230,8 million inhabitants



1.3. ACCESS SITUATION IN THE OTHER ECOWAS COUNTRIES 2009



2.2. ENERGY SECURITY

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. Additionally, the energy intensity and the electricity losses during generation, transmission and distribution are very high, thus compounding the problem. Power shortages lead to regular blackouts and load shedding causing huge social and economic costs. 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.

The consumer tariff structure is often not cost reflective. The average consumer tariff lies at 13.6 c€/kWh, but in some countries it is even much higher. This is largely because of rising dependence on oil-based generation. The operating average cost of diesel is 20.4 c€/kWh. Nevertheless, in almost all countries of the region, rates charged to enable residential/commercial/industrial consumers do not enable full cost recovery. This has led to offering of large blocks of highly subsidised electricity to different customers regardless of their incomes. The issue of high connection fees has also not been addressed, which leaves out many poorer households from the grid.

Existing power generation costs are high, partly because of the dependence on diesel and heavy fuel whose prices have been rising and much of it has to be imported, for most of the smaller oil importing countries in the region. As a consequence, tariffs are either high or highly subsidised, considerably straining national budgets. The state utilities are often plagued by weak management capacity resulting in less efficient operations and uncertain financial viability. As these utilities continue to be under-capitalized, their capacity to access financial markets for upkeep and expansion projects remains severely constrained.

2.3. CLIMATE CHANGE

With the consideration of climate change, another concern was added to the already heavy energy agenda of the ECOWAS region. West Africa is 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 lifetime and determine the GHG emissions for the next 20 to 30 years. Climate change impacts (temperature rise, extreme weather events, and droughts) 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. POLICY ENVIRONMENT FOR RENEWABLE ENERGY

The institutional, regulatory, legal, tariff structure and frameworks for RE in the region are largely non-existent or weakly implemented. So far there are only a few incentives for private capital to invest in the renewable energy (RE) sector in West Africa. Investments in RE power projects have had a predominant share of Official Development Assistance (ODA) funding. The success stories regarding Independent Power Producers (IPP's) are mostly related to power production through natural gas. If one looks at the big picture, of the total investment of 1.92 billion EUR for the ECOWAS energy sector, total renewable energy investment accounts for only 5% and IPP investment 3.5%. New projects of wind and solar energy through IPP in Cape Verde could be the harbinger of change. Investors want transparency (easily understood/open to all), longevity, certainty, and consistency. Such frameworks would have to be developed.

4. CONTEXT FOR THE EREP

The EREP has been developed within the context of several recent regional and global energy policy initiatives and strategy frameworks:

- The ECOWAS White Paper on a Regional Policy for Increasing Access to Energy Services in Peri-Urban and Rural Areas by 2015.
- The UN Sustainable Energy for All (SE4ALL) Initiative.
- The WAPP Revised Master Plan for an integrated regional power market.

- UEMOA-IRED initiative for sustainable energies.
- CILSS initiatives on PV and traditional biomass.

5. OPPORTUNITIES AND PROMISING TRENDS

5.1. NATIONAL RE POLICY DEVELOPMENT

Several countries have adopted or are in the process of developing a renewable energy policy and favourable institutional structure. However, only some countries have taken concrete steps to implement the policies. There is a lack of clear responsibility for renewable energy policy implementation in most countries, and only a few have dedicated agencies in this area. There is also a lack of clear mandate to promote renewable energy. In general, the responsibility for renewable energy is located within the Ministry of Energy (Senegal created a Ministry of Renewable Energy but the policy action was reversed). There are only few cases where there are separate Directorates, but most are poorly staffed, funded and organised. Except for Cape Verde, Ghana and Nigeria, there are no regulatory authorities dealing with renewable energy.

Cape Verde has been, in general, the pioneering country making renewable energy a priority for the development of the country. It aims at 50% penetration of renewable energy in the electricity mix by 2020 and has taken a number of steps towards implementation (e.g. RE law and other incentives). Recently, Cape Verde installed 25.5 MW of grid-connected wind farms and 7.5 MW of grid-connected solar PV plants. Senegal, Ghana, Mali, Liberia, Guinea, and Nigeria have developed a detailed renewable energy policy. Ghana and Senegal have passed a renewable energy law and feed-in-tariff systems are under preparation. Liberia, Mali, and Senegal have adopted ambitious RE targets of 30%, 25% and 15% (of installed capacity) respectively by 2021, and Ghana and Nigeria 10% by 2020.

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 set targets. As a result, some countries do not take advantage of their renewable energy resources even where these could be more competitive than fossil fuel based options (diesel, heavy fuel). Also, in many of the ECOWAS countries, the development of renewable energy technologies is hindered by lack of global energy planning that include RE in a comprehensive strategy and allocation of financial means for implementation. Furthermore, 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, countries like Ghana have cut subsidies.

TABLE 1

LEVEL OF RENEWABLE ENERGY INTEGRATION INTO POLICY DOCUMENTS IN 2011

RE and Policy Documents	Benin	Burkina Faso	Cape Verde	Ghana	Guinea	Guinea-Bissau	Côte d'Ivoire	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	No	na	Yes	To some extent	Yes	No	Yes	Yes	No
RE/Electricity bill	No	No	No	Yes	No	No	No	No	Yes	No	No	Yes	na	Yes	No
Specific RE Policy	No	No	Yes	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No
Specific RE law	No	No	Yes	No	No	No	No	No	No	No	No	Yes	No	No	No

Yes — To some extent — No or not available

5.1.1. National Renewable Energy Targets

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

- Cape Verde is the leading country in RE development, with RE penetration target 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 with 10% of RE penetration respectively by 2020 and 2022 and Nigeria (10% of the installed electric capacity by 2020, and Côte 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 currently have no defined RE electricity targets: 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). The Gambia validated its draft RE law in December 2012, it is expected to be passed into law in early 2013.

5.1.2. 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 mainstreaming RE. Some of the policies are weekly developed and often lack technical basis. The ECOWAS countries can be divided into three policy groups:

- The Pioneering ECOWAS Group refers to countries that have succeeded in adopting a RE policy and are making progress in terms of implementing the policies. This group currently consists of only Cape Verde. The Government has set an ambitious target of 50% RE penetration in the overall electricity mix by 2020. To achieve these targets, the Government also developed and adopted a RE 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 inject into 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 comprises 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. Adoption of RE policies is however only the first step. Effective implementation of the policy requires continuous and significant effort. Currently, only Ghana and Senegal have passed a renewable energy law. The Ghana policy also foresees the establishment of a feed-in-tariff system. The tariffs for the different technologies are currently under negotiations. In Nigeria, the Nigerian Electricity Regulatory Commission (NERC) is also developing a regulatory framework aimed at promoting renewable energy based power generation in Nigeria.
- A third ECOWAS group is made up of countries where renewable energy is not the focus, but is mentioned as a 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 faced with the challenge of recurrent lack of power capacity and are unfortunately focused on the development of their conventional power system (which is in some cases more expensive than the renewable energy option).

5.2. RENEWABLE ENERGY POTENTIAL

There is a huge technically and economic feasible potential for renewable energy development in West Africa. These resources are generous and well distributed among the countries.

- Wind potential is concentrated in the costal zones (Cape Verde, Senegal, The Gambia, and possibly Ghana, Mali and Nigeria). The overall wind assessments provide only general information on the potential. Site specific surveys and measurements are required to verify the seasonal variation of wind regimes and determine the financial viability of the potential.
- Small hydro potential is located particularly but not exclusively in the southern part of the region (Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Togo and Sierra Leone) 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 across the region, with a propitious potential in the Southern region. When considering biomass resources, it is important to distinguish: (i) the diffused biomass resources from agricultural by-products, which are 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-industry sites like rice husk, cotton seed shells, groundnuts and cashew shell, sawdust, manure and dung at dairies or slaughterhouses, which can constitute a proper resource 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 1,700 kWh/installed kWp/year. The coastal areas of Liberia, Côte d'Ivoire, Ghana and Nigeria do not benefit to the same extent from this resource with an average potential of 1,200 kWh/installed kWp/year. For the remaining areas, the average potential is about 1,500 kWh/kWp/year.

Based on the data collected, a tentative matrix is presented in Table below showing a possible contribution of the potential energy resources for each country. This matrix indicates the type of resources that are available and the share of these resources.

TABLE 2

INDICATIVE RANKING OF RE RESOURCES BY COUNTRIES

	WIND	PV	SMALL SCALE HYDRO	BIOMASS
Benin	10%	20%	50%	20%
Burkina Faso	0%	60%	30%	10%
Cape Verde	90%	10%	0%	0%
Côte d'Ivoire	0%	10%	50%	40%
The Gambia	60%	30%	0%	10%
Ghana	25%	35%	30%	10%
Guinea	0%	20%	50%	30%
Guinea-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%

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 small scale hydro for Cape Verde. Three countries have good wind potential (Senegal, The Gambia and Cape Verde), and therefore the wind resources are given a high ranking for these countries.

Countries like Mali and Nigeria, which have an equal distribution of their renewable energy resources, are 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 is a significant solar resource in Northern Mali, it 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 take advantage of their renewable energy potentials to satisfy the energy demand of their respective mining industries, which are located in remote areas far from the national grid. The two main sources are, by order of priority, the small scale hydro power and the solar PV. The energy demand of the mining sector generally ranges from 30 to 150 MW.

Therefore, there is considerable potential to address both grid and off-grid related energy needs of the region.

5.3. RENEWABLE ENERGY BECOMING MORE COMPETITIVE

The market trend indicates a price decrease for renewable energy technologies on the one hand and a price increase for fossil fuel costs on the other hand. The reductions for solar PV are shown in the graph below, and price reduction for all renewable energy technologies is foreseen within the next 20 years.

The expansion of power generation from "new renewables" offers the opportunity to complement the regional power trade scenario of the West African Power Pool (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 date). 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 Côte 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 option like for instance biomass or mini hydro options.

5.4. PRIVATE SECTOR INVESTMENT

Globally and also in developing countries, investment in renewable energies is increasing. Although, there are few players and investors in West Africa, there is a nascent interest from the private sector which needs to be capitalised by putting in place appropriate and stable policy and enabling regulatory frameworks.

6. RATIONALE FOR EREP

The EREP, in combination with the ECOWAS Energy Efficiency Policy (EEEP), responds to the severe energy crisis in the ECOWAS region. The countries face the challenges of energy poverty, energy security and climate change mitigation simultaneously. The situation is characterised particularly 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 less than 20%), a deficit that is even more pronounced for rural areas.
- An unsustainable woodfuel supply that no longer meets the growing demand leading to an overexploitation of the wood resources and for 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 concept based on large bulk power generation provided and distributed by the West African Power Pool (WAPP) and on a substantial contribution provided by renewable energy options financed by the private sector and private banking institutions. Furthermore, some ECOWAS Member States have already developed renewable energy policies and strategies and the EREP wishes to take advantage of these front-liners.

The EREP therefore seeks to ensure increased use of renewable energy sources such as solar, wind, small-scale hydro and bio-energy for grid electricity supply and for the provision of access to energy services in rural areas. The EREP scenario will complement other important conventional sources for power production (e.g. large hydro and natural gas). The policy primarily focuses on the electricity sector, but also considers some additional issues regarding the use of heat in the domestic energy sector and the potential production of bio-fuels. The incorporation of gender-balanced policy aims at promoting job creation and business development throughout the value chain of renewable energy technologies (e.g. manufacturing, installation and construction, operation and maintenance).

The EREP takes into account the efforts already deployed by the WAPP through the emergence of a regional power market and by the PREDAS project in the CILSS countries, in particular:

- For electric power: the goal is to cater for short-term current national power supply deficits with renewable energy options becoming part of a long-term perspective and to promote access in rural areas.
- For wood energy: the focus will be on the technological aspects having significant positive impacts on the woodlands (improved stoves and carbonisation) and on awareness creation.
- For biofuels: the policy wishes to capitalise on the achievements of some countries (Mali, Ghana, Burkina Faso, and Senegal).

7. VISION OF THE EREP

The EREP vision is to secure an increasing and comprehensive share of the Member States' energy supplies and services from timely, reliable, sufficient, least cost and affordable uses of renewable energy sources enabling:

- Universal access to electricity by 2030.
- A more sustainable and safe provision of domestic energy services for cooking thus achieving the objectives of the White Paper for access to modern energy services by 2020.

The EREP renewable energy scenario is fully complementary to the WAPP power supply strategy, and conventional national supplies, both as a significant contribution to bulk power generation and as a prevailing contribution to universal energy access for rural areas. Renewable energy can potentially become an engine for industrial development and employment creation and lead the ECOWAS Member States on the more gender-balanced path to "the green economy". The EREP will create strong links and synergies with the envisaged activities under the ECOWAS Energy Efficiency Policy (EEEP).

8. THE EREP TARGETS

Three groups of targets are set by the EREP: for grid-connected renewable energy applications; for off-grid and stand-alone applications; and for 'domestic renewable energy applications':

TABLE 3

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%

TABLE 4

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%

TABLE 5

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%

9. THE EREP IMPLEMENTATION STRATEGY

The EREP aims to be the catalyst to turn the vision and the identified and quantified targets into concrete action and reality. However, the ECOWAS member countries will each define their own respective strategies for achieving the regional targets.

The strategy of the EREP builds on five key guiding principles:

1. *Subsidiarity:* to be applied during the implementation of the policy. The EREP will intervene in regional actions only when they can bring added value to national actions. The roles of national and

regional institutions in the EREP process will be defined precisely.

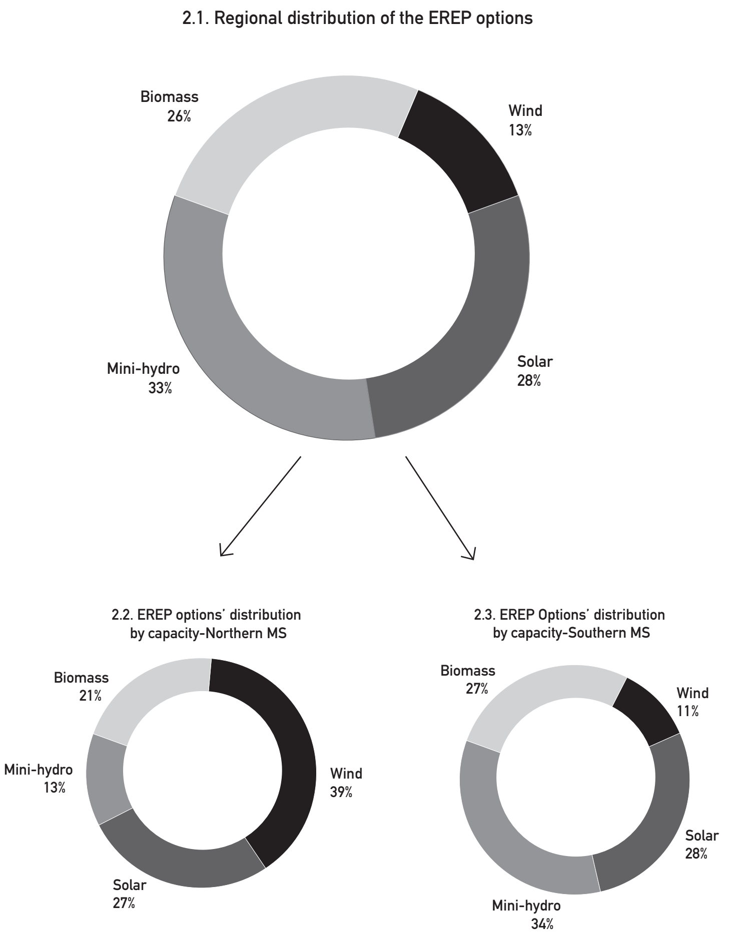
2. *Participatory approach*: promotion of the approach based on the involvement of the end users in the definition of technical and organisational options. This will be realised by creating, when needed, a forum of national stakeholders for the private sector and the civil society together with the national officials from the relevant ministries, utilities and regulatory authorities. Its role will be to provide advice during the development of National Renewable Energy Policies and to assure the follow-up of their implementation.
3. *Optimisation of the use of available financial resources*: mobilising financial resources will require a mix of Public Development Aid (multi–and bi-lateral), national public financing and private financing. This will be done by seeking complementarities between regional and national funding sources and by prioritising 'high impact/ low cost' solutions.
4. *Promoting public-private partnerships*: this partnership will cover technical aspects, management systems, fund-raising and financial risk-taking. It is highly important that public actors (state, public institutions, local authorities, etc.) and private actors (national and local entrepreneurs, financial institutions, associations and co-operatives, NGOs, etc.) are mobilised. This will entail setting up appropriate regulatory frameworks and a transparent, incentive based framework.
5. *Support to gender equality*: in the context of implementation of the EREP an effort will be made to mainstream gender issues. Participatory approaches will be applied.

In addition to the above, the strategy will be implemented through a multi-sectoral approach ensuring that all needs are taken into account as well as the financial sustainability of retained solutions which should respect the principle of technological neutrality e.g. ensuring that only least cost solutions will be considered.

At the regional level, the leading coordinating organisation for the implementation of the EREP is ECREEE. The Centre will work closely with its counterpart ECOWAS institutions – the WAPP and the ECOWAS Regional Electricity Regulatory Authority (ERERA). ECREEE will coordinate most of its activities in cooperation with the National Focal Institutions (NFIs) in the Ministries of Energy among all ECOWAS countries and a network of regional and international research institutions and the business community.

FIGURE 2

DISTRIBUTION OF RENEWABLE ENERGY OPTIONS IN THE ECOWAS REGION



At the national level, the implementation of the NREP will lead to the development of portfolios of bankable projects that can be attractive for private investors and financial institutions in order to fulfil the quantitative and qualitative targets. Finally, the role of the private sector (manufacturers, energy services providers, investors, etc.), of the banking sector and of the civil society, including universities, research centres, NGOs, foundations, consumers associations, etc., will be vital for the success of this policy.

These figures are indicative and have been used for the modelling of the EREP scenarios.

10. GRID CONNECTED EREP'S OPTIONS

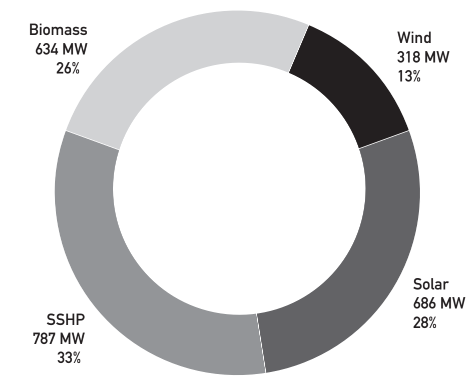
It is expected that 2,424 MW of new RE will be installed by 2020 and 7,606 MW by 2030. The possible contribution of each renewable energy technology to the targets could be as follows: wind 13%, solar 28%, hydro 33% and biomass 26% (as presented in Figure 2). Until 2020, solar technology will be restricted to the use of PV which is less expensive and easier to implement than CSP technology. As of 2020, 1,000 MW CSP with energy storage is proposed as the investment cost is decreasing. In terms of energy produced, the different technologies have different capacity factors, which mean that the production per installed MW can vary from 5,250 MWh/year for biomass plants, to 3,900 MWh/yr for small scale hydro, to 2,600 MWh/year for wind and 1,600 MWh/year for PV.

A tentative investment plan for the EREP scenario is developed in order to assess the financial viability of the proposal. As illustrated by the figures below, when it comes to initial investment, the cheapest technologies are large wind turbines and solar PV (it looks different when it comes to the economics). In general, the price for wind turbines or PV still remains higher than in developed countries due to certain barriers. Larger wind turbines (several MW) cannot be used in many cases in West Africa due to the lack of appropriate cranes. However, for both technologies it is expected that their investment costs will be close to 1 million EUR/MW in 2030.

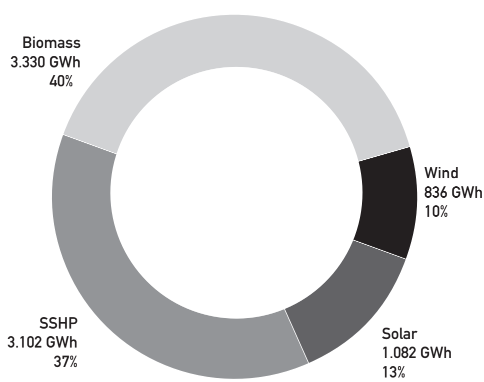
FIGURE 3

GRID-CONNECTED EREP SCENARIOS

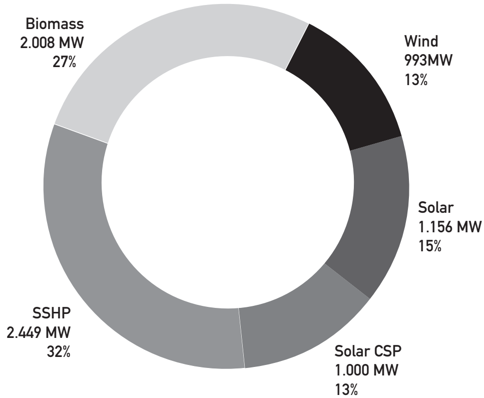
3.1. Installed RE Capacity 2020
2,424 MW



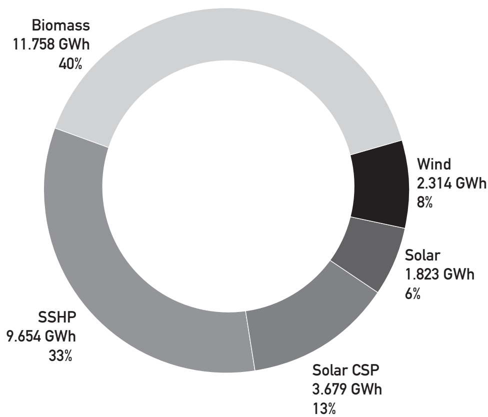
3.2. Estimated RE power generation
2020-8,350 GWh



3.3. Installed RE Capacity 2030
7,606 MW



3.4. Estimated RE power generation
2030-29,229 GWh



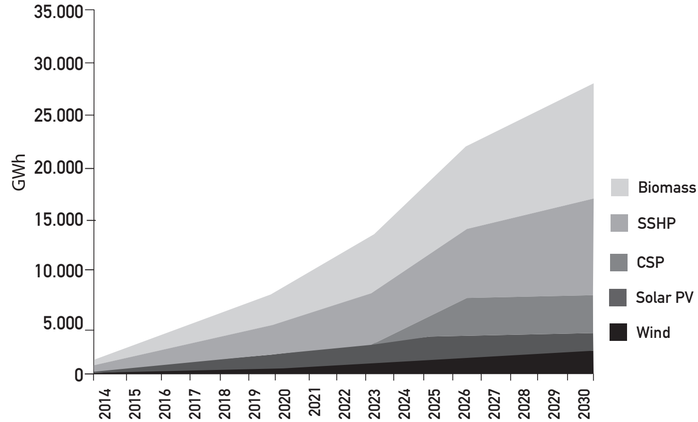
For biomass, it is expected that the size of the biomass plants will grow over time with the modernisation of agriculture, considerably reducing the investments costs. Stating a cost for small scale hydro is often difficult as the cost of civil works will depend on the specific condition of the selected location.

Although CSP has attained technological maturity in other regions, its current investment cost implies that the technology is yet to be fully commercialised in the ECOWAS region. It is expected that the cost of CSP with storage capacity, which is relevant for the ECOWAS region with a developing late evening peak load, will decrease over time to reach a level comparable to small scale hydro plants. That is the rationale for deferring the deployment of this technology to 2024 when the investment cost is expected to be 4 million EUR/MW.

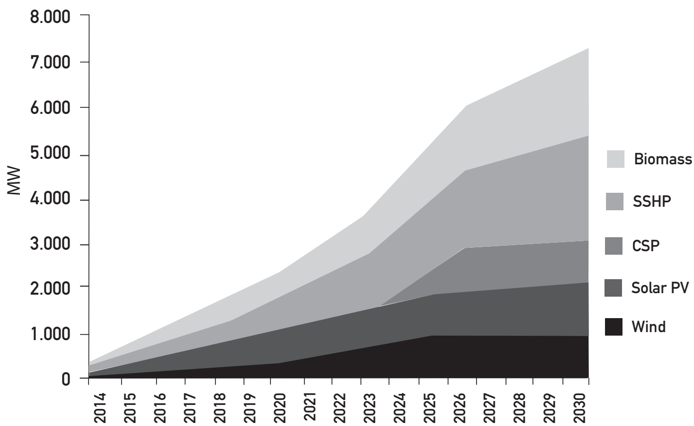
FIGURE 4

RE INSTALLED CAPACITY AND PRODUCTION 2014-2030, RE UNIT COST AND INVESTMENT NEEDS 2014-2030

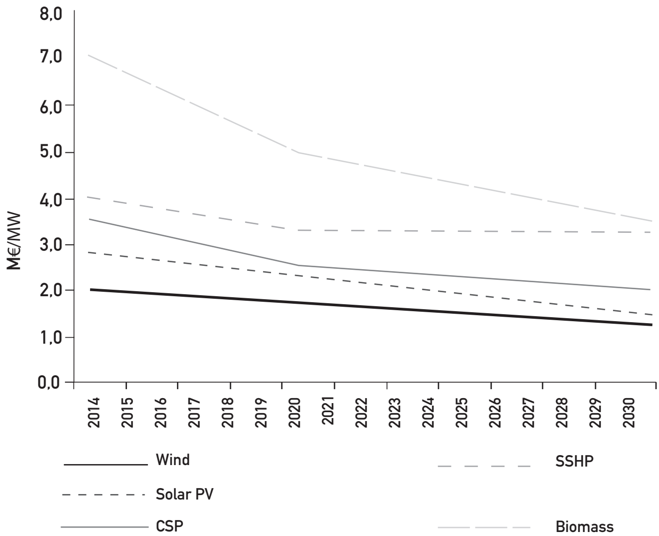
4.1. RE power generation



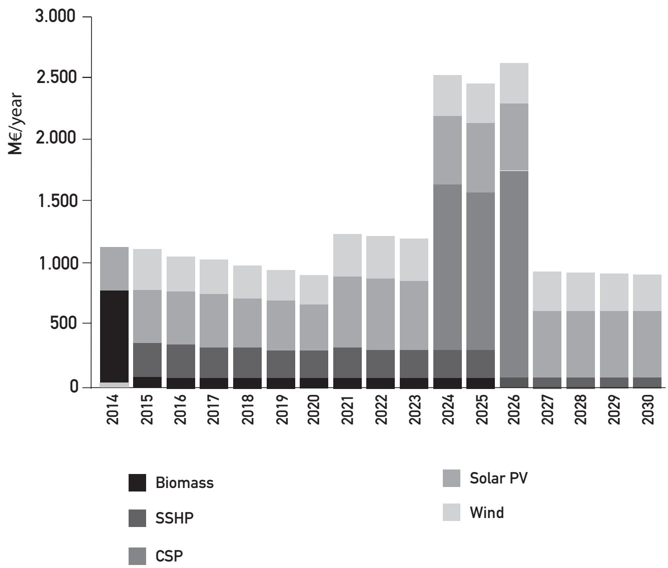
4.2. RE installed capacity



4.3. RET-Unit investment costs



4.4. RE investment per year

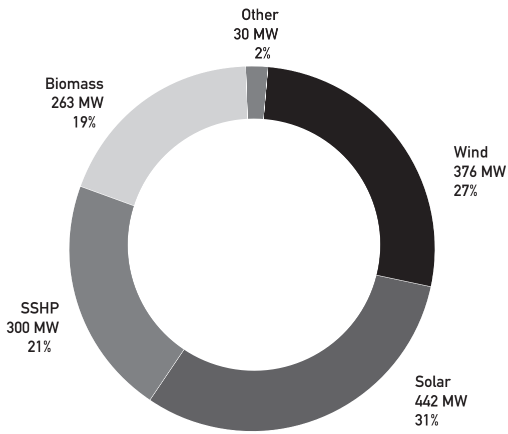


10.1. ECREEE'S RENEWABLE ENERGY PROJECTS PORTFOLIO

The ECREEE's identified renewable energy project pipeline has also been used to develop the EREP scenario (see figure below).

FIGURE 5

ECREEE'S PORTFOLIO OF RE PROJECTS 1411 MW



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

TABLE 6

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 million EUR						
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

AUTHORS

Hyacinth Elayo. Analist of political energies in ECREEE.

Martin Lugmayr. Renewable Energy Expert at ECREEE/UNIDO.

David Vilar. Technical assistance of AECID in ECREEE.

Mahama Kappiah. Executive Director in ECREEE.

www.ecreee.org

INTEGRATING GENDER INTO RENEWABLE ENERGY POLICIES

ROSE MENSAH-KUTIN
REGIONAL OFFICE FOR WEST AFRICA
OF "ABANTU FOR DEVELOPMENT"

ABSTRACT

There is an urgent need to promote modern energy services for women to minimize the drudgery and health consequences of the use of inferior fuels especially for cooking and lighting in rural households. Yet the availability of abundant renewable energy resources in the West Africa sub-region has not translated into concrete initiatives to benefit women and impact positively on gender relations. In this paper, access to modern energy services is articulated along poverty, social and gender lines. Just as gender is not sufficiently integrated in many areas of development policy and practice, so has the important links between energy and gender relations not been sufficiently underlined in renewable energy development. While recognizing the value of prioritizing extensive energy infrastructures such as electricity for development in the sub-region, this paper attempts to underline the key elements of gender in renewable energy and their significance in enhancing access to modern energy services for women. Recognising the multiple roles and valuable contributions of women as agents of change, knowledge creators and decision-makers, some renewable energy initiatives are discussed and key gender implications drawn as lessons learnt. Finally, the need to integrate gender analyses into renewable energy policies, programmes and projects at all levels in the West Africa sub-region is stressed.

Keywords: Gender, gender relations, social and gender inequalities, modern energy services, women, renewable energy, policy and practice.

1. INTRODUCTION

Access to modern and affordable energy has been recognised as a major condition for addressing the experience of poverty.[1] This is because energy is a pre-requisite in enabling women and men meet their basic livelihood needs in different locations and socio-economic contexts. As with other resources, access to and control of energy resources and services is mediated by social inequalities including that of gender inequality. Depending on one's gender, age, location and socio-economic background, one is more or less likely to have easier and/or greater access to particular types of energy sources and services.[2] Taking such different needs and concerns into account is critical for energy policy making if effective and equitable access and distribution of energy services is to be achieved in the context of Africa.

This paper therefore provides information about the critical importance of promoting energy services including renewable energy, from a gender responsive manner in the context of the West Arica sub-region. After this introduction, the next section draws attention to the gaps in energy policy with reference to gender concerns and provides a basis for addressing gender issues in energy in section three (3). Section four (4) then makes an attempt to demonstrate how gender issues manifest themselves in renewable energy services and the benefits to women of a number of initiatives. Lessons learnt and the way forward in the effort to address gender perspectives in renewable energy policies, programmes and projects is provided in section five (5).

2. GENDER GAPS IN ENERGY POLICY PLANNING

Even as there is enough justification for promoting gender in energy policy planning processes, huge gaps continue to exist at all levels. There are three main reasons for this namely, the gender neutral conceptualization of energy policy; the persistent nature of women's unequal position in society; and the attitude of energy institutions to gender issue.

To start with, traditional energy planning and policy making has tended to focus on supply issues related to modern energy forms such as electricity and diesel. In the context of the West Africa sub-region, these modern forms of energy are critical for development and the improvement of the quality of life of different women and men. For example, in Ghana, despite major challenges, the enhanced accessibility of electricity of 72 % is significant for women and socio-economic development even though gender issues were not specifically considered in the implementation of the National Electrification Scheme (NES)[3]. At the same time however, the almost exclusive policy focus on such 'modern' types of energy and their promotion from a gender blind perspective, tend to exacerbate existing inequalities between women and men and sometimes even create new forms of disparities. It has been noted that access to modern energy can reduce drudgery and save time but it can also enhance men's ability to utilise energy technologies for leisure including listening to radio or watching television.[4] While such habits by men are not bad in themselves, if women's needs are not factored into the planning process, the likelihood that they would be excluded from such opportunities and remain solely responsible for accessing energy for cooking only is high. It is also the case that in the West Africa sub-region, even in situations of high electricity access, women do walk long distances to collect firewood or purchase them with their own cash incomes mainly because policy making has not paid enough attention to the provision of modern cooking fuels or appliances. Thus even in Ghana where rural electrification has enhanced electricity access, women's work burdens has not minimized because of the woodfuel crisis and the fact that traditional fuel use patterns remain almost intact. This gender-blind approach to energy policy is experienced in all sectors of the economy and is fostered by political ideology, culture and tradition.

Related to the above is the issue of women's unequal position in society relative to men. In the West Africa sub-region as in the rest of the world, women's unequal decision-making power in relation to men in both households and the public domain limit their capacities and choices even on issues such as cooking which is essentially characterised as 'women's work or space'. This is worsened by the limits placed on energy planners in terms of their understanding of the differential access to and impacts of energy services. By their training, engineers and technicians concentrate more on large scale energy infrastructural development and supply issues. Without multidisciplinary approaches it becomes difficult for them to appreciate issues about women and their primary responsibility for accessing biomass fuels in urban and rural poor contexts in the West Africa sub-region. Biomass and indeed renewable energy programmes are therefore often tangential activities in Ministries of Energy in the sub-region. The result is that two main energy sources usually provided by women, that is, biomass and metabolic energy used in households and small-scale informal productive activities by women, attract limited interest traditionally as these are often missing from energy statistics.

3. THE NEED FOR GENDER IN ENERGY

These gender gaps in approach to energy planning are embedded in the wider global issue of gender inequalities which is experienced differently in different contexts. In the various countries of the West Africa sub-region, underlying political, economic, social and cultural norms that shape the roles and relationships between women and men also permeate energy structures and institutions including legal and regulatory frameworks, policies and programmes. In spite of some progress, there remain huge differences among women and men in these countries in terms of rights and opportunities in access to and control of resources, division of labour and participation in decision-making.[5] Such experiences of inequality in the context of the West Africa region work to limit women's rights and overall socio-economic development. The lack of availability of modern energy services such as lighting, cooking and heating, refrigeration, pumping, transportation and communication creates "energy poverty" that disproportionately affect women and girls.[6] The argument for a linkage between gender and energy in the context of sustainable development therefore is a call on how the experience of energy poverty can be addressed through integrating gender into energy development policies, programmes and projects. This is important because, in West Africa, women are particularly affected by the lack of access to affordable energy services even as they are traditionally responsible for energy provision in the household. As well, women in the sub-region are largely recognized as major producers and distributors of goods and services in-country and across borders. Yet the agriculture and informal sectors of the economy where they predominate where such contributions are evident have not sufficiently been targeted in terms of access to modern energy services that can reduce their hardships and enhance their incomes.

The UN General Assembly has designated 2012 as the International Year of Universal Energy Access and is also promoting a global initiative on Sustainable Energy for All (SE4ALL) by 2030.[7] Indeed, in a one day European Union (EU) Summit to launch the Sustainable Energy for All initiative held on April 16, 2012 in Brussels, one of the two panel sessions focused specifically on "Gender Equality and Access to Modern Energy Services" with the head of the UN Women, Michelet Bachelet, leading the discussion. In the discussion, four key messages were developed to be carried to the "Women Leaders" forum for Heads of State and Government, organised by UN Women in cooperation with the government of Brazil and other partners in Rio de Janeiro on 19 and 21 June, 2012 during the Rio + 20 Conference.[8] The first message was that women and men can benefit extensively from enhanced access to adequate, reliable and clean modern energy services; secondly, access to sustainable energy services for all should be addressed through a right-based approach which also takes gender considerations into account within the broader context of the realization of other basic economic and social rights. The third point was that ensuring women's enhanced access to modern energy services require the systematic integration of gender perspectives into energy related policies, programmes and decision-making processes at all levels. The final message was that all actors including governments, the international community, civil society and the private sector should work collaboratively to enhance local communities' access to sustainable energy services and women's empowerment.

The SE4ALL initiative therefore provides an important opportunity for countries within the West Africa sub-region to focus on gender equality and access to energy services as part of their overall commitment to women's rights and gender equality. It is important to consider gender issues as key components for addressing issues such as access, use, opportunities and control over the various resources in the sub-region. Renewables such as solar, wind, hydro, tidal wave and geothermal potential which are sources of clean and affordable modern energy services tend to have a lower level consideration in terms of policy making. Ironically women who experience the hardships related to insufficient modern energy access tend to be absent in decision-making. According to a study by the West Africa Civil Society Institute, of the four West African countries studied, none had achieved the 30% legislative benchmark.[9] Thus even as some progress has been recorded in women's quest for leadership since independence in West Africa; this is "inadequate with regards to fair and equitable gender-based representation in contemporary democratization and governance processes."[10] This has implications for all facets of development including the energy sector where policy decisions are made in legislatures with a high concentration of males. The result is that women's energy needs and concerns are excluded with negative consequences for gender relations.

Women in the sub-region also face challenges in realizing their need for modern energy services because of their inequitable access to resources worsened by privatization polices favouring natural resources exploitation with implications for climate change. Women's lack of control over land, property, income, credit, technology, extension service and education are all barriers against their ability to access energy services equitably. Solar systems, wind turbines and bio-fuel plantations require land, but women often lack direct access and have to go through male members of the family for use rights. Lack of income prevents women's ability to invest in useful technologies that can minimize their labour requirements, while lack of credit is a major reason for inability to pay upfront the costs of improved energy technologies or connection fees for electricity connections finally; limits to extension service and education are hindrances to women's desire to become energy entrepreneurs.

4. GENDER AND RENEWABLE ENERGY

The West Africa sub-region is endowed with an abundance of renewable energy sources. It is estimated that a total of 23,000 MW of small hydro-electric potential is concentrated in five ECOWAS member states and that of this only 16% has been exploited.[11] Already traditional biomass is the main source of energy for the poor majority and accounts for 80% of total energy consumed for domestic purposes. There are also considerable wind, tidal, oceans, thermal and wave energy resources available. The region also has vast solar energy potential. These sources could be developed to reduce the burdens on poorer women in their efforts to meet their energy needs. Yet there are insufficient efforts to address women's rights to affordable and accessible energy services. This is due to a number of factors namely the lack of recognition of women's energy needs, knowledge and contributions, and the failed redistribution of control over resources and benefits from energy services. There is a need to recognize that a woman's status within the household determines her access to and control over resources as well as how she might benefit from development interventions and responses.

With specific reference to renewable energy there are four key areas where gender issues can be identified. First of all, women's knowledge is critical for natural resource management and technological innovations to enhance energy access; secondly, there are specific energy needs associated with women's productive activities;

thirdly, women are key agents of change and their own self empowerment which thus points to the need to involve them actively in energy decisions; finally there is a need to place an economic value on women's care work especially in the household and community levels where activities such as water and fuelwood collection are critical.

There are a number of renewable energy initiatives that have been promoted in the West Africa sub-region to benefit women taking the above considerations into account. In targeting women as energy users and consumers, women have been engaged in a number of stove programmes. Especially between the periods 1990-2000, the Ministry of Energy in Ghana worked directly to promote a number of improved stoves. Key lessons for the programme demonstrate that women's involvement was a key factor for success of designs and dissemination. Women did not only make significant contributions of their indigenous knowledge into the designs but they also actively used and marketed the appliances to benefit other women. This means that stove programmes must involve women and target them for marketing and credit facilities. As energy entrepreneurs, women are mainly interested in those renewable energy technologies that can increase their incomes as a means of enhancing their own livelihoods and those of their families. In a number of countries such as Mali, Burkina Faso and Senegal, women operators of Multifunctional Platforms (MFP) have reported substantive benefits.[12] With the Burkina Faso case study, the Multifunctional Platform Programme was promoted as part of the country's Poverty Reduction Strategy Framework. It sought to reduce poverty in the rural and peri-urban areas of Burkina Faso by promoting access by women to modern energy services which are essential for economic growth and well-being. With the installation of 233 MFPs significant impacts have included time savings by women relieved from the domestic tasks; increased agricultural production, development of income-generating activities, mobilization of local banking systems and introduction of micro-financing and creation of employment opportunities.

A similar case is the use of the "Chorkor Smoker" in fishing communities in Ghana where majority of the women are fishmongers. The fishmongers in the Central Region of Ghana, smoked fish with the traditional smoker, made of clay with big openings at the base and spaces at the top edges. This traditional smoker could only take one layer of fish during smoking. The process was associated with some operational challenges including the high cost of production, as the smoker uses much firewood and therefore reduced profit margins. The method, like the traditional Swish Stove used in roasting "Gari", generated too much smoke and excessive heat with their attendant effects on the health of the fishmongers. The design of the Chorkor Smoker gives it much more improved features over traditional one and could contain up to five layers of fish which allows for easy turning during the smoking process. This produces very attractive smoked fish which then sells fast. The Chorkor Smoker is also associated with less smoke and heat, thus improving the quality of fish and reducing the health risk associated with too much smoke and heat. Besides, it also uses less firewood, lowering production cost and increasing profit margins. The Chorkor Smoker can be constructed using cement blocks to withstand excessive rains as most of the production sites are not covered. Within two years of the introduction of the Chorkor Smoker in these communities, majority of the women who received the training have adopted the technology, increased their incomes and increased their asset ownership.[13]

Other projects have concentrated on reversing gender roles by enhancing women's capacities as technicians through effective training. A case in point is the installation of solar panels in Mali under the project, the Malian National Program for Renewable Energy for the Advancement of Women (PENRAF) since 2003. Local women and men have been trained under the project to make solar dryers and water heaters and young women have been trained to install and maintain solar panels. To date about 30,000 women and men in 55 communities directly benefit from the project. The Women and Youth Association manages the solar drying facilities and the charging of the solar batteries. At the health centre, solar lighting has replaced kerosene lamps and flashlights originally used for check-ups and delivering of babies. A water heater also provides constant water for patients and a solar –powered refrigerator stores vaccines and medications at the right temperatures.[14]

Another major break-through has been the prioritization of women's role as managers of energy services. In the West Africa sub-region many of the Multifunctional platforms are managed by women Training received in countries such as Senegal, Burkina Faso, Ghana and Guinea enable women to develop their entrepreneurial skills and produce and distribute energy, but also enhance their capacities as business owners.

5. LESSONS LEARNT AND THE WAY FORWARD

Experience has shown that renewable energy interventions that fail to understand the gender division of labour can worsen women's burdens or exclude them from new opportunities. Structural inequalities such as women's lack of access to and control over resources and benefits such as land, credit, income and education, act as barriers for women to realize their rights through renewable energy technologies and programmes. This means that women are often disadvantaged from benefitting equitably from potential opportunities offer as well as place them in a position of vulnerability since such initiatives sometimes add to their burden.

At the same time however several studies have demonstrated that women can benefit from access to adequate and reliable modern energy services. Among the lessons learnt are that modern energy services can positively impact on women's health by deducing smoke related hazards from biomass. They can also support the functioning of health clinics in rural areas which is crucial to improving women's health. Again, women and girls can also benefit from time savings and effort from availability of improved technologies for cooking and through the provision of mechanical power for water collection, agriculture and small-scale businesses.[15] These lessons point to the need to ensure that renewable energy policies and programmes need to address gender and power relations within and outside households to ensure direct improvements in women's lives through access to improved energy services. Removing barriers that hinder women from making critical decisions that affect their lives and strengthening women's market and income-earning opportunities are also critical.

In terms of the way forward, the utilization of gender responsive planning processes and tools can help develop more effective interventions in renewable energy. Gender actions can be formulated explicitly for successful interventions in renewable energy. It is also important to note that one can build a number of gender outcomes into one energy intervention. The MFPs, for example, combine benefits of time-savings, entrepreneurship, enhanced income and transformation of gender roles and relationship opportunities. The role of women in energy policy institutions is also crucial in catalyzing the change for enhanced access to modern energy services.

In conclusion, achieving universal access to energy services requires actions that integrate gender perspectives. This is about deciding on concrete actions and setting goals and targets to bridge gaps in access to energy services and resources among women and men on an equitable basis. It is also about addressing structural inequalities and recognizing the valuable contributions of different social categories of women and men. In this connection, public policy on renewable energy in the sub-region need to be more responsive to the livelihood decisions faced by rural and urban poor women and men and the potential impact of these on power and gender relations.

NOTES

1. Clancy, J.S., Skitsch, M.M., and Bachelor, S., 2003.
2. Wamukonya, N., 2002.
3. *Ghana has since the year 1989 implemented a National Electrification Scheme (NES with a huge component* for rural electrification under the Self-Help Electrification Programme (SHEP). See Mensah-Kutin (2002) *Gendered Access to Electricity in Rural Ghana (*Unpublished PhD dissertation.
4. Mensah-Kutin, R., 2007.
5. Many of the countries in the sub-region lag being the minimum 30% participation rate proposed by the UN. Senegal is an exception with 43% parliamentary representation.
6. UNIDO (United Nations Industrial Development organization), 2003.
7. UN (United Nations), 2012.
8. Rio+20 is the short name for the United Nations Conference on Sustainable Development which took place in Rio de Janeiro, Brazil in June 2012 – twenty years after the landmark 1992 Earth Summit in Rio.

9. WACSI (West African Civil Society Institute), 2009.
10. Ibid, p. 98.
11. UN (United Nations), 2010.
12. ENERGIA (International Network on Gender and Sustainable Energy), 2012.
13. FAO (Food and Agriculture Organisation of the UN), 1989.
14. UNDP (United Nations Development Programme), 2012.
15. ENERGIA (International Network on Gender and Sustainable Energy), 2012.

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[3] FAO (Food and Agriculture Organisation of the UN), 1989. *Chorkor smoker, an efficient post-harvest processing technique, Africa.* Available at ftp://ftp.fao.org/sd/sda/SDAR/sard/English%20GP/EN%20GP%20Africa/Fisheries_Chorkor_oven_Africa.pdf

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[5] UNIDO (United Nations Industrial Development Organization), 2003. *A Path out of Poverty: Developing Women Entrepreneurship.* Available at http://www.unido.org/file-storage/download//file%5fid=11092

[6] UN (United Nations), 2012. Available at http://www.sustainableenergyforall.org/

[7] UN (United Nations), 2010. *Looking to the Future*, UN-Energy 2010.

[8] UNDP (United Nations Development Programme), 2012. Solar *power in Mali: A miracle for women*. Available at http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/successstories/l_energie_solaireaumaliun-miraclepourlesfemmes.html

[9] WACSI (West Africa Civil Society Institute), 2009. *Status of Women's leadership in West Africa*, Accra-Ghana.

[10] WAMUKONYA, 2002. *A critical look at gender and energy mainstreaming in Africa.* Draft paper distributed at the 'gender perspectives in sustainable development' side event organized by UNDESA/DAW and WEDO at Prep Com III, April 2002.

AUTHOR

Rose Mensah-Kutin. Director of the Accra-based West African Regional Office of ABANTU for Development.

www.abantu-rowa.org

REGULATORY POLICY AND FRAMEWORK FOR THE DEVELOPMENT OF RENEWABLE ENERGY IN SENEGAL

ISMAÏLA LO
MINISTRY FOR ENERGY AND MINING OF SENEGAL

ABSTRACT

Senegal has great potential in the field of renewable energy, in particular in the solar, wind, biomass and hydroelectricity sectors.

Since 2008 the new Energy Sector Development Policy Paper has been in place, and has provided a clear direction for renewable energy, setting a penetration rate for renewable sources of energy and biofuels of at least 15% of internal energy consumption by 2020. This article describes the characteristics, prospects and various regulatory features of the promotion of renewable energy in Senegal.

Keywords: Renewable energy, Senegal, regulatory framework

1. CONTEXT

After nearly four years implementing the 2003 Energy Sector Development Policy Paper, the Senegalese Government adopted a new Paper, signed on February 2008.

This decision was based on the observation that the energy sector was still undergoing a wave of difficulties in supplying households, industries and all other areas of activity.

The unprecedented rise in the price of oil products was the catalyst for a severe crisis in the energy supply system, leading to periods of shortages in the distribution of fuels, butane gas and electricity.

Due to the depth of this crisis, and the sustained nature of certain factors, such as the tensions on the international oil market, the Senegalese government re-examined the policies in place and selected new measures to promote the development of the energy sector from 2007-2012. The aim is to fit these measures, some of which are being implemented, into the global framework of a clear policy and strategy, well-argued enough to serve as a guide for all stakeholders: the State, energy companies, investors, development partners and consumers.

Senegal's new energy policy therefore sets out three major goals:

- guarantee the country's energy supply in sufficient quantities, in the best quality, sustainability and cost conditions;
- increase access to modern energy services and;
- reduce the vulnerability of the country to external vicissitudes, in particular on the global oil market.

The Energy Sector Development Policy Paper adopted in February 2008 sets out the following goals:

- a commercial energy independence rate (excluding traditional biomass) of at least 20% by 2012;
- a penetration rate for sources of renewable energy and biofuels of at least 15% of internal energy consumption by 2020.

These goals will be reached in particular thanks to biofuels, hydroelectricity and renewable energy.

- Furthermore, to reach these goals an exhaustive study will be conducted to:
- review the technical and economic potential of electricity which could be supplied to the interconnected and non-interconnected electricity grid in Senegal from renewable energy;
- determine the technical, financial and economic conditions necessary to promote the development of this electricity generation from renewable sources of energy.

The study should enable the following:

- determine the current technical, economic and financial opportunities and obstacles relating to the development of electricity generation from renewable sources of energy;
- explore the various promotion plans possible to encourage its development;
- propose an implementation strategy for these plans.

2. A FEW REMARKS ON RENEWABLE ENERGY POTENTIAL IN SENEGAL

Due to its geographical location, Senegal has great potential in the field of renewable energy, in particular in the solar, wind, biomass and hydroelectricity sectors.

2.1. SOLAR POWER

The solar resources in Senegal are characterized by 3,000 hours of sunshine per year, and average overall daily solar irradiation of 5.8 kWh / m^2 / day.

Until now, these resources have been harnessed through photovoltaic and thermal solar systems.

Photovoltaic solar systems have seen the most sustained development in Senegal. It has been the subject of significant development in various fields (telecommunications, water pumping and centralized and decentralized electricity generation).

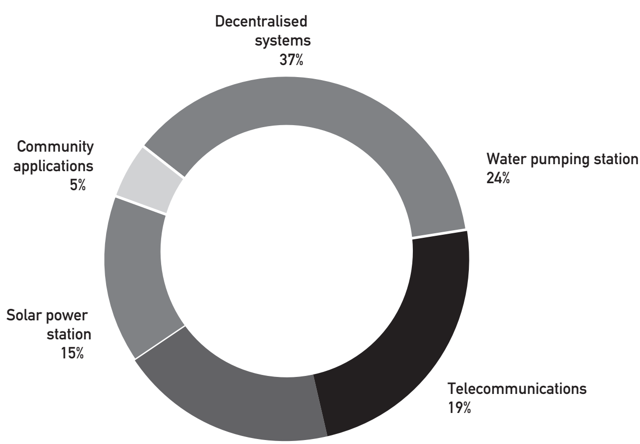
The first facilities were set up in the 1980s at a regular pace, through the following main programme and projects:

- Senegalese-German Solar Power Project (PSAES - *Projet Sénégalo-allemand d'Energie Solaire*), financed by Germany;
- Regional Solar Programme (PRS - *Programme Régional Solaire*), financed by the European Union;
- Senegalese-Japanese Project financed by Japan;
- Senegal Catholic Private Healthcare Stations Association Project (APSPCS - *Association des Postes de Santé Privés Catholiques du Sénégal*), financed by FONDEM (*Fondation Energie pour le Monde* - World Energy Fund);
- Sinthiou Boubou Inter-village Association Project (AISB - *Association Inter-villageoise de Sinthiou Boubou*), financed by the European Development Fund (EDF);
- Spanish projects (Isophoton and Atersa), financed by Spain.

In 2007 the total installed capacity was 2 MWc, rising to around 2.5 MWc in 2012. The distribution of this power by application is displayed in the following graph:

FIGURE 1

DISTRIBUTION OF INSTALLED POWER IN 2010



Twenty-five years ago Senegal initiated a large-scale research and development project in solar thermal systems, developing the first thermodynamic pumps and solar water heaters in the Henri Masson Meteorological Physics Institute (IPM - *Institut de Physique Météorologique*) at Dakar University, which has now become our Research Centre for Renewable Energy (CERER - *Centre d'Etudes et de Recherches sur les Energies Renouvelables*).

2.2. WIND POWER

Wind power could be an interesting field to develop for electricity generation, in particular on the 50 km coastal strip between Dakar and Saint-Louis, where the average wind speed at 10 m in height is 4 m/s. New measurements conducted between 30 m and 40 m in height have revealed the existence of speeds of more than 6 m/s.

To take advantage of this potential, several projects and programmes have been implemented since the 80s:

- wind turbines (with French cooperation through the French Agency for Energy Management [AFME - *Agence Française pour la Maîtrise de l'Energie*]);
- 200 wind-powered pumps through the FIASA Project (with cooperation with Argentina in 1982);
- a wind farm (10 turbines) at Mboro, with Italian cooperation, in 1989;
- 45 wind-powered pumps through the Senegal-Alizés Project from 1997.

The wind power sector remains little-developed, and the total installed power which is truly operational at present does not exceed 0.5 MW throughout the country.

However, the sector offers interesting prospects given the wind data recorded by private developers on the north coast, and in particular given the development of technology over recent years.

2.3. BIOMASS

In Senegal, biomass, in the shape of fuel wood, is the main source of power for households. It provides around 80% of their energy consumption, and is also the main source of energy in the national energy mix, at 55%. In terms of potential, the studies conducted reveal considerable reserves of forests to the east and south of the country.

Other resources can be added to this, which offer interesting prospects for energy, in particular the production of biofuels:

- agricultural by-products (around 3.3 million tonnes of dry agricultural matter) and agro-industrial by-products (rice husks, bagasse, groundnut shells, cotton stalks, etc.), mainly in the north, centre, south and south-east of the country;
- plant species (jatropha, typha, sunflower, cotton, castor plant, sorghum, etc.), whose large-scale cultivation could be carried out in various geographic areas of the country.

In addition, the biomass sector presents proven prospects for the production of biogas, in particular from:

- animal waste, with an estimated potential of 32,000 tonnes of dry matter per day (ENDA report - March 2005);
- industrial waste from the abattoirs managed by the SOGAS (*Société de Gestion des Abattoirs du Sénégal* – Senegalese abattoir management company); in a year, the potential production of biogas from abattoir waste could reach 95,000 m^3 or 53 toe for solid waste, and 125,000 m^3 or 70 toe for liquid waste (base: slaughter, 1999 in all regions of the country);
- household waste, with an estimated potential biogas production of 41.4 million m^3 per year in urban areas, equivalent to 23,000 toe, if we consider that one tonne of dry matter would produce 180 m^3 of biogas;
- human waste (faeces and urine).

For several decades Senegal can boast considerable knowledge in the use of biomass as an energy source in agro-food industries to meet a large part of their electricity and heating consumption. In particular, groundnut shells and palm husks used by the "SUNEOR Group", the bagasse used by the *Compagnie Sucrière Sénégalaise* (CSS – Senegalese sugar company), and the cotton stalks used by the *Société de Développement des Fibres Textiles* (SODEFITEX – Textile fibres development company).

In terms of potential, the amount of available biomass-energy is estimated at 130,000 tonnes.

The CSS plans to produce 10,000 tonnes of biofuel (ethanol) per year to reduce the consumption of petrol, with a 10% ethanol content.

2.4. HYDROELECTRICITY

2.4.1. Large-scale hydroelectricity

The studies conducted by the *Organisation pour la Mise en Valeur du Fleuve Sénégal* (OMVS – Organization for the Development of the Senegal River) and the *Organisation pour la Mise en Valeur du Fleuve Gambie* (OMVG – Organisation for the Development of the Gambia River), have shown the existence of several sites with a potential estimated capacity of 1,400 MW on the Senegal and Gambia Rivers, as well as their affluents. The harnessing of this considerable potential is planned under the aegis of these two sub-regional organizations.

2.4.2. Small-scale hydroelectricity

Senegal has localized useable sites, mainly in the Kédougou region (south-east of the country).

There are a few waterways which could generate small units, in particular near consumption sites.

However, we must note the lack of knowledge on the potential for small-scale hydraulics. No experience has yet been recorded in the area.

3. ORGANIZATIONAL SYSTEM TO SUPPORT THE DEVELOPMENT OF A REGULATORY FRAMEWORK SPECIFIC TO RENEWABLE ENERGY

In order for the development of legal and regulatory frameworks to benefit from a broad consensus, a ministerial decree established an ad hoc working group bringing together a panel of representatives from public and private structures and institutions in the energy sector in Senegal.

This working group was charged with coordinating the planning and priorities of a legal and regulatory framework on renewable energy, working together to put forward opinions on key points, continuously monitor the various stages of the drafting of the law and its application decrees, provide regular updates on the status of work to all concerned stakeholders.

The group is comprised of a representative from each of the following organizations or institutions:

- Ministry of Energy.
- Ministry of Renewable Energy and Biofuels.
- Ministry of the Environment and Protection of Nature.
- *Commission de Régulation du Secteur de l'Electricité* (CRSE – Senegalese Energy Sector Regulatory Commission).
- *Agence Sénégalaise pour l'Electrification Rurale* (ASER - Senegalese Rural Electrification Agency).
- *Société Nationale d'Électricité du Sénégal* (SENELEC - Senegal's National Electricity Company).
- *Programme pour la Promotion de l'Electrification Rurale et de l'Approvisionnement Durable en Combustible Domestique* (PERACOD – Programme to Promote Rural Electrification and the Sustainable Supply of Domestic Fuel) / GIZ.
- *Agence Française de Développement* (AFD – French Development Agency).
- *Syndicat Professionnel des Industries Du Sénégal* (SPIDS - the Senegalese Industry Professionals Trade Union).

Note: *When carrying out its assignment, the working group consulted any experts they deemed necessary.*

Therefore, to facilitate and speed up the process of drafting the law, two studies were launched by the Ministry of Energy, in collaboration with the working group. One focused on the technical, economic and financial aspects of electricity generation from renewable energy sources in Senegal, and was entrusted to a consultant, in compliance with the rules regulating public markets. The other focused on the proposal of a legal and regulatory framework to promote the development of electricity generation from renewable energy sources.

4. OBSTACLES

4.1. POLITICAL WILL OF DECISION-MAKERS

The decision-makers did not always have the same views as those designing the chosen approach to implement the legal and regulatory framework. The opposition between the two entities caused a delay in starting up services in particular, and required considerable efforts to raise awareness, despite the availability of clear points of reference.

4.2. THE DIVERSITY OF PLAYERS INVOLVED

The diversity of players often made the task more difficult within the group, since the concerns of each group sometimes differed, and texts had to be consistent and take into account the economic realities of the country.

4.3. DIFFICULTIES IN COLLECTING INFORMATION AND TECHNICAL DATA

The collection of data required a great deal of time, since the information was not centralized in a national database. Therefore this required several trips to various sources to collect as much information as possible.

Some of this data needed to be updated before being used.

4.4. EXTERNAL FACTORS

The existence of community regulations meant national experts had to take into account certain measures. For example, UEMOA Directive no.02/2009/CM/UEMOA for the standardization of the laws of Member States in terms of VAT: Article 29 sets out a reduced VAT rate of between 5 and 10%, which can only be applied to a maximum of ten (10) goods and services, including solar energy production equipment.

From this point of view, a major difficulty presented itself to experts when drafting new texts in Senegal, since the equipment for other sectors such as wind power, biomass, small-scale hydroelectricity, and biofuels are not affected by tax benefits. Yet the framework law on renewable energy should guarantee a total exoneration for the acquisition of equipment for the generation of renewable energy for domestic self-consumption.

This situation strongly restricted the ambitions of the country to take into account and develop renewable energy sources targeted for their proven potential.

5. DEVELOPMENT OF THE RENEWABLE ENERGY REGULATORY FRAMEWORK IN SENEGAL

To make the institutional environment favourable to the development of renewable energy sources, Senegal adopted a series of legal and regulatory measures. In particular:

- Circular no. 10-226/PM/SGG/EC5 of 21 December 1978 on taking into account the solar variant in energy supply public markets.
- Law no. 81-22 of 25 June 1987 introducing tax benefits for the use of solar or wind energy.
- Decision Memo no. 0706/DGD/DERD/BE (1992), exempting solar equipment from tax legislation and VAT.
- Reduced customs rates for photovoltaic and thermal equipment.

- Decree no. 29/MEMI of 21 April 1999, implementing a quality control unit for photovoltaic components.
- The creation of unit CT13 within the Senegalese Standardization Institute (*Institut Sénégalais de Normalisation*), in charge of the adoption of national standards for photovoltaic components.
- The creation in 1999 of a test and inspection laboratory for photovoltaic components.
- The creation in 2000 of a Master Plan for Rural Electrification using Photovoltaic Solar power.

While this series of measures relating to regulations and tax partially enabled the development of renewable energy in Senegal, it should still be noted that to really make electricity generation from clean sources of energy take off within the current climate, the adoption of a more incentivising laws had become a necessity.

Therefore 2010 was used to complete the process of consolidating the institutional, legal and regulatory framework and align it with the government's new vision.

To do so, two framework laws – one on renewable energy and the other on biofuels – were created in December 2010.

Two decrees to implement this framework law on renewable energy were then adopted to provide a coherent and attractive framework for participation from the private sector both nationally and internationally in the development of renewable energy. These two decrees are Decree no. 2011-2013 of 21 December 2011 and Decree no. 2011-2014 of 21 December 2011.

The first decree set out the conditions for the purchase and remuneration of electricity generated from renewable energy sources by power plants and their connection to the grid.

The second set out the conditions for the purchase and remuneration of excess electricity from renewable energy sources generated for self-consumption.

These two texts aimed to encourage companies and households to invest in the renewable energy sector for their own consumption requirements.

The framework law on biofuels was created, and the decree to implement it is in the process of being adopted.

6. IMPLEMENTATION OF THE REGULATORY FRAMEWORK

To implement Decree no. 2011-2013, an order establishing the creation of a selection and approval committee was initiated, to enable on the one hand promoters and investors to obtain a certificate (approval) to develop their projects, and on the other to enable the government to obtain an overview in planning its requirements in terms of independent electricity generated from renewable sources of energy to inject into the grid.

Therefore, until 21 December 2012 renewable energy projects were the subject of an in-depth study by this Committee, in compliance with article 19 of law no. 2010-21 establishing the Framework law on Renewable Energy.

However, it should be noted that after 21 December 2012 the Government will exclusively use calls for proposals for all new generation projects within the country.

AUTHOR

Ismaïla Lo. Head Division of Solar Energy. Direction of Promotion of Renewable Energy Sources. Ministry for Energy and Mines.

www.gouv.sn

RENEWABLE ENERGY'S ROLE IN RURAL ELECTRIFICATION CONCESSIONS IN SENEGAL

CHEIKH WADE
ASER

ABSTRACT

Over the last few years, the rural electrification policy in Senegal has been redefined compared with the situation in the 90s. A new approach was developed after 2000, and a few years later all instruments were in place to enable the country to increase rural electrification in an effective and sustainable manner. This article provides an overview of the various options which have been implemented in the country, as well as opportunities for investors.

Keywords: Rural Electrification, Renewable energy, Senegal, regulatory framework.

1. LEGAL AND REGULATORY SITUATION FOR RURAL ELECTRIFICATION IN SENEGAL

1.1. OVERVIEW OF THE HISTORY OF THE DEVELOPMENT OF RURAL ELECTRIFICATION

In 1998, more than 95% of Senegalese rural households did not have access to electricity. In some parts of the country, schools and healthcare institutions had to provide their services without electricity. The rural electrification context was characterized by:

a) At the institutional level:
- the lack of a long-term vision for the development of rural electrification;
- a public monopoly;
- a single source of financing: the State;
- the lack of an attractive and incentivising framework for the private sector;
- a single rate for the whole country (national equalization).

b) At a technical level:
- a dominant electrification approach based on the expansion of SENELEC's MV electricity grid, or independent mini-grids supplied by generators;
- the marginal use of decentralized options and renewable energy.

Given this context, it seemed apparent that opportunities for the sustained development of rural electrification were strongly restricted. Yet the objective of the Senegalese government in this sub-sector is to ensure access to electricity for the greatest number of rural households, in order to meet the social and economic development requirements in the country. Senegal aims to raise the electrification rate to around 50% by 2012.

The scale of the challenges, with technical approaches that are not always suitable and the scarcity of financial resources, has led the public authorities to turn towards a new rural electrification approach, based on a Public-Private Sector Partnership (PPP).

1.2. INSTITUTIONAL REFORM AND THE NEW LEGAL FRAMEWORK FOR RURAL ELECTRIFICATION

To take this new consideration into account, the Senegalese government passed law 98-24 of 14 April 1998. With this option, Senegal set new milestones, underpinned by:

- the confirmation of the specific and priority nature of rural electrification, both in terms of the commercial sector and rural equipment;
- the positioning of rural electrification in a sustainable social and economic development approach (Poverty Reduction Strategy - PRS), with the requirement of reproducibility and technical and economic viability in setting up operations;
- the involvement of national and international private investors, associations, NGOs (non-governmental organizations), and local authorities as drivers for the development of rural electrification.

The new law enabled the definition and implementation of a legal and regulatory framework, liberalizing the electricity sub-sector, including:

- the creation of an agency dedicated to rural electrification: the Senegalese Rural Electrification Agency (ASER);
- the creation of the Electricity Sector Regulatory Commission (CRSE - *Commission de Régulation du Secteur de l'Électricité*);
- the adoption of a policy paper on the development of rural electrification in 2004, amended in 2007;
- the implementation of a long-lasting financing mechanism for the development of rural electrification: the Rural Electrification Fund (FER - *Fonds d'Electrification Rurale*), created through decree no. 2006-247 of 21 March 2006;
- the implementation of mechanisms to finance the FER, through law no. 2006-18 of 30 June 2006, establishing the rural electrification license-fee;
- the promotion of the private sector as a major player for rural electrification, as part of a Public-Private Partnership (PPP);

- the adoption of a rural electrification concession approach as a framework for the implementation of a rural electrification policy;
- the implementation of technological neutrality in electrification approaches, promoting the diversification of technology and giving a considerable amount of space to renewable sources of energy.

1.3. CONCESSION-BASED APPROACH TO ELECTRIFICATION

The Senegalese Rural Electrification Agency (ASER), in charge of the rural electrification programme, has committed to an ambitious programme based on a sustainable public / private partnership (national and foreign), to attract the considerable investment required. This comprehensive programme is based on the introduction of electricity concessions throughout the country, through two approaches:

- Type-1 concessions, known as Rural Electrification Concessions (CER – Concessions d'Electrification Rurale), adopted as a framework for the implementation of the State's priority rural electrification programme.
- Type-2 concessions, called Local Initiative for Rural Electrification (ERIL - Electrification Rurale d'Initiative Locale), supported by local operators (local authorities, emigrant or consumer associations, village groups and other basic community associations).

1.4. TYPE-1 RURAL ELECTRIFICATION CONCESSIONS (CER)

This is a priority programme for the State, which divides the country into 10 CERs that are allocated to private operators to manage for a period of 25 years. Each concession groups together non-electrified villages outside the scope of traditional operator SENELEC in one or more departments into a geographical area. They present the following characteristics:

- a potential pool of users of around 5,000 to 20,000 households spread out over an area with an average radius of 100 km;

- the investment required for the coverage of a concession: between 3,326 and 10,337 billion FCFA;
- subsidies of between 20% to 80% of investments, to ensure economic viability, depending on whether the area is rich or poor.

1.5. TYPE-2 CONCESSIONS: LOCAL INITIATIVE FOR RURAL ELECTRIFICATION (ERIL), OR "SPONTANEOUS" ELECTRIFICATION PROJECTS

Rather than waiting to be covered by the CER programme, local populations, as part of associations (consumer associations, energy associations) and local operators (retailers) can carry out rural electrification projects, with the support of the ASER. ERIL projects are local initiative projects which enable the start of the electrification of one or more villages until the area in question is granted a concession, or until they meet the contractual requirements for a concessionaire - private operator holding a CER. The ASER must regularly (on a half-yearly basis) conduct calls for proposals for ERIL projects.

1.6. SUPERVISION AND SUPPORT FOR RURAL USERS

The implementation of this rural electrification approach has been accompanied by the introduction of the following innovative measures to manage the clientele in concessions:

- service rates based on the sale of electricity services rather than kWh for customers with low consumptions, and the application of flat rates;
- same rate for the same level of service, whatever the technology used;
- different rates from one concession to another;
- pre-financing by the operators of related services, such as indoor facilities, the installation of energy-saving light bulbs;
- staggered payment of subscription rates through periodic invoicing (non-energy component).

2. PLACE AND ROLE OF RENEWABLE ENERGY IN RURAL ELECTRIFICATION

The concept of "technological neutrality" – placing all mature and proven technology on an even keel – with the main goal of providing electricity to the maximum number of households, at the lowest possible price, based on a single foundation: technical and economic optimization. This approach has enabled the considerable use of renewable energy, in particular photovoltaic solar energy, adapted to the geographic configuration of the rural areas in Senegal.

The use of photovoltaic technology, used only marginally beforehand as an electrification technique (only 850 kWc of installed capacity in 2000), has been strongly promoted by the authorities. As a result, the situation in the country in terms of electricity coverage improved considerably between 2000 and 2007, with an overall rural electrification rate climbing from 8 to 16%, with an installed capacity of more than 2,000 kWc as at the end of 2007, and nearly 3,000 kWc in 2010 with a 23% electrification rate.

The various technical solutions offer a wide range of services:

a) *hybrid solar power plants:* currently, it should be noted that the ASER has a very advanced policy on hybrid systems (PV-diesel-battery or PV-wind-diesel-battery), and assigns particular interest to the idea of hybridizing all existing diesel plants in independent grids. These types of plants present the following characteristics: i) PV field of 5 to 40 kWp; ii) generator of 10 to 60 kVA; iii) storage battery bank of 1,200 to 2,300 Ah. Supply of low voltage mini-grids with uninterrupted service.
b) *individual solar systems:* i) household photovoltaic systems for the electricity requirements of households, with potential power requirements of 50 to 160 Wp; ii) community systems for the electrification of socio-economic structures (schools, rural hospitals, community centres, places of worship), with power requirements of 300 to 1,500 Wp;
c) *solar streetlamps:* to light streets, thoroughfares and public spaces;

d) *systems for revenue-generating activities:* solar mills; mini pumps and irrigation systems to promote the development of productive uses.

3. IMPLEMENTATION OF RENEWABLE ENERGY PROJECTS IN RURAL ELECTRIFICATION PROGRAMMES

3.1. IN TYPE 1 CONCESSIONS

From the implementation of the first CERs, financed by the World Bank for a total sum of 29.9 million USD, a 5 million USD grant from the Global Environment Facility (GEF) was added to promote renewable energy through positive discrimination. This should enable one of the first concessions financed by the World Bank and already awarded to a Moroccan company (ONE) to carve out a prime spot for renewable energy in fulfilling the obligation to provide electricity to 19,574 rural customers, based on the principle of technological neutrality, or electrify households with the most suitable technological option (connection to the grid or through decentralized systems such as generators, hybrid power plants, solar power plants, or household photovoltaic systems).

In the same vein, in order to finalize the assignment of all planned concessions, the ASER had to develop electrification projects and programmes exclusively or partially focusing on the use of solar photovoltaic panels to strengthen the attractiveness of concessions. The following projects should be mentioned:

- Electrification project with 300 household photovoltaic systems in 9 municipalities: in the rural community of Wack Ngouna (Kaolack region).
- Public lighting project: installation of 1,000 solar streetlamps in 90 targeted municipalities in the following regions (Thiès, St-Louis, Ziguinchor, Kolda and Tambacounda).
- Second Development Aid Fund (FAD) programme (Spain): Installation of 10,000 household photovoltaic systems, 9 hybrid (solar / diesel) power plants, one sea water desalination plant and 20 solar mills;

- First ADF programme (Spain): Installation of 2,648 solar public streetlamps and 662 photovoltaic community systems in various parts of the country.
- Electrification programme financed by India: Standardized electrification of 24 villages (household and community PV systems, public lighting) through the installation of 640 household PV systems, 120 solar streetlamps and 468 community PV systems. Solar power electrification project for the islands in the area of Ziguinchor, financed thanks to the cancellation of the debt between Spain and Senegal: two central villages with two hybrid power plants; 30 kWc PV field + 50 kVA generator + 300 kWh battery bank (each) and 22 standardized villages (household and community PV systems, public lighting).

3.2. IN TYPE 2 CONCESSIONS

The examination of the first wave of proposals for ERIL projects after the first call to proposals launched in January and July 2007 had looked at all solar PV projects. The proposals selected are the subject of ERIL projects financed by the OUWENS programme.

3.2.1. ERSEN programme

As part of the type-2 concessions, the Senegalese-German Programme to promote rural electrification and the sustainable supply of domestic fuel (PERACOD) initiated the ERSEN project. This project, jointly financed by the Netherlands, supports the ASER with a view to reaching the targets set by the government of Senegal. The ERSEN Project is mainly based on the use of renewable energy, and focuses on villages of less than 800 inhabitants, non-priority municipalities within the context of the CERs.

215 isolated villages will be provided with electricity, mainly through solar systems, and then though connection to the grid.

The methodological approach of the project enables electricity to reach isolated areas which are not immediately electrified through traditional means such as the expansion of the grid. In order to improve the quality of basic services provided to the villagers, each selected village must have at least one school and a public healthcare structure. Therefore, solar electric systems will provide electricity to households as well as schools and health centres.

This programme has enabled the following:

- ERSEN I Programme: Standardized electrification of 74 villages, including 57 through household PV systems (1,000 household PV systems and 200 solar streetlamps), 17 through hybrid power plants (PV – diesel).
- ERSEN NDELLE Project: Electrification of a village through a Power plant of 8.2 kWp of installed power (in operation), managed by a Sony Island, with the injection into the grid ensured through three Sony Boys, with a low voltage mono-phase network.
- ERSEN II Programme: Standardized electrification of 141 villages: 74 villages through household PV systems (2,000 + 240 streetlamps) + 16 villages through the expansion of the MV network + 51 villages through hybrid power plants (50 PV – diesel + 1 PV – Wind – Diesel).
- the rural electrification pilot project at Sine Moussa Abdou: A PV – wind – diesel – battery hybrid power plant – PV field of 5 kWc, wind turbine of 5 kW, generator of 10 kVA and storage battery of 2,500 Ah / 48 Vdc.

3.2.2. OUWENS Programme

The Daey Ouwens Fund aims to enable the largest number of inhabitants from the least developed countries to have access to energy, encouraging small-scale projects in the field of sustainable energy which create jobs.

This fund fits in with the Netherlands' overall objective of contributing to the fulfilment of the eight United Nations Millennium Development Goals, in particular the first goal (eradicate extreme poverty and hunger), and goal n°. 7 (ensure environmental sustainability).

The projects likely to benefit from a subsidy must contribute to the access to energy of households, small companies, schools, medical centres or telecommunications and IT infrastructures. The investments in technical facilities must be part of a wider whole, which also take into account issues such as maintenance and management.

The ASER responded to the second call for proposals, and its programme was selected.

The programme put forward by the ASER planned the electrification of 35 villages, with 7 ERIL projects located in the Matam and Ziguinchor regions.

19 mini-power plants will be installed in 19 villages, as follows:

- 1 mini power plant of 10 KWp.
- 11 mini power plants of 15 KWp.
- 5 mini power plants of 20 KWp.
- 2 mini power plants of 25 KWp.

In the 16 other villages, in total 194 household PV systems will be installed, with three levels of power:

- 26 power systems of 50 Wc.
- 50 power systems of 75 Wc.
- 118 power systems of 150 Wc.

4. TAKING INTO ACCOUNT THE NEW INSTITUTIONAL FRAMEWORK FOR THE RENEWABLE ENERGY SECTOR IN RURAL ELECTRIFICATION PROGRAMMES

Senegal has committed to a process of promoting renewable energy by initiating the development of laws and regulations to enable the private sector to invest in this field of energy in general, and authorize their injection into the grid. This has given rise to the recent promulgation of a framework law on renewable energy, and the adoption of application decrees which have enabled the final drafting of all fundamental legal and regulatory documents for the new institutional framework for the renewable energy sector.

In the partial provisions for this new regulatory framework, individual PV systems (household PV systems, community PV systems, PV hybrid power plants, etc.), will have the possibility of injecting excess production onto the grid. This should prove significant, following the experience of countries such as Germany, Spain and Japan. It should be noted that in Germany nearly 6 GW of installed power on roofs is injected back into electricity grids.

However, the approaches developed in these countries are focused on systems which inject the entirety of their production into grids. The option recommended by Senegal should give users who own the facilities the possibility of supplying themselves with clean energy and injecting excess production into the grid, taking advantage of the incentives set out in new regulatory texts.

This approach will require an adaptation of the traditional systems in place in developed countries, to take into account the specific situation in Senegal. The MACSEN-PV project will take control of this entire aspect.

"MACSEN-PV" – Study of alternatives for electricity supply using renewable sources of energy in Tenerife and Senegal – technology transfer and pilot installation project of a PV System connected to the grid.

The MACSEN-PV project has been designed as a technical cooperation platform between Senegal and the Canary Islands (Spain), in the field of the integration of renewable energy into electricity grids, financed by the European programme PCT MAC-2007-2013 (Second call for proposals: cooperation with third-party countries - http://www.pct-mac.org/).

4.1. A SUMMARY OF THE MACSEN-PV PROJECT

- Project duration: 24 months (October 2012 – September 2012)
- The following entities, partners in this project, drafted the application for this European financing programme on the renewable energy sector:
  - *Instituto Tecnológico y de Energías Renovables*, S.A. – ITER (Institute of Technology and Renewable Energies) – Leader (Tenerife) - www.iter.es

- *Agencia Insular de Energía de Tenerife, Fundación Canaria* – AIET (Tenerife Energy Agency) – Partner 1 (Tenerife) - www.agenergia.org
- *Agence Sénégalaise d'Électrification Rurale* – ASER (Senegalese Rural Electrification Agency) – Partner 2 (Senegal) - http://www.aser.sn/
- *Centre d'Etudes et de Recherches sur les Énergies Renouvelables* – CERER (Research Centre for Renewable Energy) – Partner 3 (Senegal) - http://cerer.ucad.sn/

The Senegalese Rural Electrification Agency (ASER), one of the main players in the country for the dissemination of individual systems (household and community PV systems, PV solar power plants), should make use of this grid injection technology (skills and technology transfer) in order to connect photovoltaic facilities to the grid in rural areas as soon as possible (electrification by expansion of the grid) in areas with high levels of sunlight.

In the future, this will enable private operators of rural electrification concessions and their users to take advantage of the opportunities offered (incentives) by the new legal framework for the renewable energy sector.

AUTHOR

Cheikh Wade. Senior Expert in Energy, Head of the Renewable Energy and Innovation Unit at the Senegalese Rural Electrification Agency (ASER - Agence Sénégalaise d'Électrification Rurale).

www.aser.sn

RENEWABLE ENERGY: EXPERIENCES, DEVELOPMENT AND TRENDS IN MAURITANIA

A. K. MAHMOUD, A. MOHAMED YAHYA AND A. MAOULOUD
ANADER

ABSTRACT

This work presents the experiences and development trends in the renewable energy sector in Mauritania. The first section provides a list of the projects completed prior to the creation of the *Centre de Recherche appliquée aux Energies Renouvelables* (CRAER – Renewable Energy Applied Research Centre). The second section presents the numerous, prestigious and ambitious renewable energy projects which came after the creation of the CRAER. Finally, the third section explores the implementation of the first "Hybrid systems" (HS), which aim to provide electricity to isolated sites. Within this context, particular attention is paid to the last two years, which were the most significant in terms of power, highlighting the link with the implementation of the Mauritanian National Agency for the Development of Renewable Energy (ANADER - *Agence Nationale de Développement des Energies Renouvelables*), while noting development trends and causes.

Keywords: Development, Mauritania, Renewable energy, CRAER, ANADER.

1. INTRODUCTION

Renewable energy has now established itself as one of the solutions to the energy problems in developing countries; their competitiveness no longer needs to be demonstrated in areas which are difficult to connect to the electricity grid, in terms of the improvement of living conditions and the development of industrial activities. This has been described by several authors and has been demonstrated in practice in the field. Indeed, until recently electricity generation in Mauritania mainly came from the transformation of natural fossil resources. This mode of production poses problems which grow in scale over the years. The main sources of fossil energy are predicted to be depleted during the 21st century, and environmental concerns surrounding the emission of greenhouse gases into the atmosphere are also an issue (mainly CO_2 and CH_4).

Furthermore, Mauritania's energy dependence is increasing, and could pass the threshold at which economic growth would be slowed down in the next twenty years if nothing is done to try and redress this trend. The margins for manoeuvre are extremely tight in terms of energy provision. Conscious of the danger, most countries in the Sahel region have highlighted the need to promote renewable sources of energy.

Mauritanian experience in the field of renewable energy can be divided into three phases: an initial phase restricted in time by the creation of the Renewable Energy Applied Research Centre (CRAER). This phase saw a certain number of projects destined to fail due to the lack of human resources and specialized personnel. Renewable energy projects prior to the creation of the CRAER therefore all too often took a turn for the worse, and the facilities now lie completely abandoned. The second phase, following the creation of the CRAER, saw the implementation of a team of specialized trainers in the field; therefore several technicians and specialists monitored the training offered by the centre. Since the CRAER is a university research centre, projects remained constrained within the confines of Nouakchott University and were restricted to scientific and university communities, unable to reach a large enough number of people and therefore permeate the socio-economic fabric of Mauritanian society. Renewable energy was boosted during the third and current phase, with the creation of the Mauritanian National Renewable Energy Development Agency (ANADER). With this new organization, the Mauritanian government implemented an energy policy whose main purpose is to integrate renewable sources of energy into the country's energy mix on a massive scale.

This paper on the renewable energy projects and trends in Mauritania can therefore be placed within this context. These three phases are illustrated by examples that follow.

2. FIRST PHASE

The projects of this period were in part related to the Alizés project in Mauritania, the *Projet Régionale Solaire* (PRS—Sahel Regional Solar Programme), the improvements carried out by the CNEA (*Cellules Nationales des Energies Alternatives* — National Alternative Energy Units), the water desalination projects in Banc d'Arguin National Park, and finally the projects of the ADER (*Agence de Développement de l'Electrification Rurale* - Rural Electrification Development Agency), with individual solar kits. The lack of experience in the field and the lack of skilled and specialized personnel to maintain facilities, along with the inadequacy of the installed equipment on sites, meant that most of these facilities met setbacks, or were even completely abandoned.

The table below presents a certain number of projects from this period, and their respective situations at present:

TABLE 1

PROJECT LOCATION	METHOD AND NUMBER OF UNITS	ENERGY SOURCE AND INSTALLED POWER	GENERATION CAPACITY	YEARS IN OPERATION	CURRENT SITUATION
Ten Alloul	Provision of drinking water to Ten Alloul village	2 wind turbines of 2 x 15 KVA, coupled to a 22 KVA diesel generator		1991	Failure before start-up
BLAWACK	Solar stills - 20 units	Solar Energy	100 l /d	1982-1989	The facility was comprised of 10 fixed solar stills, to provide drinking water to the village of BLAWAK. Production was initially expected to be 100 l/d, but in reality never exceeded 50 l/d, and progressively deteriorated until 1989. The lack of maintenance and replacement of equipment spelt the end for the facility.
IWIK	Solar stills - 60 units	Solar Energy	380 l /d - 200 l /d	1981- overhaul in 1988	Facility of 60 cascaded solar stills to supply the IWIK research station with drinking water. The first operating phase from 1981 highlighted a number of faults in the system and its unsuitability to local conditions (poor sealing, unstuck windows, lack of insulation around the sensors, etc.). A complete overhaul of the facility was conducted in 1988 and enabled production to be increased to 380 l/d, but the lack of maintenance due to the lack of qualified personnel led to the facility being progressively abandoned.

TABLE 1 (CONT.)

PROJECT LOCATION	METHOD AND NUMBER OF UNITS	ENERGY SOURCE AND INSTALLED POWER	GENERATION CAPACITY	YEARS IN OPERATION	CURRENT SITUATION
PNBA (1st project)	Individual solar stills - 100 units	Solar Energy	4(l/m2) – from 2 to 3 l/m2	1980-gradually abandoned	The installed still model was revealed to be fragile and unsuitable for the difficult conditions at the site (window panes coming unstuck, etc.). The water produced was of poor quality (bad taste, not mineralized enough), so the project did not last more than a year. The stills were gradually abandoned.
M'Bilal	Recharging of batteries for domestic use by village inhabitants	Wind energy: X wind turbines			A sample of the first wind turbines were abandoned

IMAGE: BALAWACK – EXAMPLE OF AN ABANDONED SOLAR STILL (MAURITANIA).

3. SECOND PHASE

The creation of the Renewable Energy Applied Research Centre (CRAER) enabled the formation and availability of qualified human resources personnel who were able to support the implementation of Renewable Energy projects. The CRAER, through experimentation with pilot systems, was able to provide a reliable, validated, flexible and upgradable library of configurable models, representative of electricity sources and exchangers: wind farms, photovoltaic systems and accumulator batteries. Following this period exclusively dedicated to promotion, training and research in this area, the CRAER was unable to generate great interest in its projects in society at large. This connection has proven to be very difficult to establish.

The table below presents a few of the numerous prestigious and ambitious renewable energy projects, of which the most significant came after the creation of the CRAER.

TABLE 2

TYPE OF PROJECT	THEME	LOCATION	PROJECT OWNER	FINANCING	DATE
	Projet Eau Mauri: installation of solar stills on the Mauritanian coast, to meet drinking water needs	CRAER	CRAER	France- Mauritania inter-university cooperation	2007
	Installation of a solar still at Nouakchott University's Faculty of Sciences and Techniques (FST)	CRAER	CRAER	France- Mauritania inter-university cooperation	2007
	Installation of stills at the ISET, Rosso, Senegal	Higher Education Institute of Technology (ISET)		ISET	2009
	Installation of solar dryers at the ISET, Rosso, Senegal	ISET			2009
Solar	Installation of 950 kWc of power, distributed as follows: pumping 19%, and lighting and refrigeration 81%				2001
	Project to provide electricity to 208 towns and villages using photovoltaic solar systems (3,000 kits)	Wilaya de l'Adrar de Dakhlet Nouadhibou and Trarza		African Development Fund (ADF) - Spain	
	Electrification of 4,000 households with solar kits	Hodh Echargui, Hodh el Gharbi, Assaba, Tagant and Brakna.			
	Study of the wind potential of the coast		ITC		1997-1998
	Installation of a hybrid system (wind-diesel-PV) in the renewable energy facility	Nouakchott University's Faculty of Sciences and Techniques (FST)	ITC	Spanish cooperation	2000

4. THIRD PHASE

The current political and economic climate in Mauritania is focused on liberalizing the electricity market, upon request by the main investors. Within this context, the State passed law no. 2001-19 defining the Electricity Code, which stipulates that apart from power plants with an installed capacity of less than 30 kVA and those for military facilities, any electricity generation, transportation, distribution or sale requires a permit from the minister in charge of energy, at the proposal of the *Autorité de Regulation* (ARE – Regulatory Authority). The permit is awarded based on a call for proposals combined with specifications. The Electricity Code also stipulates that electricity rates must be validated by the minister in charge of energy, and the principles to define tariffs are set by the ARE. The purpose of this law is to diversify electricity generation and distribution, thereby promoting competition. To attain this goal, other progressive regulatory procedures are being implemented. In any case, in the future ANADER will be equipped with clear and vigorous incentivising legislation, which will ensure the sustainable growth of the renewable energy sector in our country.

Therefore, despite the difficulties linked to an unfavourable international context and typology, these last three years have seen a non-negligible increase in the electrification rate in rural and semi-urban areas. Seventeen towns were connected to electricity grids, and nearly 8,000 solar kits were distributed; more than 40 municipalities are currently being connected to electricity grids (by APAUS [*Agence de Promotion de l'Accès Universel aux Services* - Agency to promote universal access to services] and GRET [Professionals for Fair Development]; financing obtained and projects launched), and 4,000 solar kits are being installed (by ADER and APAUS; financing obtained and projects launched), with large-scale wind and solar power plant projects carried out by ANADER. Once these projects are completed, hundreds of thousands of citizens will have access to electricity.

With this in mind, ANADER has combined all these projects with the existence of a strong solar, wind and hydraulic potential, along with the efforts by all stakeholders in the field, to begin the process to integrate renewable sources of energy into the national energy mix. In addition to highlighting natural energy resources, the agency aims to attract private investors by developing several financing mechanisms, including PPAs (Power Purchase Agreements). Several types of contracts have been cited as partnership models during the Brussels round table discussions on Mauritania, which would provide an essential development driver in the main fields in the future.

Nevertheless, the modes of production chosen in this area by ANADER, the National Industrial and Mining Company (SNIM - *Société Nationale Industrielle et Minière*), the Mauritanian Electricity Company (SOMELEC - *Société* Mauritanienne *d'Électricité*), and APAUS currently focus on the transformation of renewable energy (wind, solar, etc.), through two systems:

1. Electricity generation using renewable energy sources injected into the grids which will develop around the large towns of Nouakchott and Nouadhibou.
2. Electricity generation through hybrid systems for isolated sites, which will be increasingly used in the rest of the country. This decentralized power generation will aim to design high-performance, low-cost and low-pollution power generation systems. This fits in perfectly with new power generation (wind turbines, photovoltaic systems) and storage (new accumulators, super condensers, etc.) technology, which is now an integral part of decentralized production chains.

To develop renewable energy, ANADER has highlighted existing solar and wind potential, the size of the country, and a strategic geographical positioning to "Export energy to Europe and neighbouring countries".

The table below presents a considerable number of projects completed or planned for the next two years in the renewable energy field.

TABLE 3

PROJECT LOCATION	SOURCE AND INSTALLED POWER	YEARS OF OPERATION	PROJECT OWNER	COMMENTS
NOUADHIBOU	4.4 MW Wind Farm	Inaugurated in 2011	SNIM	Wind farm designed to strengthen the production capacity of the SNIM.
NOUADHIBOU	15 MW solar power plant	Planned for 2014	SNIM-SOMELEC-ANADER	Feasibility study underway.
NOUAKCHOTT	30-40 MW wind farm	Planned for 2013	SOMELEC-ANADER	Feasibility study already completed, the company selection procedure is underway.
NOUAKCHOTT	15 MW solar power plant	Planned for 2013	SOMELEC-ANADER	Financed by the UAE, monitored by MASDAR. The procedure to award contracts is underway.
KIFFA	5 MW-3 MW Hybrid Solar Power Plant	Start-up planned for 2014	SOMELEC-ANADER	Project financed by the AFD; feasibility study underway.
NOUAMGHAR	210 KW wind farm, with development of an MV and LV grid.	Start-up planned for 2012	APAUS-ANADER	Plant to supply electricity to the village of Nouamghâr; part of production will be used by the desalination station and ice plant, two integral parts of the project.
CHAMI	250 KW wind farm, with development of MV and LV grid.	Start-up planned for 2012	ANADER	Plant to supply electricity to the new town of Chami.
TERMESSA	115 KW wind farm, with development of MV and LV grid.	Start-up planned for 2012	ANADER	Plant to supply electricity to the new town of Termessa.
MPEM-NOUAKCHOTT	40 KW Solar Power Plant connected to the grid	Start-up planned for 2012	ANADER	Solar power plant to supply electricity to the public building of the Ministry for Oil, Energy, and Mining (MPEM).

The last few years have therefore seen an increase in both the number and power of renewable energy production units. Technological progress is expected by producers, in terms of the improvement of the transformation of primary energy, as well as grid operators in terms of the transportation, distribution and management of this new type of energy, which fluctuates a great deal.

AUTHORS

A. K. Mahmoud. Chairman of the National Renewable Energy Development Agency (ANADER).

A. Mohamed Yahya. Technical Director of the National Renewable Energy Development Agency (ANADER).

A. Maouloud. Project Assessment and Monitoring Director (ANADER).

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SPANISH COOPERATION SUPPORT FOR RENEWABLE ENERGY IN WEST AFRICA

MAITE MARTÍN CRESPO AND SERGIO COLINA MARTÍN
AECID

1. SPANISH COOPERATION IS BETTING ON A LOW CARBON ECONOMIC AND ENERGY MODEL IN ORDER TO FIGHT CLIMATE CHANGE AND ERADICATE POVERTY

One of the most difficult challenges faced by humanity today and during the upcoming century is found in two closely related issues: the fight against the adverse effects of climate change and the eradication of poverty. On the one hand, the effects of climate change are a barrier to overcoming poverty; on the other, international cooperation efforts are limited because they have not incorporated climate risk mitigation into their plans and programmes. Therefore, while international cooperation has to integrate the fight against climate change into all of its actions, at the same time all approaches to dealing with climate change have to also consider the international development agenda a priority.

The energy model is related to this challenge: according to estimates by the International Energy Agency, 1.6 billion people in developing countries do not have access to electricity, of which close to 600 million are found in the Least Developed Countries (LDC). In sub-Saharan Africa, 90% of the rural population has no access to energy. This data indicate that many countries do not have enough access to energy to meet the Millennium Development Goals. To reach Objective 1 (half the proportion of people living in poverty), it is estimated that almost 1.1 billion people must be given access to electricity in 2015 and that 2 billion need access to modern fuels. In addition, according to the Intergovernmental Panel on Climate Change's Fourth Assessment Report, fossil fuel use is the main cause of the increase in CO_2 levels in the world which cause climate change. In this context, it is clear that to combat climate change and eradicate poverty requires an economic model based on low carbon energy.

2. INTEGRATING CLIMATE CHANGE INTO SPANISH COOPERATION

Spain has completely integrated environmental concerns and the fight against climate change into its development cooperation policy, as defined in its programme and planning documents, such as the *3rd Master Plan for Spanish Cooperation* 2009-2012, *Environment and Sustainable Development Strategy Paper – Spanish Development Cooperation*, or the Spanish Agency for International Development Cooperation's (AECID) *Environment and Climate Change Action Plan.* The AECID's *Sectoral Environmental Action Plan*, establishes a new development paradigm as the foundation of Spanish cooperation, based on sustainable economies characterised by low carbon emissions and high levels of biodiversity, social justice and fairness.

This plan prioritises the fight against climate change, as specified in four lines of action, one of which is to promote renewable energy in order to: (i) improve access to energy, since this is one of the main obstacles to development; (ii) promote sustainable economic development, following a low carbon model and encouraging the creation of green jobs; and (iii) contribute to the reduction of greenhouse gas emissions (mitigation).

3. SPANISH COOPERATION'S PLAN TO PROMOTE RENEWABLE ENERGY

Over the past few years the energy sector has received considerable support from Spanish Cooperation, increasing from 34 million EUR in 2006 to 136 million EUR in 2010, with a peak of €300m in 2009 (total net ODA). From 2008 to 2011 Spanish Cooperation distributed a total of 555.6 million EUR for renewable energies, the majority to countries in northern Africa. The AECID managed 17.6 million EUR of this money, 50% of which was directed at sub-Saharan Africa[1].

In 2011 the energy sector represented 2.1% of the ODA (€68.3m), of which 96.5% (65.9 million EUR) were for renewable energies[2]. In 2011 the AECID disbursed 3,953,513.25 EUR to the energy sector. The majority was managed by the public sector (45.3%), followed by NGOs and civil society, with 36.3%. The rest of the aid was channelled through multilateral bodies and other actors, including universities, through the AECID's Interuniversity Cooperation Programme.

The Public Administration is Spain's leading cooperation agent in terms of renewable energy, responsible for 98.7% of the total Spanish ODA disbursed to that sector in 2011. The Ministry of Industry, Tourism and Commerce (currently the Ministry of Industry, Energy and Tourism) was the most notable institution, followed by the Ministry of Foreign Affairs and Cooperation.

4. MAIN ON-GOING PROJECTS AND COMMITMENTS

In the area of financing to mitigate climate change, through its ODA Spain heavily contributes to various funds that deal with renewable energies. The most notable are the Sustainable Energy Initiative (European Bank for Reconstruction and Development), the Clean Energy Financing Partnership Facility (Asian Development Bank), the Sustainable Energy and Climate Change Initiative (Inter-American Development Bank), the Climate Investment Funds (Clean Technology Fund and the Strategic Climate Fund and Scaling Up Renewable Energy Program), the International Renewable Energy Agency (IRENA), or the Green Climate Fund. Also new and significant in this area is funding for the new Development Promotion Fund (FON-PRODE).

In Latin America a great deal of emphasis has been placed on improving dialogue on climate change and renewable energies in the Ibero-American Summit. Spain is very active in this area and supports the activities of the Ibero-American network of Climate Change Offices, created on the initiative of the Spanish government during the 4th Ibero-American Forum of Environment Ministers, held in 2004.

In Asia a programme was initiated in Vietnam in 2011 to promote the development of the industrial sector of renewable energies, in particular solar energy, based on Spanish experience. Its objectives are to strengthen the capacity of the Vietnamese government to take decisions related to the solar energy sector, stimulate technology transfer and promote public-private alliances between Vietnam and Spain.

Finally, in the area of multilateral actions, since 2011 the AECID has contributed 2,5 million EUR to the Renewable Energy Observatory for Latin America and the Caribbean through the United Nations Industrial Development Organization (UNIDO). This objective of this programme, currently operating in 12 countries in the region, is to promote renewable energy and encourage investment in this field. The initiative is being implemented in close cooperation with the Latin American Energy Organization (OLADE) and with the ministries of energy and similar institutions in each of the participating nations. When South-South or triangular development cooperation is considered, collaboration between the observatory and the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) is always a strong possibility.

5. SPANISH COOPERATION SUPPORTS ECREEE AS A WAY TO CONTRIBUTE TO THE RENEWABLE ENERGY SECTOR IN WEST AFRICA

West Africa is a priority region for Spain, both bilaterally and from a regional perspective. In this regard, Spain maintains a close relationship with ECOWAS, as reflected by its current planning and strategy papers, especially the Africa Plan 2009-2012 and the 3rd Master Plan for Spanish Cooperation. In December 2005 the

Minister of Foreign Affairs and Cooperation and the Executive Secretary of ECOWAS signed a general memorandum of understanding which established the foundations for the increasing collaboration between Spain and ECOWAS. The Migration and Development Fund launched in 2007, endowed with 10 million EUR to date, is their first major joint project directed at stimulating and strengthening regional development. The first Spain-ECOWAS Summit was held in Abuja in 2009, opening a new era of collaboration which inaugurated a broad and ambitious cooperation plan. This programme is articulated in the Final Declaration of the summit, which defines specific proposals to support ECOWAS in different areas, such as infrastructure, professional training, health, gender, agriculture, rural development, food safety and nutrition, as well as strengthening institutions and promoting renewable energies.

These commitments have led Spanish Cooperation to contribute 7 million EUR to ECREEE, to be paid from 2010-2014, making it the centre's main donor. The memorandum of understanding articulating this contribution was signed in June 2010. The donation enters directly into the centre's budget and allows it to carry out priority activities and cover major financial gaps, giving it budget stability and predictable funding and stimulates the capture of new funding. The scheduled distribution of the contribution is an essential to strengthening the institution, as the centre is responsible for planning and managing the resources.

Spain's commitment to ECREEE is based on the convergence of different priorities for Spanish Cooperation: first, support for sustainable development in sub-Saharan Africa, with a special emphasis on the western region; and second, the resolute belief that this development should be led by Africans and their institutions, further supported by the recognition that regional integration initiatives are the motors of development and catalysts of change.

In this sense, Spain's contribution is fully in line with ECOWAS priorities on energy and development, in accordance with the commitments of the Paris Declaration and the Accra Agenda for Action, and is an essential support for one its commission's most dynamic areas of action. At the same time, it enables strategic activities to be carried out, such as the development of regional policy documents on renewable energy and energy efficiency or the launch of the ECOWAS Renewable Energy Facility (EREF), which allows small and medium scale projects to be financed up to 50,000 EUR, especially in rural and peri-urban areas.

However, Spanish Cooperation's support of renewable energy and energy efficiency in West Africa is not limited to financial contributions. Spain is one of the leading countries in the world in renewable energy due to the competitiveness of its firms and technologies and the high level of penetration that those energies have in Spain. In the memorandum of understanding signed with ECOWAS, Spain committed to facilitating specialised knowledge and promoting the exchange of information and best practices in the field of renewable energy and energy efficiency. Among other activities it helped the UNPD organise a study visit to Spain for five countries of the region and it has signed cooperation agreements with Spanish institutions, such as the Canary Islands Institute of Technology (ITC), the University of Zaragoza, the Polytechnic University of Catalonia and the Polytechnic University of Madrid. It has signed an agreement with the CEDDET Foundation to carry out an online course on renewable energies using a platform supported by the World Bank and it has promoted various collaborations with the Institute for Energy Savings and Diversification (IDAE) in the area of regional policies. Therefore, in addition to providing funds, Spain wants to share its experience, knowledge and knowhow with African countries.

Much has been written on the importance of renewable energy and energy efficiency in West Africa from the perspective of environmental protection, the fight against climate change and access to modern energy services. These objectives are self-explanatory. But there are other equally important reasons to continue promoting renewable energies in the region, including energy security, reducing dependence on fossil fuel imports and, of course, job creation. This is what the General Secretary of International Development Cooperation emphasised recently in his speech given at the *side event* organized by ECREEE to celebrate Rio+20.

Spanish Cooperation is heavily committed to consolidating a pro-poor focus on energy issues. Currently, renewable energy systems isolated from the power network are the most efficient (in economic and social terms) way to provide access to energy to the greatest number of people who live in isolated rural areas in West Africa. In other cases, systems connected to the network are also a competitive option, and they will be increasingly so in the upcoming years.

But the major challenges are not just economic or financial, but also institutional. ECREEE has adequately identified many of these institutional aspects and is efficiently working to deal with them in a rigorous, often innovative way. The adoption of a regional focus to deal with energy challenges in West Africa has proven to be the best way to overcome the existing gaps in regulation, information, building capacities and available technologies.

The United Nations General Assembly has declared 2012 the International Year of Sustainable Energy For All. Initiatives such as *Sustainable Energy for All* (SE4All), led by UN Secretary-General, Ban Ki-Moon, and whose High Level Group is co-chaired by an African, Kandeh Yumkella, Director-General or the United Nations Industrial Development Organisation and Chair of UN-Energy, are seeking to revitalise the efforts of all actors committed to environment and sustainable development. Without a doubt, the best way we can contribute to achieving universal access to clean and sustainable energy in the region is to continue working tenaciously on the premises explained above in a coordinated and rational way.

NOTES

1. This percentage includes the following CRS codes 23030 –energy production – renewable resources; 23065- Hydroelectric power stations; 23066- Geothermal energy; 23067- Solar energy; 23068-Wind energy; 23069- Tidal power y 23070- Biomass.
2. CRS codes 23030, 23065, 23066, 23067, 23068, 23069, 23070.

AUTHORS

Maite Martin Crespo. Head of the Environment and Climate Change Area Department of Sectorial Cooperation of the Spanish Agency for International Development Cooperation (AECID).

Sergio Colina Martín. Technical Advisor on Regional Cooperation. Department of Cooperation with sub-Saharan Africa.

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SECOND PART

POTENTIAL AND TECHNOLOGIES OF RENEWABLE ENEGIES IN WEST AFRICA

SOLAR PV AND CSP OVERVIEW AND TRENDS

JOSÉ HERRERO AND FÉLIX M. TÉLLEZ
CIEMAT

ABSTRACT

Solar based generation of electricity is the most promising alternative to provide energy in a sustainable way. Solar potential is based on the availability of resources and by the continuous development of the different technologies with the aim to reduce the cost of solar energy production.

In recent years Photovoltaic (PV) implementation has shown dramatic growth a wide-spread way of power generation. This implementation is lead by European countries. New areas for developing PV are located in the Sunbelt regions of Africa, Middle East, and South America. These regions are creating new opportunities dedicated to supplying local demand. At mid-long term, all PV technologies should contribute to production of solar electricity as actual alternatives to sustainable Renewable Energies all over the world.

With some delay relating to PV, Concentrated Solar Power (CSP) are still at an initial commercial deployment or at the research and development stage; however the actual "learning curves" show high learning ratios towards the

competitiveness in costs. There is therefore a need for bold and enduring efforts in research, development and commercialization, including strategic legislative measures and infrastructure investments.
This overview briefly outlines the potential, principles and possibilities as well as some of the challenges of solar energy conversion.

Keywords: Solar energy, Photovoltaic, concentrated solar power, solar thermal energy.

1. SOLAR PV

Photovoltaic Solar Energy is nowadays a mature technology for production of electricity with low carbon emissions, and for a wide range of applications. Small scale and stand alone applications are often the least cost options for a given energy service need. Grid-connected applications are by far the largest potential market segment. Annual growth rate of cumulative installed PV has been relatively stable since 2000, at 40% per year. Market for PV is estimated to be 37 GW in 2011 (Photon International magazine claims), while the total business value in the sector is estimated at over 100 billion EUR. However, this impressive market is located in countries outside of the named world's Sunbelt PV [1]. West African countries are located under this Sunbelt, where PV can contribute significantly to cover the electricity demand, mainly by off-grid applications, including small villages supply and water pumping. This would provide sustainable energy to the population. In addition, to solving electricity demand, PV can offer a reduction of import dependence of fossil fuels, providing the economic and social development by the utilization highly versatile PV systems adapted to local needs

According to the Sunbelt Potential of Photovoltaics [1], in an ambitious scenario with adequate political support and deployment measurements PV energy could be a sustainable and competitive energetic technology providing up to 12% of the Sunbelt countries electricity demand by 2030 (depending on the geographic location). Representing, about 1.100 GW installed. This vision could only have been achieved by decision makers in Sunbelt countries (such as governments and utilities), where PV is included as a fundamental contribution to their energy portfolio. Contribution of developed countries to this effort should be done by transferring financial support through International Programmes and Institutions, and technical experience. Also, support to elaborate market development roadmaps for selected Sunbelt countries will be needed.

Fundamental technological issue for Photovoltaics is reduction of cost of the PV systems (through technological advancement, and improving the experience curve). Cost reduction is needed for all elements of the PV systems, throughout the economic value chain [2]. Modules cost is a relevant part of the PV system, moreover the cost of module materials (raw material, encapsulants, wiring, etc) is in most of the photovoltaic technologies around 50% of the total module cost.

PV technological development has seen different periods of evolution. The period 2004-2009 encompasses several significant events for PV market and deployment such as the proliferation (mostly in Europe, Germany, Spain, Italy...) of the feed-in tariff (FIT) as a global incentive model, and the rise of multi-megawatt (utility-scale) installations. Nowadays, a paradigm shift is occuring: grid parity [3]. Grid parity means that the price of the electricity in the market is similar or higher than the cost of the PV electricity; the residential sector will be much sooner than expected. Thus, the governments should revise their solar sector's potential, and then economic rational measurements should take its course with a weak off generous aid for the Photovoltaic implementation and deployment.

Concerning costs of PV, the steady price increase from 2004 through 2008 for photovoltaic cells and modules, and a ~50% price decrease in 2009 over 2008. The last events are directly related with the materials for Photovoltaics: silicon shortage, with significant high prices for this raw material and significant increase in market share for thin films. In 2005, 85% of total silicon supply was provided by only 5 companies and a strong demand from the PV industry led to a shortage of polysilicon. This accelerated the move towards cost reduction by increasing efficiency, decreasing usage of raw materials, improving manufacturing processes etc, including the entrance of new polysilicon producers' whose presence balanced demand and supply, thereby decreasing the prices level to normal ranges. Also the maturity of thin-film materials technologies have produced a significant market share for this kind of technology, mainly for cadmium telluride (CdTe).Thus, secure amounts of polysilicon together with R&D have produced an immense impact on PV process during 2008-2009. In 2010, owing to the strong growth of the PV industry, silicon prices have slowly risen. However, the price of PV modules is decreasing continuously, mainly by the high offers from East Asian countries.

The photovoltaic industry makes use of different technologies for cells and modules production. Typical classification of PV technologies, mainly based on the solar active material, is:

- Wafer-based crystalline silicon technology.
- Thin film technologies.
- Emerging and novel technologies.
- Concentrator's technologies.

Polysilicon based technologies are dominant in the Photovoltaic market with an 88% share of the global Photovoltaic solar production in 2011. Thin layer share dropped to 11% in 2011 (12% in 2010), other technologies have a testimonial presence in the market with less than 1% of the total. At mid-long term all PV technologies should contribute to production of solar electricity as actual alternative to sustainable develop of Renewable Energies over the world

2. CSP OVERVIEW AND TRENDS

Concentrated Solar Power (CSP) involves power generation using direct normal solar radiation. CSP systems consist of a large reflective surface collecting the incoming solar radiation and concentrating it onto a solar receiver with a small aperture area. The solar receiver is a high-absorbance radiative/convective heat exchanger with reduced convection and conduction losses and, in some cases, with selective coatings to reduce the radiative losses. In the receiver, the incident solar energy is transferred to a thermal fluid at an outlet temperature high enough to feed a heat engine or a turbine that produces electricity. The CSP optional technologies are usually distinguished by the shape of its concentrator element which can be a parabolic trough field, a linear Fresnel reflector field, a central receiver system or a field of parabolic dishes. Adequate solar resources of sites varies from 1800 to 2800 kWh/m^2, allowing from 2000 to 6500 annual full-load operating hours with the solar element, depending on the available radiation at the particular site and the relative size of solar field aperture, heat storage capacity and nominal power of the power block.

CSP may provide distributed and centralized solutions for electricity supply and it is one of the main candidate technologies to find a viable transition to a sustainable electricity supply (that is inexpensive, compatible with the environment and from safe resources).

Just like conventional power stations, concentrating solar power plants can deliver base-load or balancing power, directly using sunshine during the day, making use of thermal energy storage facilities during the night and in case there is a longer period without sunshine, using fossil or biomass fuel as backup heat source. This capability of storing high-temperature thermal energy leads to economically competitive design options, since only the solar part has to be oversized. This CSP plant feature is tremendously relevant, since penetration of solar energy into the bulk electricity market is possible only when substitution of intermediate-load power plants of about 4,000-5,000 hours/year is achieved.

Another feature that distinguishes CSP is the possibility of combined generation of electricity and heat to achieve the highest possible efficiencies for energy conversion. In addition to electricity, such plants can provide steam for absorption chillers, industrial process heat or thermal seawater desalination.

The combination of energy on demand, grid stability and high share of local content that lead to creation of local jobs, provide a clear niche for CSP within the renewable portfolio of technologies. Nowadays, the deployment of CSP is rapidly increasing with more than 200 commercial projects taken up in Spain, USA and other countries such as India, China, Israel, Australia, Algeria, South Africa, United Arabs Emirates, Italy, etc. This re-launching, started in 2006-7 has added (by mid of 2012) about 2 GWe of new plants to the precedent 350 MWe of power plants of this type with 30 - 80 MW unit capacity that are operating successfully in California since the eighties.

CSP implementation involves high costs when compared with other conventional sources and requires government support in the form of subsidies and incentives for making it a profitable proposition for electricity generation. Governments in some countries in the Mediterranean region have taken appropriate initiatives to formulate feed-in tariff laws, to establish government agencies and to set regional CSP capacity targets to promote CSP implementation. This is also encouraging private investors to invest in CSP plants and technologies to harness the full potential of CSP in the region.

Spain with 2,400 MW connected to the grid in 2013 is taking the lead on current commercial developments, together with USA where a target of 4,500 MW for the same year has been fixed and other relevant programs like the "Solar Mission" in India recently approved and going for 22 GW-solar, with a large fraction of thermal [4].

The first generation of commercial CSP projects is mainly based on technological developments and concepts that matured after more than two decades of research. Nevertheless, the current solar thermal power plants are still based on conservative schemes and technological devices which do not exploit the enormous potential of concentrated solar energy. Most of the commercial projects use technologies of parabolic troughs with low concentration in two dimensions and linear focus, or systems of central tower and heliostat fields, operating with thermal fluids at relatively modest temperatures, below 400°C [5]. The most immediate consequence of these conservative designs is the use of systems with efficiencies below 20% nominal in the conversion of direct solar radiation to electricity; the tight limitation in the use of efficient energy storage systems; the high water consumption and land extension due to the inefficiency of the integration with the power block; the lack of rational schemes for their integration in distributed generation architecture and the limitation to reach the temperatures needed for the thermo chemical routes used to produce solar fuels like hydrogen.

In the first commercial projects involving parabolic trough technology some improvements are being introduced such as the use of large molten salt heat storage systems able to provide high degrees of dispatch for the operation of the plant, such as the plants Andasol 1 and 2 in Guadix, Spain, with 7.5 hours of nominal storage, or the use of direct steam generation loops to replace thermal oil at the solar field. Central towers are opening the field to new thermal fluids like molten salts (Gemasolar tower plant in Seville, Spain, which also includes a large molten salts heat storage equivalent to 15 hours of nominal power) and air, and new solar receivers like volumetric absorbers.

In parallel a new generation of concentrating solar thermal power systems is starting deployment. This new generation is characterized by its modularity and higher conversion efficiencies. The design strategy is based on the use of highly compact heliostat fields, using mirrors and towers of small size, and looking for integration into high temperature thermodynamic cycles. There are currently some initiatives with prototypes at an experimental stage and announcing large commercial projects like the one proposed by BrightSource with a prototype of 6 MWth at the Neguev desert in Israel, the 100 kWe prototype promoted by the AORA company and researchers of the Weizmann Institute in Israel, and the 5 MWe prototype built by the company eSolar in California.

Currently, research is undertaken on various CSP technologies for varying levels of high temperature generation capabilities and conforming high thermodynamic efficiencies. As above mentioned there are four major CSP systems:

2.1. PARABOLIC TROUGH SYSTEMS (PT)

Parabolic-trough collectors are linear-focus concentrating solar devices suitable for working in the 150ºC-400ºC temperature range. Current research with new thermal fluids intends to increase the operating temperature up to 500ºC [6]. The concentrated radiation heats the fluid that circulates through the receiver tube, thus transforming the solar radiation into thermal energy in the form of the heat. Currently, most of the CSP projects under construction employ this technology.

2.2. POWER TOWER SYSTEMS OR CENTRAL RECEIVER SYSTEMS (CRS)

In power towers or central receiver systems (CRS), incident sunrays are tracked by large mirrored collectors (heliostats), which concentrate the energy flux onto radiative/convective heat exchangers called solar receivers, where energy is transferred to a thermal fluid, mounted on top of a tower. Plant sizes of 10-to-200-MW are chosen because of economy of scale, even though advanced integration schemes are claiming the economics of smaller units as well [7]. The high solar flux incident on the receiver (averaging between 300 and 1,000 k W/m^2) enables operation at relatively high temperatures of up to 1,000ºC and integration of thermal energy into more efficient cycles in a step-by-step approach. CRS can be easily integrated in fossil plants for hybrid operation in a wide variety of options and has the potential for generating electricity with high annual capacity factors through the use of thermal storage. With storage, CRS plants are able to operate over 6,500 hours per year at nominal power [8]. Currently, CSP-CRS plants in Spain such as PS 10 and PS 20 and Gemasolar are showing the high reliability and especially good performances that are quickly reducing risk perception associated to the even small commercial experience (of only four years).

2.3. PARABOLIC DISH-STIRLING SYSTEMS (DS)

Dish-Stirling systems track the sun and focus solar energy onto a cavity receiver, where it is absorbed and transferred to a heat engine/generator. An electrical generator, directly connected to the crankshaft of the engine, converts the mechanical energy into electricity (AC). To constantly keep the reflected radiation at the focal point during the day, a sun-tracking system continuously rotates the solar concentrator on two axes following the daily path of the sun. With current technologies, a 5 kWe dish/Stirling system would require 5.5 m diameter concentrator, and for 25 kWe, the diameter would have to increase up to 10 m. Stirling engines are preferred for these systems because of their high efficiencies (40% thermal-to-mechanical), high power density (40–70 kW/liter), and potential for long-term, low-maintenance operation. Dish/Stirling systems are modular, i.e. each system is a self-contained power generator, allowing their assembly in plants ranging in size from a few kilowatts to tens of megawatts.

The actual cost of the 10-kW unit without transportation and installation cost and excluding foundations is approximately US$10,000/kW. The cost projections at production rates of 500 and 5000 units per year are US$2,500/kW and US$1,500/kW, respectively based upon replication of automotive mass-production processes. Nevertheless the lack of an economically feasible solution for storage (of electricity) makes this technology to directly compete with photovoltaic's which has accelerated its cost reduction.

This technology has the advantage of functioning as stand-alone systems and can provide decentralized power. Currently, small CSP projects are planned in USA, Europe and Australia using this technology.

2.4. LINEAR FRESNEL REFLECTOR SYSTEMS (LFR)

Conceptually, Linear-Fresnel Reflectors (LFR) are optical analogues of parabolic troughs. They are 2-D concentrating reflectors with linear focus, where the parabolic reflective surface is obtained by an array of linear mirror strips which independently move and collectively focus on absorber lines suspended from elevated towers. They are fix focus reflectors where the absorber is static. Reflective segments are close to the ground and can be assembled in a compact way up to 1 ha/MW. The objective is to reproduce the performance of parabolic troughs though with lower costs. However optical quality and thermal efficiency is lower because of a higher influence of the incidence angle and the cosine factor, and therefore the temperature obtained at the working fluid is also lower (150-350ºC). Because of that, LFR are mainly oriented to produce saturated steam via direct in-tube steam generation, and application into Integrated Solar Combined Cycles (ISCCS) or in regenerative Rankine cycles, though current R&D is aiming at higher temperatures above 400ºC. Spain is implementing a pilot project using this technology which is still in nascent stage. Currently, Fresnel systems is less efficient but also less costly than other CSP technologies.

2.5. CSP TECHNOLOGY DEVELOPMENT AND MARKET OPPORTUNITIES

A clear indicator of the globalization of CSP commercial deployment for the future energy scenario has been elaborated by the International Energy Agency (IEA). This considers CSP to play a significant role among the necessary mix of energy technologies for halving global energy-related CO_2 emissions by 2050 [9]. This scenario would require capacity addition of about 14 GW/year (55 new solar thermal power plants of 250 MW each). However, this new opportunity is introducing an important stress to the developers of CSP. In a period of less than 5 years, in different parts of the world, these developers of CSP are forced to move from strategies oriented to early commercialization markets based upon special tariffs, to strategies oriented to a massive production of components and the development of large amounts of projects with less profitable tariffs. This situation is speeding up the implementation of second generation technologies even though in some cases still some innovations are under assessment in early commercialization plants or demonstration projects. The projected evolution of Levelized Electricity Costs (LEC) of different CSP technologies is in the order of 13-25 c€/kWh, depending on the choice of technology, solar resource of site, the size of the plant, etc.

The reduction in electricity production costs should be a consequence, not only of mass production but also of scaling-up and R&D. A technology roadmap promoted by the European Industry Association ESTELA states that by 2015, when most of the improvements currently under development are expected to be implemented in new plants, energy production boosts greater than 10% and cost decreases up to 20% are expected to be achieved. Furthermore, economies of scale resulting from plant size increase will also contribute to reduce plants' CAPEX per MW installed up to 30%. CSP deployment in locations with very high solar radiation further contributes to the achievement of cost competitiveness of this technology by reducing costs of electricity up to 25%. All these factors can lead to electricity generation cost savings up to 30% by 2015 and up to 50% by 2025, reaching competitive levels with conventional sources (e.g. coal/gas with stabilized Electricity Costs <10 EUR cts/kWh). Similar projections are published in another recent roadmap issued by the IEA [10]. Other roadmaps coordinated by R&D centers expect larger influence of innovations (up to 25%) in cost reduction [11]. Some of the key general topics on medium to long-term R&D proposed by the CSP community are [12]:

- Build confidence in the technology through:
  - pilot applications based on proven technologies;
  - high reliability of unattended operation;
  - increased system efficiency through higher design temperatures;
  - hybrid (solar/fossil fuel) plants with small solar share.
- Reduce costs through:
  - improved designs, materials, components, subsystems and processes;
  - exploitation of economies of scale.
- Increase solar share through:
  - suitable process design;
  - integration of storage.

In all cases, R&D is multidisciplinary, involving optics, materials science, heat transfer, control, instrumentation and measurement techniques, energy engineering and thermal storage.

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AUTHORS

José Herrero, researcher in the R&D department of CIEMAT (Centro de Investigaciones Energética, Medioambientales y Tecnológicas).

Félix M. Téllez, researcher in the R&D department of CIEMAT-PSA (Centro de Investigaciones Energética, Medioambientales y Tecnológicas – Plataforma Solar de Almería).

www.ciemat.es
www.psa.es

SOLAR HEATING AND COOLING - OVERVIEW AND TRENDS

WERNER WEISS
AEE-INTEC

ABSTRACT

The article gives an overview on the worldwide trends in solar thermal and the market developments in different economic regions. Furthermore it shows the different applications of solar thermal technologies, ranging from small-scale solar water heating systems, systems for solar air-conditioning and cooling to large-scale systems for district heating and for industrial applications. Finally the opportunities and large potential for West Africa is presented.

Keywords: Solar thermal energy, solar water heating, markets, solar thermal applications, reduction of solar power consumption.

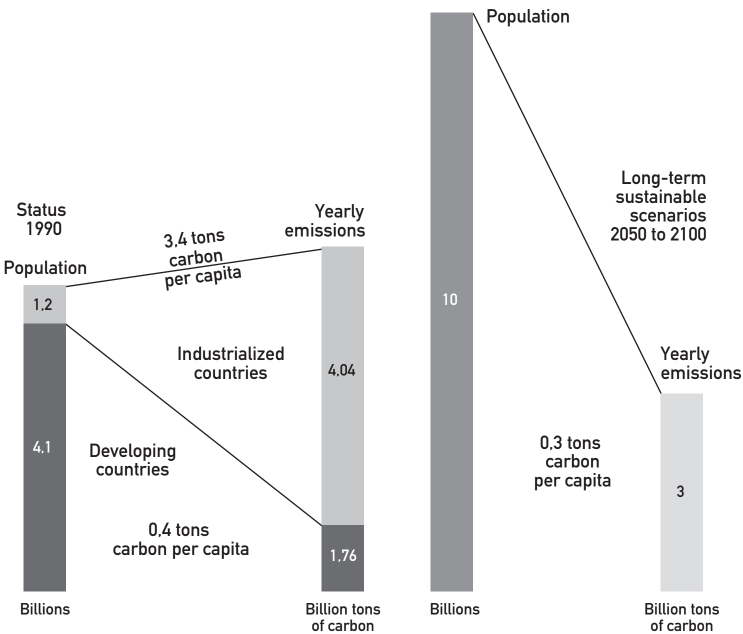
1. THE WORLD'S ENERGY SUPPLY

The increase in greenhouse gasses in the atmosphere and the potential global warming and climatic change associated with it, represent one of the greatest environmental dangers of our time. The anthropogenic reasons of this impending change in the climate can for the greater part be put down to the use of energy and the combustion of fossil primary sources of energy and the emission of CO_2 associated with this.

Today, the world's energy supply is based on the non-renewable sources of energy: oil, coal, natural gas and uranium, which together cover about 82% of the global primary energy requirements. The remaining 18% divide approximately 2/3 into biomass and 1/3 into hydro power.

FIGURE 1

PER-CAPITA EMISSIONS OF CARBON INTO THE ATMOSPHERE REQUIRED TO MEET CLIMATE STABILISATION AGREEMENTS WITH A DOUBLING OF POPULATION LEVELS



The effective protection of the climate for future generations will, according to many experts, demand at least a 50% reduction in the world-wide anthropogenic emission of greenhouse gases in the next 50 to 100 years. With due consideration to common population growth scenarios and assuming a simultaneity criterion for CO_2 emissions from fossil fuels, one arrives at the demand for an average per-capita reduction in the yield in industrial countries of approximately 90%. This means 1/10 of the current per-capita yield of CO_2. Even in the developing countries a CO_2 reduction of 10% would be required to reach this goal.

A reduction of CO_2 emissions on the scale shown in Figure 1 will require the conversion to a sustained supply of energy that is based on the use of renewable energy with a high share of direct solar energy use.

2. WORLDWIDE MARKET TRENDS

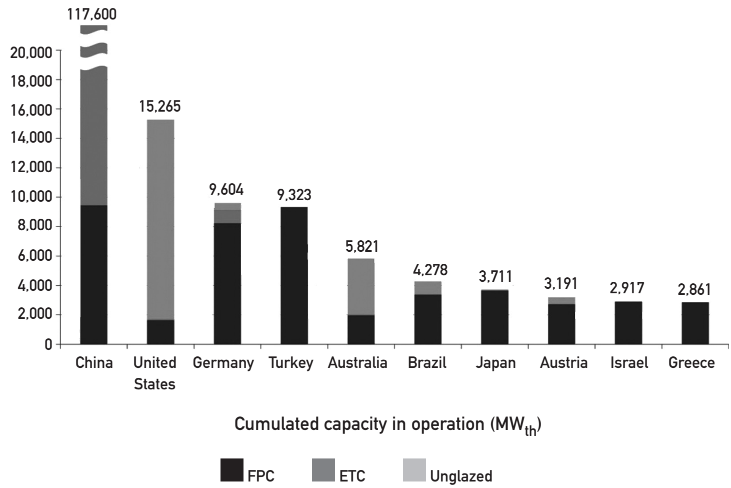
According to the report "Solar Heat Worldwide", published by the IEA Solar Heating and Cooling Programme [1] the solar thermal collector capacity in operation worldwide equalled 195.8 GW_{th} corresponding to 279.7 million square metres at the end of the year 2010.

The total capacity is divided into 62.1 GW_{th} flat-plate collectors (88.8 million square meters) and 111.0 GW_{th} evacuated tube collectors (158.5 million square meters), 21.5 GW_{th} unglazed water collectors (30.7 million square meters) and 1.3 GW_{th} glazed and unglazed air collectors (1.8 million square meters).

The vast majority of the total capacity in operation is installed in China (117.6 GW_{th}), Europe (36.0 GW_{th}), and the United States and Canada (16.0 GW_{th}), which together account for 86.7% of total installed. The remaining installed capacity is shared between Asia excluding China (9.4 GW_{th}), Australia and New Zealand (6.0 GW_{th}), Central and South America (5.5 GW_{th}), the MENA[1] countries Israel, Jordan, Lebanon and Morocco (4.1 GW_{th}) as well as between some African countries (1.2 GW_{th}), namely Namibia, South Africa, Tunisia and Zimbabwe.

FIGURE 2

TOTAL CAPACITY OF WATER COLLECTORS OF THE 10 LEADING COUNTRIES AT THE END OF 2010. DISTRIBUTION BY APPLICATION



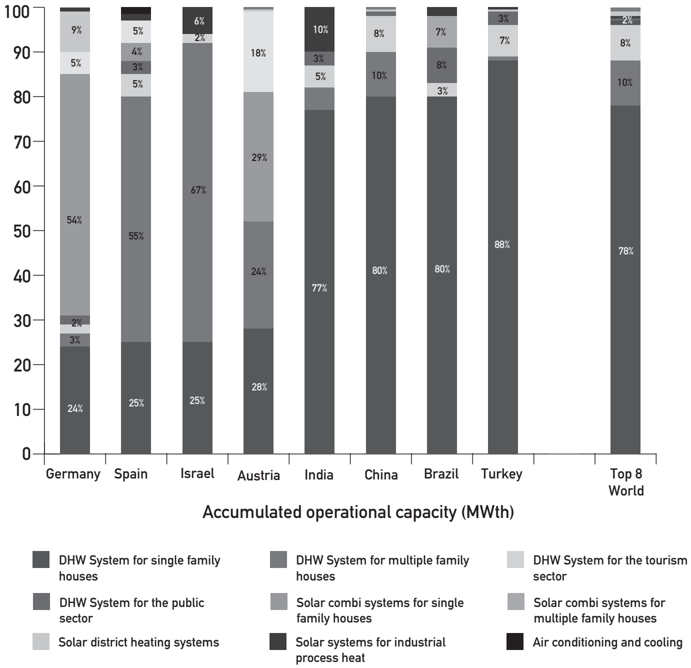
At a basic level, solar heating systems are a straightforward application of renewable energy; solar domestic hot water heating is already widely used in a number of countries. However solar thermal applications also include technologies for other purposes such as space heating, air conditioning and cooling as well as heat for industrial processes.

In the United States, Europe and Australia mainly pumped systems are installed, whereas in Japan, Brazil and China thermosiphon systems are predominant.

Thermosyphon systems are also the main system type used in most African countries. These systems consist only of a collector, a tank and the necessary piping. Thermosiphon systems do not need a circulation pump as they take advantage of gravity differences in their operation. The water heated in the collector rises to the top and is replaced by cooler water from the tank (thermo siphon principle). The water in the tank continues to be heated as long as the temperature difference between the collector and the tank is large enough to maintain the circulation.

FIGURE 3

DISTRIBUTION OF DIFFERENT APPLICATIONS OF THE NEWLY INSTALLED CAPACITY OF GLAZED WATER COLLECTORS FOR THE 8 LEADING COUNTRIES (CONCERNING DIFFERENT APPLICATIONS) WORLDWIDE IN 2010



PICTURE 1.
LOCALLY PRODUCED THERMOSYPHON SYSTEM FOR A BOARDING SCHOOL, ZIMBABWE.

3. A NEW TREND - MEGAWATT-SCALE SYSTEMS

One major trend shows that solar thermal systems reached the Megawatt-scale in several applications. The world's biggest solar thermal plant with a capacity of 25 MW_{th} (36,000 m^2 collector area) was installed in 2011 in Saudi Arabia. The solar thermal system supplies a district heating network for a women's University with 40.000 students and teachers. The hot water is used for showers, kitchens, laundries, a hospital and in the cold season even for space heating.

PICTURE 2.
OVERVIEW OF THE 36.305 M² ROOF MOUNTED SOLAR THERMAL COLLECTOR FIELD ON TOP OF A HUGE WAREHOUSE (PICTURE SOURCE: MILLENNIUM ENERGY INDUSTRIES).

In Singapore, a huge solar cooling plant with a cooling capacity of 1.6 MW driven by 3,900 m^2 of flat plate collectors was also installed in 2011.

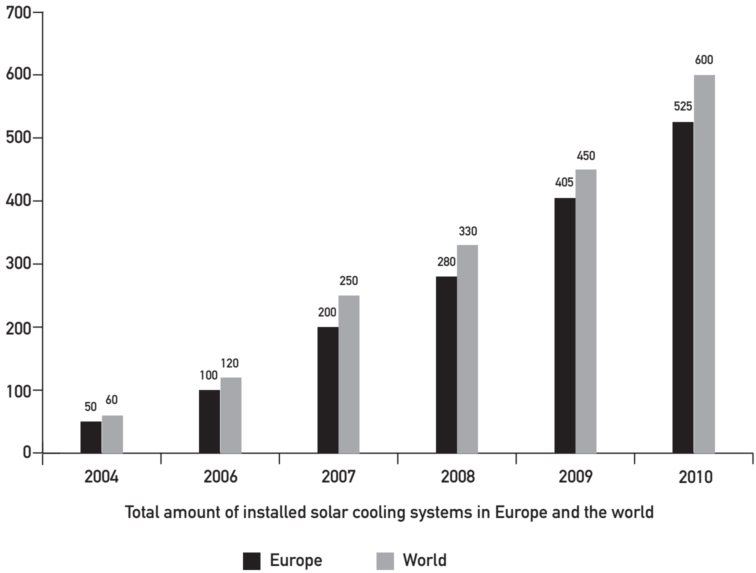
The largest solar **process heat applications** connected to Dyeing and Weaving Mill factories are installed in China: A first plant of 9.1 MW_{th} (13,000 m^2) was constructed in the province of Zhejiang at Shaoxing Dyeing and Weaving Mill in Hangzhou and meanwhile another two projects of 10.5 MW_{th} (15,000 m^2) have been commissioned in the neighbouring province of Jiangsu.

4. SOLAR AIR CONDITIONING AND COOLING

Solar cooling applications convert the energy from the sun into cold by means of driving a thermal cooling machine.

FIGURE 6

MARKET DEVELOPMENT OF SMALL TO LARGE-SCALE SOLAR AIR CONDITIONING AND COOLING SYSTEMS WORLDWIDE AS WELL AS IN EUROPE (SOURCE: SOLEM CONSULTING / CLIMASOL, FRAUNHOFER ISE, ROCOO, TECSOL)



SOURCE: SOLEM CONSULTING / CLIMASOL, FRAUNHOFER ISE, ROCOO, TECSOL.

By the end of 2010 around 600 solar cooling systems were installed worldwide and the major markets were Spain, Germany and Italy. The market still can be categorized as a niche market under development but nevertheless the annual growth rates are high as can be seen in the figure above.

5. OPPORTUNITIES FOR WEST AFRICA

The use of solar thermal energy in West African countries is still on a very low level, even if the resource – the availability of solar radiation – is quite high in all African countries.

The increasing energy costs due to the rise of the oil price and the global discussion on climate change and CO_2 reduction has raised the awareness of most governments in West Africa for solar thermal energy.

6. THE UNIQUE BENEFITS OF SOLAR THERMAL ENERGY

Within the renewable heating and cooling portfolio, solar thermal applications have specific benefits:

- Solar thermal always leads to a direct reduction of the primary energy consumption.
- Solar thermal can be combined with nearly all kinds of back-up heat sources.
- Solar thermal does not rely on limited resources, which are also needed for other energy and non-energy purposes.
- Solar thermal does not cause a significant increase of electricity demand, which in case of a large-scale deployment could otherwise imply substantial investments to increase power generation and transmission capacities.
- Solar thermal is available everywhere in West Africa.
- Solar thermal prices are highly predictable, since the largest part of them occur at the moment of investment, and therefore do not depend on future oil, gas, biomass, or electricity prices. The running costs are negligible.
- The environmental impact of solar thermal systems during its life cycle is extremely low.
- Significant poverty reduction is possible by creating new jobs in renewable energies, which provide employment opportunities.
- If solar thermal systems are installed at social institutions like hospitals, orphanages, AIDS/HIV clinics or homes for elderly people, it will increase the hygienic situation and reduce significantly the running costs of these institutions by substituting biomass, electricity or fossil fuels with solar energy.

As described in detail in the IEA Solar Heating and Cooling Roadmap [2], solar thermal technologies can have an important role to play in realizing targets in energy security and economic development and in mitigating climate change. Solar thermal technologies have specific benefits. They are compatible with nearly all sources of back-up heat and almost universally applicable due to their ability to deliver hot water, hot air as well as heat and cold. Further, solar thermal technologies can increase resilience against rising energy prices as most costs are incurred at the moment of investment, ongoing operating costs are minimal and there is no exposure to the volatility of coal, oil, gas or electricity prices. Local energy supply leads to reduced energy transmission, which enhances efficiency and cost effectiveness. Moreover, solar heating and cooling creates regional and local jobs – since a large portion of the value chain (engineering, design, installation, maintenance) cannot be delocalized. Solar thermal technologies based on flat-plate or vacuum tube collectors are offering opportunities for local manufacturing and local economic development, in developing as well as developed economies.

7. SOLAR THERMAL APPLICATIONS CAN SIGNIFICANTLY REDUCE THE ELECTRIC POWER CONSUMPTION

In addition to replacing fossil fuels that are directly burned for heat production, solar thermal technologies can replace electricity used for hot water and space heating. This would be especially welcome in warm climate countries without a gas infrastructure and lacking alternative heating fuels (*e.g.* limited biomass resources). For example, in South Africa electric water heating accounts for a third of average household (coal-based) power consumption. Solar thermal cooling technology can also reduce electric grid loads at times of peak cooling demand by fully or partially replacing conventional electrically powered chillers or room air conditioning. Solar cooling technologies benefit particularly from the strong correlation between supply of the solar resource and energy demand for cooling.

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AUTHOR

Werner Weiss, Director of AEE-Institute for Sustainable Technologies (AEE-INTEC).

www.aee-intec.at

MICROGRIDS WITH RE
NEW CONCEPTS OF ELECTRIC MICROGRIDS FOR ISOLATED AND POORLY-CONNECTED AREAS

DANIEL HENRÍQUEZ-ÁLAMO
ITC

ABSTRACT

More than 1.2 billion people around the world have no access to electricity. Low cost, secure access to energy is crucial for the economic and social development of Africa. The incorporation of renewable energy sources to existing electrical grids and the electrification of isolated areas is an important challenge whose aim is to provide energy in optimum conditions of supply quality at the lowest possible cost.

Isolated photovoltaic (PV) systems, mainly small PV installations such as "solar home systems", PV hybrid mini-grids, PV-diesel systems and the integration of PV plants in existing power grids are significantly improving people's quality of life. More than 80% of the population who have no access to electrical power live in the rural areas of developing countries, in locations which normally have a large solar energy potential [1].

This article describes the different topologies of electrical microgrids for isolated electrification, current technological development and the new concepts of electrical microgrids that allow the integration of renewable energy sources into weak electrical grids.

Keywords: Microgrids, PV hybrid minigrids, utility distribution microgrids, smartgrids, RO desalination.

Diesel generators have historically been the solution for remote electrification needs. The capital investment cost for isolated installations is extremely low per kW installed. Gradually increasing fuel and transport costs to remote areas do however reduce the advantages associated with diesel power generators due to the prohibitive cost of generating kWh in small electrical grids - costs which reach up to 2 €/kWh. [2]

Faced with this situation, alternatives need to be found to reduce costs, both in isolated areas and in those areas where power grids are already installed - these grids are usually very weak due, among other factors, to their size and because they accrue high losses in terms of transport and energy distribution. Not only are

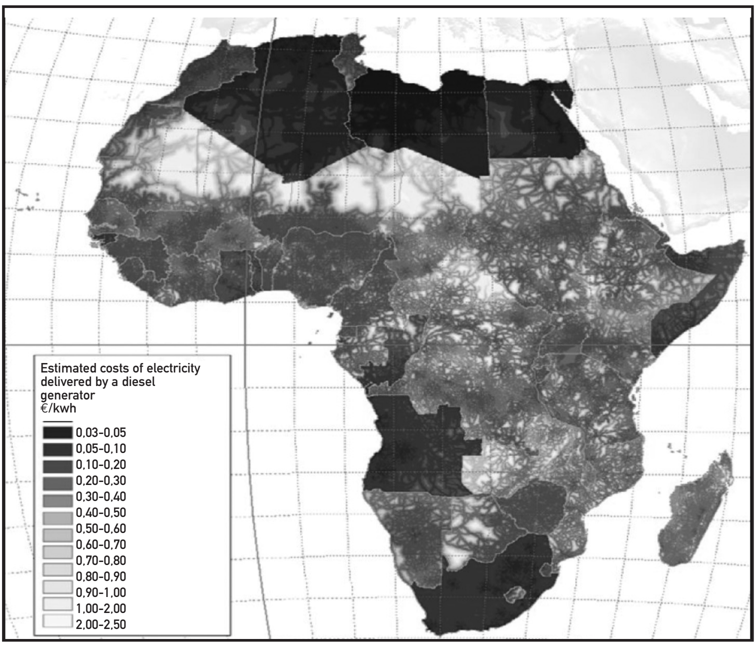


FIGURE 1. ESTIMATED COSTS OF ELECTRICITY (EUR/kWh) FOR DIESEL GENERATORS USING THE DIESEL PRICE FOR EACH COUNTRY AND TAKING INTO ACCOUNT THE COST OF DIESEL TRANSPORT. (SOURCE: [2]).

microgrids with a high penetration level of renewable energy sources an alternative to reducing the cost associated with generation in existing grids, they are also often the only optimum solution for supplying energy to remote areas that have usually been connected by mini / microgrids dominated by diesel-powered generators. The use of renewable energy sources reduces the environmental impact of electricity generation, displacing fuel consumption and reducing overall electricity costs.

However, when a high penetration of renewable energy sources exists, the fluctuating characteristics of these sources (solar and wind power), together with the high variability of the demand curve in rural communities, generate technical challenges in terms of creating a grid with a high quality power supply. These challenges can be overcome by applying adequate topology and control strategies.

Microgrids for isolated electrification may be classified according to the nature of the components that form the grid [3]:

- Microgrids dominated by various diesel-powered generators: in which the diesel generators form the grid, while the remaining power sources (if any) transmit the power and the frequency of the microgrid.
- Microgrids dominated by a single generation component, which changes from one to another. This type of microgrid has multiple sources of generation connected to the microgrid itself (usually battery inverters and diesel generators) and the migrogrid generator changes from one source to the other.
- Microgrids dominated by several inverters. This type of decentralised microgrid is used when the generation is shared throughout the grid network. This type of microgrid requires a communications link in order to coordinate the numerous generation devices.

If the microgrids are connected to the conventional electricity grid or they are planned to be connected, a series of aspects must be considered during the design phase in order to guarantee the quality of the energy and the reliability of the power supply [4]:

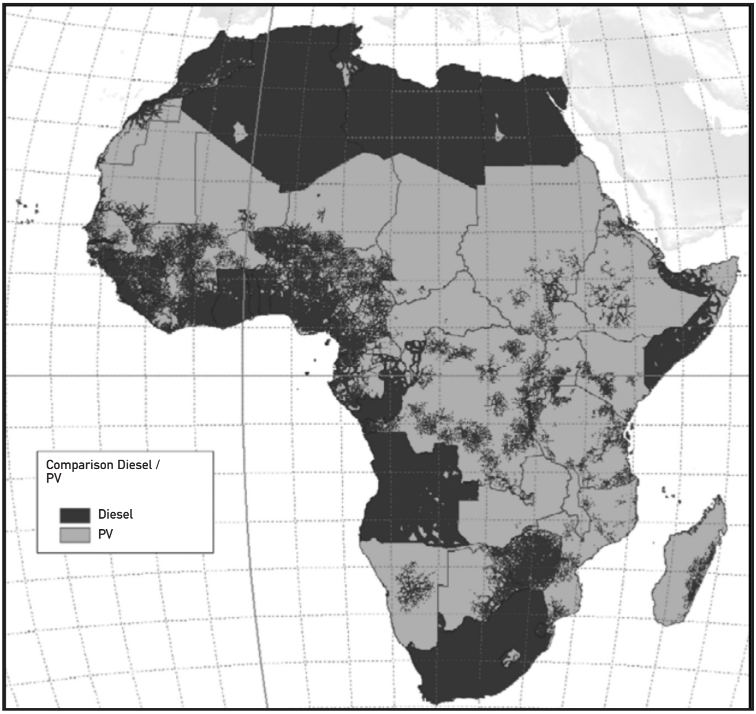


FIGURE 2. OFF-GRID OPTIONS: ECONOMIC COMPARISON OF DIESEL VERSUS PV. (SOURCE: [2]).

- The fulfilment of current regulations on energy quality and connections to the mains power supply.
- The implementation of specific additional measures for the location.
- The consideration of the development of existing regulations, especially with respect to quality standards of power supply.

1. THE ITC AND ISOLATED MICROGRIDS

Historically the ITC - the Canary Islands Institute of Technology - has focused on developing energy solutions based on microgrids dominated by inverters for remote areas in developing countries, and it has concentrated on providing solutions for water supply needs. Some of these projects include:

1.1. THE MINIGRID DESALINATION PROJECT IN KSAR GHILÈNE (TUNISIA)

This project was executed as part of Spanish-Tunisian cooperation. It focused on a photovoltaic (PV) driven RO desalination system to provide fresh water. The project is located in Ksar Ghilène, an isolated inland village of 300 inhabitants, in the south of Tunisia, in the Sahara desert. The village is 150 km away from the nearest electrical grid and 60 km away from the nearest fresh water well. The nominal capacity for water production is 50 m^3/day, but as the power supply depends on solar radiation, the average fresh water production is 15 m^3 day–1, i.e., the system can operate about 7.5 h day–1. Untreated water comes from a brackish well, at a nearby oasis. The power supply is provided by a 10.5 kWp PV solar generator with battery-accumulated energy. The PV field supplies energy to the stand-alone electric grid, which comprises a charge controller, a battery bank with a 660 Ah (C10) nominal capacity, and a 10 kW inverter.

FIGURE 3. THE PV DESALINATION PLANT AT KSAR GHILÈNE (SOURCE: ITC).

1.2. PV-REVERSE OSMOSIS PROJECTS IN MOROCCO

These systems were constructed as part of the ADIRA project (2003–2008) (an initiative co-funded by the European Commission through the MEDA-Water Program) with the participation of local partners (local governments from the provinces of Essaouira and Tiznit, municipal authorities and local associations) and the Moroccan partner in the project (the NGO FM21). The European Commission and the Government of the Canary Islands (through the General Directorate for African Affairs, ITC and the provincial authorities of Essaouira and Tiznit provided financial support. The unitary nominal capacity of the reverse osmosis desalination plant is 1000 l h–1 (for 3 units) and 500 l h–1 (for the 4th unit). The RO plant operates at two different "feed flow - pressure" points, which allows the plant to shift from partial to total power demand and vice versa. This is possible due to a frequency converter that modifies the AC frequency supplied to the electric motor, which is coupled to the high pressure pump: the higher the frequency, the more feed flow and pressure available, and consequently more power supplied.

The concept of the photovoltaic system is similar to the case of Tunisia: PV field, charge controller, batteries, inverter and loads. The PV panels are connected in parallel (8 sets) and series (412 VDC), the configuration is therefore 84 and nominal output voltage is 48 VDC.

FIGURE 4. PV-RO SYSTEM INSTALLED IN TANGARFA (MORROCO) (SOURCE: ITC).

1.3. AN ISOLATED MICROGRID IN VALE DA CUSTA (CABO VERDE)

This project was developed by RICAM, the Canary Islands cluster of renewable energy companies, with the technological support of the ITC. It was financed by the Spanish Agency for International Development Cooperation (AECID) and the Directorate General for Foreign Relations of the Government of the Canary Islands. This microgrid supplies electricity to 117 houses in the village of Vale Da Custa, on the island of Santiago. (Cape Verde). The grid topology is dominated by battery inverters, however, when necessary, the microgrid is controlled by a 40kVA diesel generator. Power production is centralised in an 18 kW PV plant and three 3.5 kW wind turbines. The system is ready to be connected to the public mains grid if the latter reaches the town in the coming years. If this occurs, the control and operating modes of the system may be changed.

FIGURE 5. A PARTIAL VIEW OF THE MICROGRID POWER STATION AT VALE DA CUSTA (SOURCE: RICAM).

The working plans of ITC are currently focused on the integration of microgeneration in existing grids (dominated by diesel) in small sizes, through the integration of PV power generation in diesel microgrids and in the massive integration of renewable microsources in conventional power networks, in the form of UDMs (Utility Distribution Microgrids).

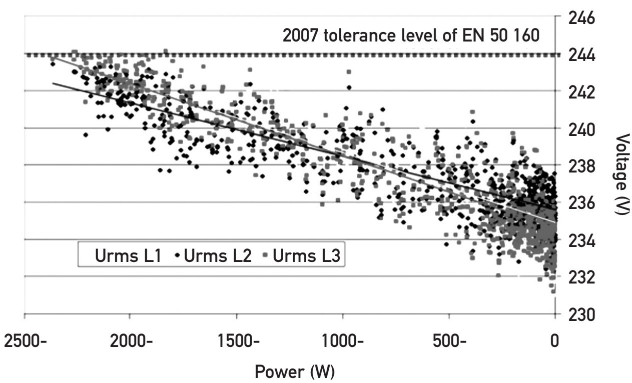
2. ELECTRIC MICROGRIDS CONNECTED TO UTILITY DISTRIBUTION MICROGRIDS (UDMS)

The incorporation of sources of mainly PV-origin microgeneration distributed among electrical grids in Africa involves an important technical challenge, as until now the grids have been uni-directional electric grids. Power stations (normally diesel) exist in conventional grids that are remote from consumption areas, where the electrical energy is produced, transported and then distributed to the end consumer.

The challenges involved in interconnecting these sources of renewable generation lie in ensuring that the generated energy proportioned is as high as possible, without deteriorating the quality of the electric supply, and in improving supply quality, where possible, in weaker grids. As an example of the risk involved in the massive integration of generation distributed on a low voltage line, the graph below shows the effects of voltage levels on a low voltage branch line (in Germany) with respect to the power delivered [5]. In this case it can be observed how the maximum permitted tolerance level established by the EN 50160 is reached.

FIGURE 1

VOLTAGE AT THE END OF FEEDER AS FUNCTION OF DELIVERED INVERTER POWER



(SOURCE: [5].)

UDMs (Utility Distribution Microgrids) are a solution to the integration of renewable microgeneration sources in distribution networks, mainly in low voltage networks, whose aim is to reduce complexity in administration and control by grouping together the installations for generation, loads and storage that are connected to a low voltage grid.

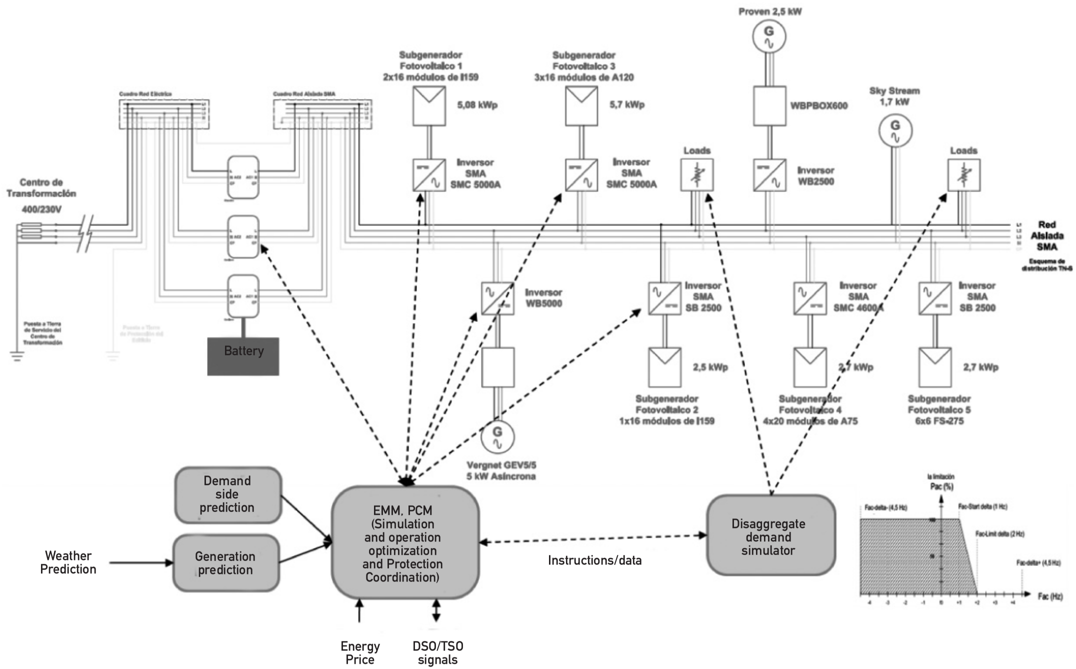
This type of microgrid may be defined as a small electric grid designed to supply electricity (and heat) to a small community, such as a suburban area, a commercial area or an industrial location. From an operational standpoint, the sources of microgeneration must be equipped with electronic interfaces for power and control systems [6] that provide the flexibility needed to ensure the operation of the microgrid as if it were an aggregated solo system and to maintain supply quality. This means that the microgrid control system must ensure that the microgrid is visible to the operator of the electric grid to which it is connected as a solo system, and this solo system behaves as an added load with the ability to operate in isolation, if necessary.

Various aspects must be used as the basis of UDM management. Since 2010 ITC has been working on a management model that considers numerous factors in order to attain optimal performance: the prediction of the renewable generation of the microgrid, demand prediction, storage system management, demand management (among them possible loadable demand points, such as desalination plants or pumping systems) and the control of the energy flow at the interconnection point with the conventional power grid.

ITC has been investigating the control of this type of system for several years and is currently involved in several projects:

- La Graciosa Intelligent Microgrid: Currently in the pre-investigation and data analysis phase, this project is being developed together with ENDESA on the small island of La Graciosa in the Canaries. The plan is to set up PV micro-sources of generation on the island on a massive scale that are distributed on the low voltage network. These micro-sources would operate in a coordinated manner in order to maximise

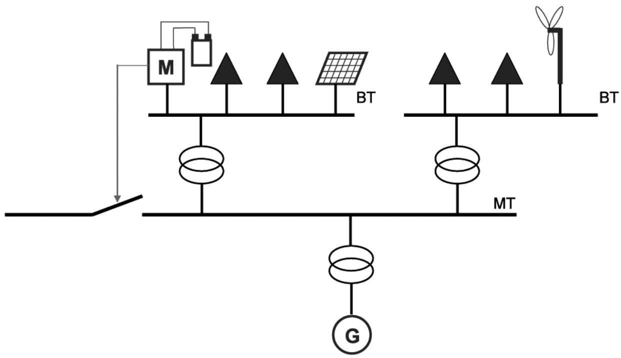
FIGURE 2
COMPONENTS OF ENERGY MANAGEMENT & PROTECTION CONTROL FOR MICROGRIDS (SOURCE: ITC)



SOURCE: ITC.

the penetration of renewable energy sources on the island, guarantee the quality of the supply and provide complementary services to the main electrical system to which it would be connected by a 1.5 km undersea cable.

FIGURE 8
A GENERAL DIAGRAM OF ONE OF THE SCENARIOS BEING STUDIED FOR LA GRACIOSA



SOURCE: ITC.

- The SINGULAR Project. An initiative co-financed by the European Union's 7th Framework Programme, in which different tools are investigated (system operation, storage management, etc.) that allow the massive integration of generation distributed in island networks, including microgrids.
- The TAKATONA 2 Project. An initiative co-financed by the FEDER-Programme for cross-border cooperation (POCTEFEX), which aims to study the technical and economic viability of intelligent microgrids connected to the ONEE electricity grid in rural areas of Morocco.

3. CONCLUSIONS

This new concept of a microgrid connected to a conventional electricity grid (UDM) is an opportunity that requires further investigation in order to integrate microgeneration from non-manageable sources into low voltage distribution networks. This concept would allow these kinds of sources to be controlled without posing a problem in terms of supply quality and they would reduce the cost of kWh generated by conventional power stations in Africa, while also allowing for the democratisation of energy production. In the coming years we will undoubtedly have to work on specific regulatory frameworks that allow the integration of this type of system in existing power grids.

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AUTHOR

Daniel Henríquez-Álamo. Renewable Energies Department in ITC.

www.itccanarias.org

BIOENERGY POTENTIALS IN WEST AFRICA

BAH F. M. SAHO
ECREEE

The energy demand of West Africa is characterized by high dependence on traditional biomass and hence the challenges of access to clean, efficient and modern energy services, particularly cooking energy. The challenges relate to the widespread use of fuelwood (firewood and charcoal) extracted from the natural forest in an unsustainable manner. According to the energy balance of the region (2010), about 78% of the total energy demand for overall energy mix for most countries comes from traditional biomass. In addition, almost 90% of the population use wood and charcoal for domestic cooking.

The consequence of unsustainable and inefficient utilization of wood resources is contributing to the destruction of the natural forest, smoke-related health problems and overall environmental challenges in the region. Other consequences of unsustainable harvest and utilization of forest resources, leading to deforestation and other environmental challenges, is the direct effect on food production thereby negatively affecting food security.

Over the past years, several national governments took various intervention strategies to reduce the heavy dependence of the populations on traditional biomass by: (i) promoting efficient cookstoves for both wood and charcoal; (ii) implementation of plantation and woodlot projects to supplement the wood requirements of the populations for both the construction industry and for cooking; (iii) promote alternative cooking fuels such as liquefied petroleum gas (LPG) and kerosene; and (iv) promotion of renewable energy resources including biogas, biomass produced from agro-industrial waste and invasive plant species such as 'typha australis'. The national interventions of the past had mixed results with some intervention having little success. However some of the gains made were eroded by increases in populations particularly in the urban areas as the demand for fuelwood increases as a result.

One of the key barriers identified in promoting sustainable and efficient production and use of biomass and modern Bioenergy relate to adhoc and unplanned approaches. Most of the countries in the region either do not have policy frameworks or no guiding principles when it comes to planning and implementation of biomass supply and demand. However, there are opportunities of producing and using modern, sustainable and efficient bioenergy products and services.

The following strategic approaches provide opportunities for bioenergy production and utilization:

1. Production and utilization of sustainable bioenergy services (including the use of efficient stoves, production of briquettes and sustainable production of biofuels) that support increased food production, etc.
2. Better management and expansion of the natural forest resources that support socio-economic development in the rural and peri-urban areas through sustainable management techniques.
3. Encourage increase food production and processing to add value for employment creation and income generation through increased and efficient agricultural production, the utilization of the produce & products to address food security as a priority.
4. Utilizing the agricultural/food residue for transformation into biofuels to increase energy access and alleviate poverty, including energy poverty.
5. Encourage production of non-food energy crops on already identified and agreed lands, taking into consideration identified sites for production of food, feed and fibre, biodiversity and other environmental considerations.

6. Encourage, where possible, efficiency in the entire value chain of production on biomass and bioenergy fuels and devices and their utilization.

Potentials for bioenergy in the region can therefore be summarised in the following programme of activities:

- *Promotion of cleaner, alternative and efficient modern cooking fuels and stoves:* New, efficient and modern fuels and stoves including bioethanol, methanol, biogas, briquettes and very efficient improved cookstoves. Modern fuels and stoves provide opportunities in the production, processing and marketing for socio-economic transformation and employment generation particularly in the rural areas. Liquefied Petroleum Gas (LPG) is not a biofuel but can be used as a substitute for traditional biomass because of its cleanliness and efficiency.
- *Efficient production and use of energy resources:* sustainable and more efficient production of wood and biomass resources such as charcoal and their use to maximise output.
- *Agro-industrial waste:*
  - Briquetting and carbonization of agro-industrial waste for ease of carrying and use. Various processes are used including carbonisation and then briquetting and vice versa. Some of the agro-industrial wastes include groundnut shell, cotton stalks and also an invasive plant called typha australis.
  - Biogas: Biogas production from animal/human waste provides opportunities that are yet to be fully exploited. The use of municipal liquid waste could also be used for biogas production. The opportunities are broad and not only in the domestic sector but in institutional, commercial and industrial sectors for cooking, power generation or lighting.
  - *Municipal Solid Waste (MSW):* The use of this waste as a source of energy has not been exploited. There is no successful project in the region due to several factors, which are claimed to be linked to its characteristics: the quality (not sorted) and quantity of waste. Unfortunately, residents of municipalities pay for the waste collection only to be dumped or buried with negative

health, social and environmental consequences. Yet, technology has evolved for transformation of any type of waste into energy. This means of deriving energy from waste has multiple benefits to the consumer: cleaner and healthier environment, energy access and savings on fuel cost.

- *Better Forest management:* The concept of forest management needs to be reinforced for efficient and effective harvesting of forest resources in a sustainable manner. Several forestry management concepts were developed and tested in the 1990s including Community Forestry, Joint Forest Park Management and Community Controlled State Forest. Effective participation of rural communities in forest management for sustainability and efficiency is crucial. Development of institutional, legal and organizational reforms for the development of these concepts is however required to implement and enforce better forest management. The forest resources of the region, if better managed, could provide sustainable supply of fuelwood.
- *Biofuel production: biodiesel and bioethanol:* The cultivation and production of biofuels provide some opportunity to rural communities in providing modern and efficient fuels. However, the issue of sustainability in the production and utilization, especially when it comes to growing of crop only for energy purposes, is critical. The ECOWAS Bioenergy Strategy encourages production of bio-crops from only approved land allocations and using agreed crops within the countries. In the production and processing of the crops, consideration should be given to the aspects of water, land and other natural environment using the GBEP Sustainability Indicators, UNEP/FAO Decision Support Tools, etc.

  The ECOWAS Bioenergy Strategy encourages increased food production and the use of residue (agricultural/food) for bioenergy production.
- *Biodiesel for Multifunctional Platform (MFP):* MFP is a multi-faceted device powered by a diesel engine with multiple functions performed simultaneously. It produces energy for electricity that can be used for productive purposes, while pumping water, charging battery and cereal grinding simultaneously. The MFP is being used in some countries for providing energy access to rural communities

in the ECOWAS region. The use of biodiesel/pure plant oil (PPO) as a source of fuel on the MFP make it attractive in some rural communities producing their own fuel to provide energy services.

- *Bioelectricity generation:* Electricity generation from biomass at scales ranging from a few kilowatts for rural village to megawatts offers opportunity to increase energy access at reasonable rates. In some countries, biomass residues are huge and provide opportunity for such services.

The development and implementation of bioenergy programmes however requires a strategic approach. In this vein, ECOWAS, together with the Global Bioenergy Partnership (GBEP) and with the support of other partners convened a Regional Bioenergy Forum in Bamako, Mali in March 2012 to discuss issues related to rolling out of the Bioenergy Programme in the Region. The Forum adopted a Regional Strategy Framework to implement the Programme. Details of the Strategy Framework can be found on www.ecreee.org.

The overall objective of this Strategy Framework is to set out priority actions to empower citizens of the ECOWAS region through the creation of an enabling environment for production and utilization of modern bioenergy in a sustainable manner. The Regional Bioenergy Strategy Framework seeks to enable and promote domestic and foreign investments that help address energy poverty prevailing in the region both in rural and peri-urban populations without compromising food security and the environment. In the implementation of this Strategy Framework, consideration would be given to local production of components/devices and fuels to spur local socio-economic development through creation of added value and employment.

AUTHOR

Bah F. M. Saho. Renewable Energy Expert, ECREEE.

www.ecreee.org

SMALL-SCALE HYDROPOWER POTENTIAL AND PERSPECTIVES IN WEST AFRICA

MAHAMA KAPPIAH
AND MARTIN LUGMAYR
ECREEE

ABSTRACT

ECOWAS defines Small-Scale Hydropower (SSHP) Plants up to 30 MW, with this approach, all countries of the region are harmonized and the compilation and follow-up of the development in Small Hydropower can be done at the regional level. In the framework of the recently adopted ECOWAS Renewable Energy Policy (EREP), it is estimated that SSHP could contribute with 787 MW (33%) by 2020 and 2449 MW (32%) by 2030 to the RE Regional targets. To achieve this target the article describes how the untapped potential for SSHP should be exploited by overcoming the several barriers for SSHP development in the ECOWAS region.

Keywords: Small hydropower, ECOWAS.

1. BACKGROUND INFORMATION

1.1. ECOWAS DEFINITION OF SSHP

Apart from other low-carbon solutions hydropower is an appropriate tool to address the challenges of energy security, energy access and climate change mitigation in the ECOWAS region simultaneously and in a sustainable manner. Hydropower of all sizes can contribute significantly to meet the electricity needs of urban and peri-urban areas as well as isolated rural areas. It can be fed into the main grids or as off-grid systems to supply one or several villages including productive uses in remote areas. 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

Usually the upper limit of “small hydro” is defined at 10 MW. The present program explicitly applies an upper limit of about 30 MW, because it intends to include all “SSHP projects in the region which require assistance”. Many potential sites in West Africa of more than 10 MW are not developed because of various reasons (e.g. lacking access to finance) and consequently need assistance. Due to economies of scale, large hydropower projects are profitable and can attract private investment capital. Smaller hydropower projects (without reservoir) have the advantage to normally result in significantly less negative environmental and social impacts but on the other hand, require more promotion and support in order to overcome disadvantages like higher specific investment cost. The "Small-scale" Hydropower Programme primarily but not exclusively focuses on projects with capacities of less than about 30 MW. However, if required also support to medium-scale projects (MSHP) up to 100 MW will be included. While talking about "small-scale hydropower" and setting a limit of 30 MW, it has to be taken into account that this wide range covers very different types of systems:

- "Purely" grid connected systems (normally in the range > about 100 kW and more often in the MW-range) which feed all produced electricity in a larger (national) grid, normally based on a power purchase agreement which guarantees that all produced electricity can be sold at a well-defined feed-in tariff. This fact which leads to a high load factors generally allows operating such plants in a profitable way. Nevertheless, given political, technical and other risks, such projects still often do not get access to finance (loan and equity) and therefore need support for their successful implementation. Since such plants normally feed electricity into the existing national grid, they mainly improve electricity supply of households who are already connected. Except in cases where the national grid is really extended to new customers due to the increased generation capacity. However, this is often not self-evident.
- "Isolated" SSHP systems which only feed a surplus to the national grid. Normally this happens if an originally isolated SSHP system which previously supplied a number of households connected to an isolated grid, is later connected to the national grid in order to feed in the part of electricity not consumed locally. Or, the owner of the system agreed from the very beginning to supply the rural households in the surroundings first before selling any surplus electricity. Whether this works or not depends on the tariff level paid by the local households compared to the feed-in tariff. A very special but extremely efficient form when considering poverty alleviation is a community owned grid-connected system where the profit gained from the feeding in of electricity flows back to the community.
- Isolated systems (often in the range < 100 kW) which supply an isolated mini-grid with electricity. Such systems often suffer from

a relatively low load factor since the rural households mainly consume electricity in the evening. Consequently, as measured by the high investment cost such isolated plants do not pay back the investment in an "attractive" time-span, if at all. The load factor can be significantly improved if productive use of electricity of small-scale industries is feasible. Given the fact that such systems are built to supply additional (rural) households and probably small and medium industries making them independent from exorbitant high fuel costs for diesel gensets, such systems normally have a significant impact on poverty alleviation.

1.2. PERSPECTIVES FOR SSHP DEVELOPMENT

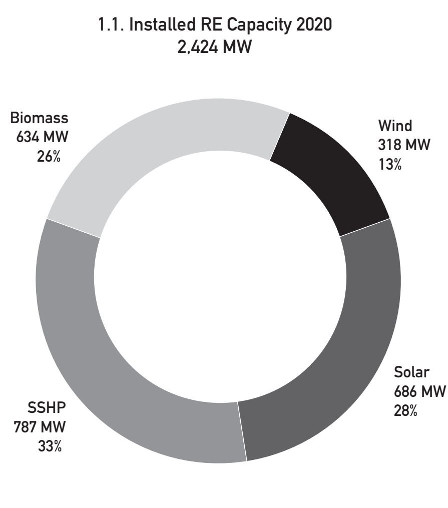
In previous decades the utilities in ECOWAS were mainly focused on large hydropower rather than small or medium scale hydro power development. Therefore, the capacities in these sectors are unequally developed. The project pipeline of the WAPP Master Plan focuses exclusively on the more competitive large hydro power and SSHP is not included in the scenario projections. The WAPP intends to implement a project pipeline of 21 large hydro power projects with an overall capacity of 7 GW by 2020. Also at the national level, countries such as Ghana and Guinea concentrated more on the development of larger sites. International financiers (e.g. development banks, trust funds) are targeting mainly large scale projects. Their required minimum level of investment excludes in many cases SSHP projects. SSHP got more attention in the context of the endeavour to boost universal access to energy services in peri-urban and rural areas. The ECOWAS White Paper on energy access in peri-urban and rural areas and the ECOWAS Renewable Energy Policy (EREP) include the use of grid-connected and decentralized renewable energy solutions into their scenarios. Specifically, the ECOWAS Renewable Energy Policy aims at the following objectives:

- The share of renewable energy (incl. large hydro) in the overall electricity mix of the ECOWAS region will increase to 35% in 2020 and 48% by 2030.

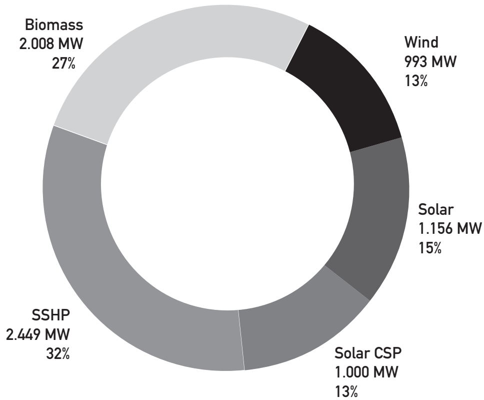
- The share of "new renewable energy" such as wind, solar, small scale hydro and bioelectricity (excl. large hydro) will increase to around 10% in 2020 and 19% by 2030. These targets translate to an additional 2.425 MW renewable electricity capacity by 2020 and 7.606 MW by 2030. It is estimated that SSHP could contribute with 787 MW (33%) by 2020 and 2449 MW (32%) by 2030 to this additional capacity.
- To provide universal access to energy services it is envisaged that around 75% of the rural population will be served through grid extensions and around 25% by renewable energy powered by mini-grids and stand-alone hybrid systems by 2030.
- By 2020, the whole ECOWAS population will have access to improved cooking facilities either through improved stoves or fuel switching to other modern forms of energy such as LPG.
- By 2030, around 50% of all health centers, 25% of all hotels and agro-food industries with hot water requirements will be equipped with solar thermal systems.

FIGURE 1

SSHP AND THE GRID-CONNECTED ECOWAS RENEWABLE ENERGY POLICY TARGETS



1.2. Installed RE Capacity 2030
7.606 MW



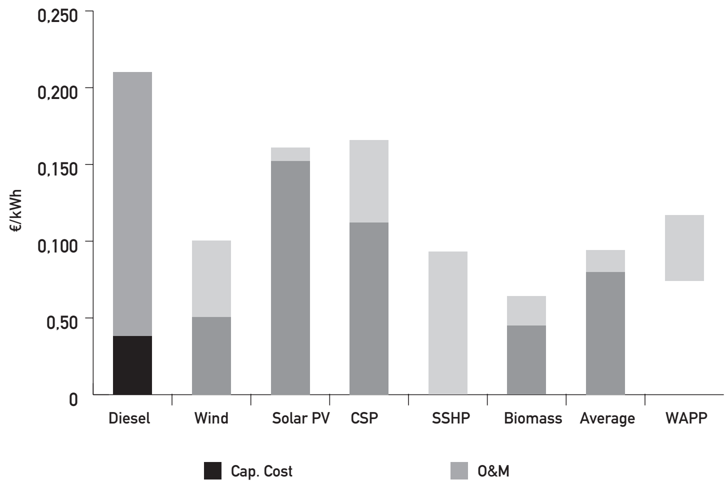
A least costs assessment undertaken for the EREP scenario has demonstrated that SSHP continues to stay one of the most cost-effective renewable energy solutions. Moreover, the technology is proven, reliable and is able to provide base load capacities under certain circumstances. SSHP can play a significant role particularly in countries depending on expensive diesel generation. It can increase the national energy security of countries and complement imports through the regional WAPP power market under establishment. Under soft loan ODA financing conditions (long repayment periods of 25 to 40 years, low interest rates of typically 1.5 to 2% and 5 to 10 years grace period), SSHP tends to be even more competitive than electricity imported through the WAPP system.

Some of the ECOWAS countries, such as Liberia and Sierra Leone, have the potential to become electricity exporters through further development of their medium and small scale hydropower resources.

FIGURE 2

LCOE FOR DIFFERENT RENEWABLE ENERGY TECHNOLOGIES IN 2020 UNDER FINANCING CONDITIONS

2.1. Resulting costs for RE grid-connected production-Commercial conditions



2.2. Resulting costs for RE grid-connected production-Soft loans conditions

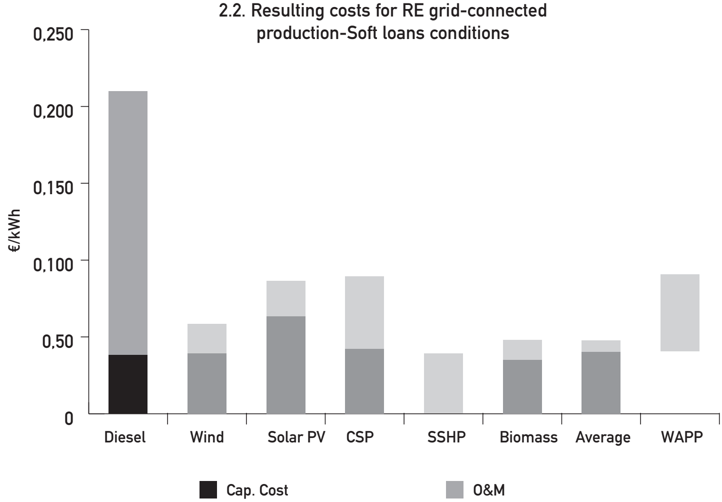
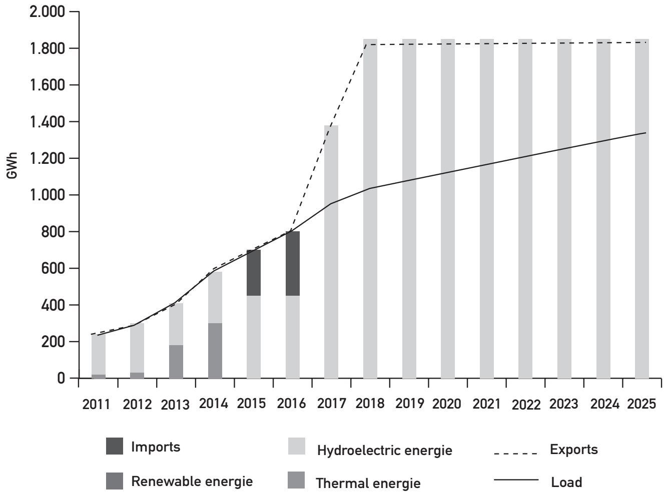


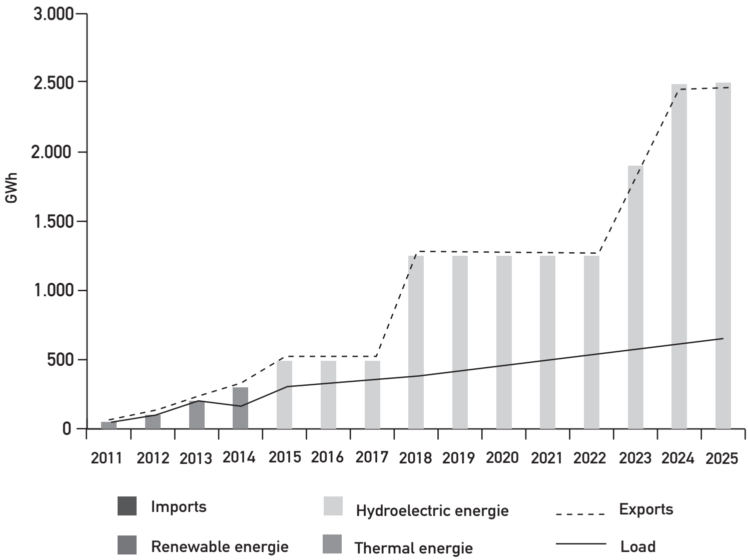
FIGURE 3

POSSIBLE HYDROPOWER EXPORTERS IN THE ECOWAS REGION IN 2025

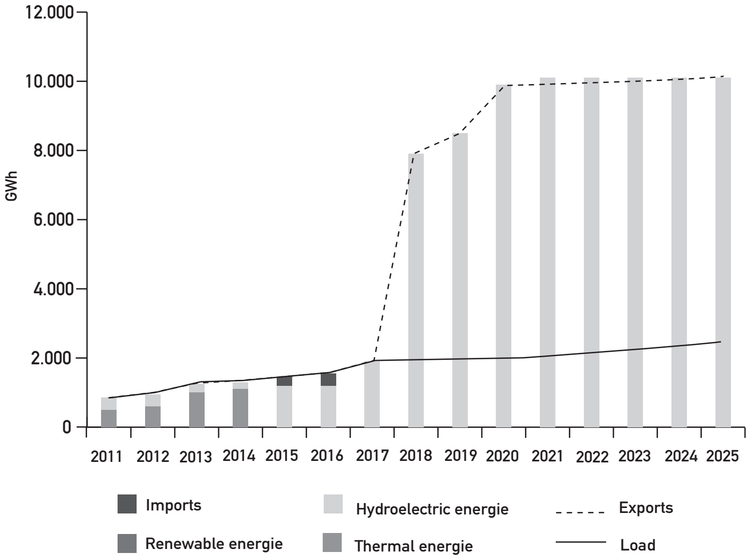
3.1. Sierra Leone



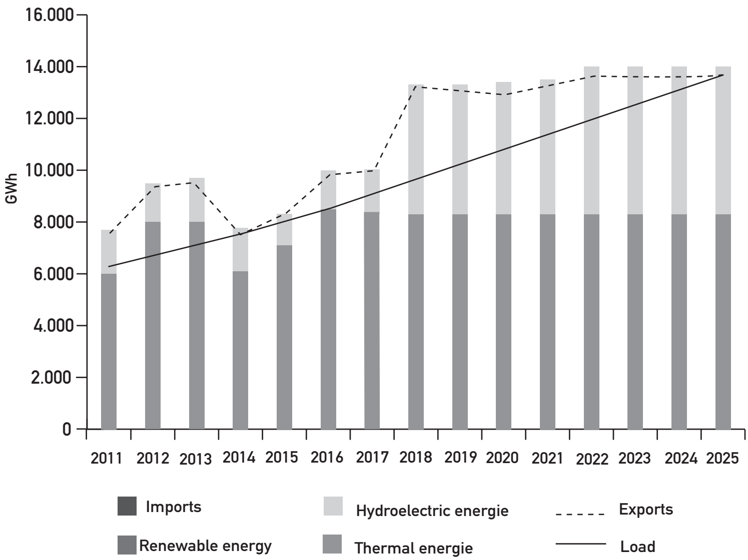
3.2. Liberia



3.3. Guinea



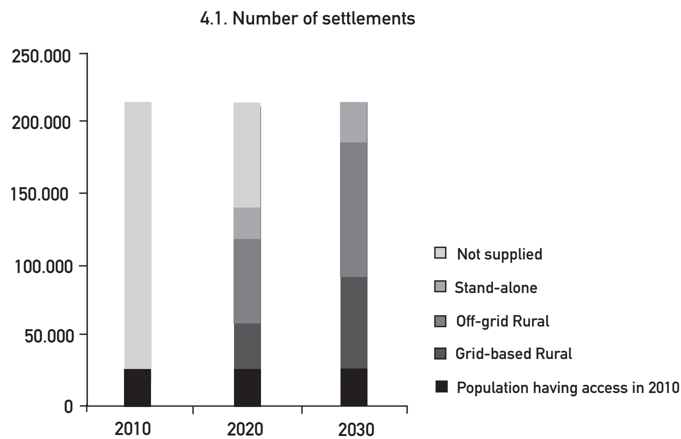
3.4. Côte-d'Ivoire

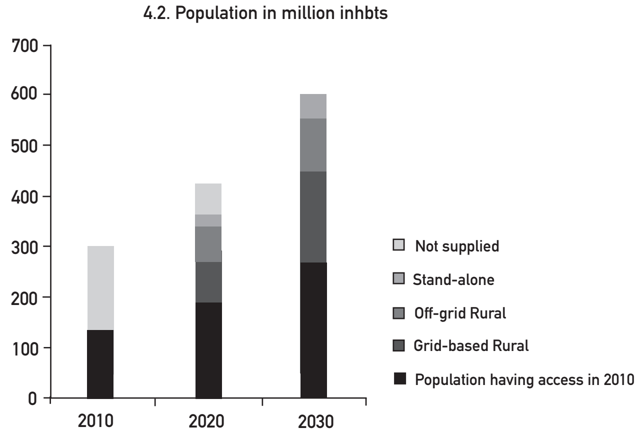


SSHP can play an important role to achieve the energy access targets in remote areas. The EREP aims at serving 25% of the rural population by decentralised renewable energy solutions in 2030 (mini-grids and stand-alone systems). The policy foresees the installation of 60,000 mini-grid systems by 2020 and 68,000 from 2020 to 2030. Parts of the mini-grids could be powered by SSHP systems in a cost-effective manner (compared to diesel generators and other renewable options).

FIGURE 4

SCENARIO FOR CENTRALIZED AND DECENTRALIZED ELECTRICITY SUPPLY IN THE ECOWAS REGION





1.3. NATIONAL AND REGIONAL INSTITUTIONAL FRAMEWORK

In most ECOWAS countries the mandate and institutional framework for SSHP is not very well defined. Many problems arise due to overlapping mandates and conflicting responsibilities of different ministries and other stakeholders (see country presentations and reports). At regional levels the mandate of the West African Power Pool (WAPP) covers the development of large hydro power resources (>100 MW) in the context of regional power trade. During the previous years, two regional institutions were created which incorporate, at least partially, the area of SSHP in their mandates:

- In 2006 the UNIDO Centre for Small Hydropower Development in Abuja, Nigeria, was launched.
- In 2010 the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) was created by the ECOWAS Commission with support of the Austrian and Spanish Governments and technical support of UNIDO.

ECREEE in cooperation with UNIDO is expected to take the lead for the implementation of the ECOWAS SSHP Program.

The UNIDO Centre for SSHP, located in Abuja, is currently in a transformation process to a private hydro service provider which could provide technical assistance for the implementation of the SSHP Program. With regard to the SSHP potential assessment it is planned to cooperate with ESMAP.

1.4. BARRIERS FOR SSHP DEVELOPMENT IN THE ECOWAS REGION

So far the ECOWAS countries do not take full advantage of their technically and economically feasible hydro potential. This is particularly true in the case of small-scale hydropower. The challenges that SSHP developers are facing are manifold and most of them are part of the larger picture of general barriers for the uptake of renewable energy. The main constraints for SSHP development in the ECOWAS region can be summarized as follows:

- *Policy and institutional barriers:* There is a lack of coherent clear-cut energy policies, regulations and associated budgetary allocations to create an enabling environment for SSHP investments and business. Most ECOWAS countries do not put a special focus on SSHP in their energy policies and rural electrification strategies. In some of the countries SSHP is not included in the regulatory arrangement for hydropower. The monopolistic role of national power utilities and the uncertainties for IPPs are other known constraints. There are no particular support policies and incentives for SSHP in place and low quality equipment enters the market due to the absence of defined quality standards and certification.
- *Financial barriers:* There is a lack of long-term financing mechanisms tailored for SSHP projects which usually have high initial investment costs and low operation and maintenance costs. Another constraint for SSHP investments is the low willingness and ability to pay of the population in rural areas. Even the smallest of the SSHP schemes possibly costing only few thousand Euros becomes a major project for the poor. Due to the complex nature of SSHP, experience in planning and implementation is required to avoid time and cost over-run in the construction phase. Associated technical, market and political risks impact the financial viability

of SSHP projects. Local lending agencies and development banks normally do not provide long term loans and in addition ask for high collaterals (project finance where the SSHP project as such is considered as collateral is still very rare). Large hydropower systems which feed electricity into the grid and which often have lower specific investment costs have fewer difficulties to attract investment capital. For SSHP systems, carbon mechanisms (e.g. CDM) are difficult to apply for and risk capital for feasibility studies is scarce.

- *Technical barriers:* As most good sites are located in remote areas, infrastructure constraints such as access to roads and transmission lines make these good sites difficult to develop. Technical risks are also the hydrological and geological uncertainties and unpredictable long-term climate change impacts. A technical challenge for off-grid SSHP schemes is also the low electricity demand in rural areas (load factor). Finally, the ECOWAS countries face difficulties in accessing appropriate quality technologies particularly in the mini, micro and pico hydro categories. There is a need for technology transfer.
- *Capacity barriers:* Public institutions such as ministries, regulatory authorities and district administrations often possess only minimal capacity to design, implement and revise SSHP supportive policies and regulations. At technical level the capacities to plan, build and run SSHP projects are very low. Most of the countries lack specialization to undertake quality feasibility studies (e.g. detailed design and financial cost benefit analysis). Most ECOWAS countries do not have any facility to manufacture even the most rudimentary turbines or parts that might be critical in maintenance of the schemes. Local lending agencies and investors are reluctant as they do not know how to appraise SSHP projects.
- *Knowledge and awareness barriers:* Another serious challenge is the missing knowledge and awareness on SSHP costs, potentials and benefits for rural electrification. Utilities are focused on large hydropower rather than the more costly small-scale hydro schemes. Public data on SSHP resources and project sites is often not available. Such a lack of sound basic data (e.g. hydrological, geographic, geological data, seasonal and long-term river flow data),

poses a major barrier for private investors in the sector. Detailed GIS based maps are in most cases not available and there is a lack of gauging stations. Increasing climate variability, deforestation, increasing erosion and decreasing storage capacity of catchment areas are making investments in hydropower systems risky.

1.5. SSHP POTENTIALS IN THE ECOWAS COUNTRIES

Apart from significant fossil fuel resources (e.g. oil and gas) the ECOWAS countries can rely on a wide range of untapped renewable energy and energy efficiency potentials in various sectors:

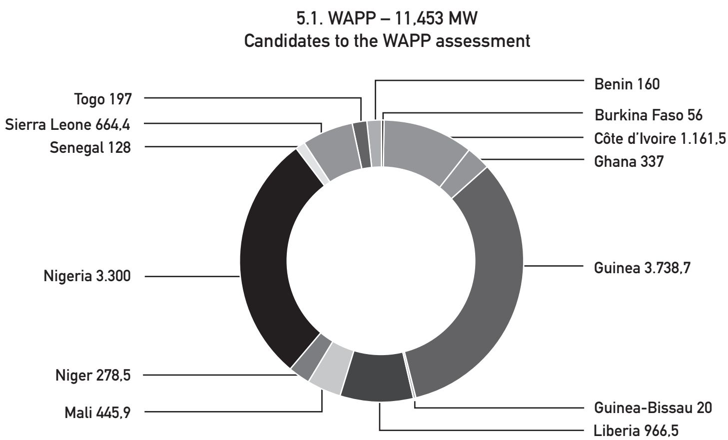
- There is also potential for all forms of bioenergy in the ECOWAS region. Traditional biomass is already the main source of energy for the poor majority and accounts for 80% of total energy consumed for domestic purposes.
- There are also considerable wind, tidal, ocean thermal and wave energy resources available in some ECOWAS countries.
- The region has vast solar energy potential with very high radiation averages of 5 to 6 kWh/m^2 throughout the year.
- There is significant potential to improve demand side and supply side energy efficiency in various sectors (e.g. appliances, buildings, industry and power generation and transmission). In the power sector the technical and commercial energy losses (e.g. theft, illegal operators) lie in the range of 20 to 40% (in comparison to 7% to 10% in Northern America and Western Europe). It is estimated that in West Africa around 30% of the total electricity supply is consumed in the building sector.

The overall hydroelectric potential (small, medium and large scale) located in the fifteen ECOWAS countries is estimated at around 25,000 MW. It is estimated 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 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 5

WAPP LARGE HYDROPOWER PROJECT PIPELINE



5.2. WAPP – 7,073 MW in the Master Plan

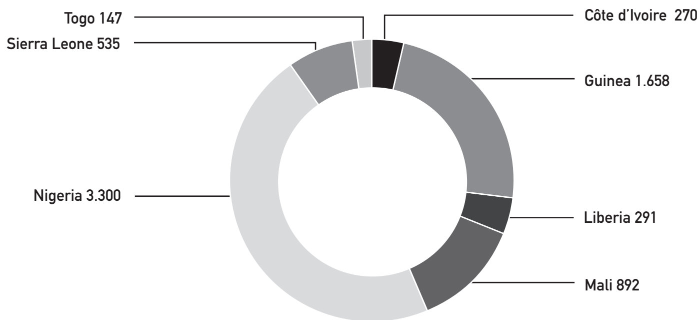


TABLE 2

POTENTIAL OF SSHP SITES IN THE ECOWAS COUNTRIES

	PLANTS<= 30 MW	
	Plant number	Capacity [MW]
Togo	9	206
Benin	99	305
Burkina Faso	<70	52-138
Niger	4	5
Mali	16	117
Nigeria	97	414
Ghana	85	110
Sierra Leone	17	330
The Gambia	?	?
Côte d'Ivoire	5	59
Guinea-Bissau	2-4	about 48
Guinea	18	107
Senegal	–	–
Liberia	30	86
Total	483	1.882

The estimates for SSHP potential (up to 30 MW) in the ECOWAS region differ widely and lack reliability. They range from 1.900 MW to 5.700 MW of feasible potential. The lower end was estimated by taking into account the provided site data by ECOWAS countries to the ECREEE inventory during the workshop. The following table gives an overview on the "small-scale" (≤ 30 MW) and the overall hydropower potential in ECOWAS countries. For the range ≤ 30 MW only those sites are counted which were found to be listed in the various studies and country reports.

PICTURE 1

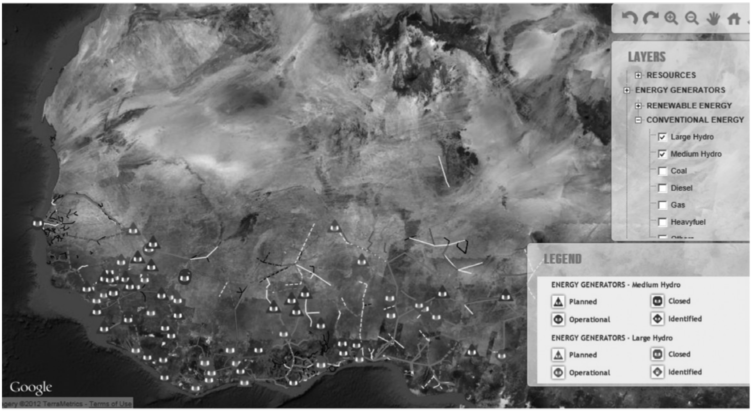
GIS MAP WITH SELECTED SSHP SITES IN THE ECOWAS REGION

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 70s, 80s and 90s by foreign consultants (e.g. EDF for the French speaking countries) and the regional expertise in hydro resources assessment is poor, if any.

Many ECOWAS countries dispose of a reasonable SSHP potential which is used to an extremely limited extent. The SSHP Programme should focus on concrete measures to make use of this widely

PICTURE 2

GIS MAP WITH SELECTED MSHP AND LSHP SITES IN THE ECOWAS REGION



untapped resource for rural electrification with the final objective of poverty alleviation. To achieve this, any activity should be appraised against its contribution to a local added value: to increase local competences and capacities, to electrification of additional rural households and small industries, to the possibility of planning, implementation and operation of SSHP by local experts etc. In the following chapters, the specific situation of each ECOWAS country with regard to SSHP is described in more detail.

1.6. LESSONS LEARNED

The following conclusions and lessons learned were drawn from the discussion at the validation workshop, held from 16 to 20 April 2012 in Monrovia, Liberia, and the SSHP baseline report. They were incorporated into the design of the program.

1. Successful SSHP development requires reliable water source. In order to start SSHP development at the most promising sites (with year round reliable runoff), a good hydrological database is required. For this purpose, a sufficient number of well-trained "hydro

scouts" with good measuring equipment and know-how on data processing and evaluation should be prepared to be "on duty" as soon as possible. The analysis of the various documents and discussions during the SSHP workshop in Monrovia, have clearly shown that many identified sites will have to be reassessed. For this purpose a comprehensive field survey campaign for data collection combined with intensive capacity building (hands-on training on how to measure runoff and head) will be required.

2. Awareness creation on catchment area protection is a crucial issue to avoid further deterioration of runoff patterns and desertification.
3. Access to finance is often considered as a shortfall for planning and implementation of hydropower systems. However, access to loan and equity as well as access to grants require convincing project proposals, presenting the crucial, concisely formulated project information. Many project descriptions analysed for the current report are lacking vital information. A standard for site assessment / pre-feasibility but also for feasibility studies should be set (depending on the order of magnitude of the project) and explained and distributed during training sessions.
4. With the exception of Nigeria and to some extent Ghana, most available studies have been elaborated by international organisations / companies. Similarly, most of the existing hydropower plants have been implemented by foreign companies. One of the main barriers for SSHP development in the ECOWAS region is the lack of indigenous planning, implementation and capacity building and has to be addressed by the Programme. The best way to convey knowledge on planning, implementation and operation of SSHP systems is the common realisation of some pilot plants facilitating real "object-teaching".
5. The analysis has shown that many hydropower plants are in bad repair and need rehabilitation. For sustainable operation, capacity building on technical and management issues is of high importance and should be part of the SSHP Programme. Another problem is the provision of spare parts and access to professional repair services. A regional network of well equipped

professional workshops e.g. on turbine production, repair and spare part production should be established by training staff of existing mechanical workshops.

6. Training and capacity building should be linked to the development of appropriate guidelines and manuals, fitting to the local conditions and the level of understanding of the respective target groups (which most probably varies from country to country).
7. A capacity needs assessment, implemented on behalf of ECREEE in 2012 revealed that in many countries, educational institutions already include renewables in their curricula. It was stressed by many interviewed stakeholders that any kind of training, workshops etc. should be integrated especially in vocational schools in ECOWAS countries and that the principle of "training of trainers" should be followed. With regard to capacity building, the UNIDO Regional Centre for SHP in Abuja and other national training centres (e.g. KNUST, 2ie) could play an important role. The URC-SHP could work as a service provider closely with ECREEE in this context.
8. Given the existing knowledge deficit and experience on SSHP, it is important to set realistic targets for the SSHP Programme. With regard to competences on technical planning and implementation, capacity building should be limited to systems below about 500 kW and should make a clear difference between isolated and grid connected plants (since the two require relatively different technical standards). As far as capacity building on legal and regulatory aspects like requirements for concessions, contracts and PPA-formulation are concerned the capacity building should also cover SSHP systems ranging from 500 kW to about 30 MW.
9. It is imperative that for any activities under the SHPP Programme the linguistic barriers have to be taken into account.
10. Exchange of experience between ECOWAS countries shall be added value of the "regional approach". Although a specific country might not have the critical number of hydropower systems which justifies the starting up of a turbine workshop, this country could benefit from the availability of competences in

neighbouring ECOWAS countries. The SHPP Programme should facilitate the exchange of experience not only on technical, legal and policy issues but also on failure and success of different management systems (e.g. village community cooperatives in Burkina Faso). The specialised agencies for rural electrification which already exist in several countries (AMADER / Mali, ABERME / Benin, etc.) could become focal points for exchange of information. In several cases, hydropower systems failed due to political difficulties on national level. In such situations, decentralised operation and management of SSHP systems by local staff is the most "robust" solution as it guarantees a certain independence.

11. In most of the countries the energy sector is already liberalised but the lack of clear responsibilities, a strong regulatory agency and streamlined procedures for SSHP development are still not fully established. The definition of capacity limits below which simplified procedures can be applied is crucial for the development of very small isolated systems. The legal and regulatory framework has to be suitable for SSHP development in different orders of magnitude.
12. The analysis has shown that the framework conditions are very different in various ECOWAS countries (identification of sites, experience with hydropower, average level of education, legal and regulatory conditions, development of the private sector, access to finance, etc.). All activities planned in the context of the SSHP Programme should take these differences as far as possible into account.
13. Although in some countries the legal and regulatory framework is (theoretically) well established, the political will to enforce its implementation is still lacking. Therefore, awareness raising on different political levels is an important activity to be included.
14. With specific reference to isolated SSHP systems which normally have a relatively low load factor and are consequently NOT profitable, full subsidisation of investment cost is indispensible. As a general rule the tariff system applied, in isolated systems, should at least cover the operation and management cost (O&M). Even if investment is subsidised, O&M should NOT be

subsidised in order to allow for a sustainable and independent operation. The SSHP Programme should take such subsidisation of investment cost into account.

AUTHORS

Mahama Kappiah. Executive Director in ECREEE.

Martin Lugmayr. Renewable Energy Expert at ECREEE/UNIDO.

www.ecreee.org
www.unido.org

THE ECOWAS SMALL-SCALE HYDROPOWER PROGRAM (2013 TO 2018)

MAHAMA KAPPIAH AND MARTIN LUGMAYR
ECREEE

The ECOWAS SSHP program was adopted by the ECOWAS Ministers of Energy in October 2012 and will be implemented between 2013 and 2018. The SSHP Program aims to contribute towards increased access to modern, affordable and reliable energy services, energy security and mitigation of negative externalities of the energy system (e.g. GHG emissions, local pollution) by establishing an enabling environment for small-scale hydro power investments and markets in the ECOWAS region. The program is a priority action under the regional SE4ALL Framework for West Africa and will seek synergies to the Strategic Program for West Africa of the Global Environment Facility.

The SSHP Program contributes to the objectives of the ECOWAS Renewable Energy Policy (EREP) to increase the share of renewable energy (excl. large hydro) in the overall electricity mix to around 10% in 2020 and 19% in 2030. These targets translate to the installation of additional 2.425 MW renewable electricity capacity by 2020 and 7.606 MW by 2030. It is estimated that SSHP could contribute with 787 MW (33%) by 2020 and 2449 MW (32%) by 2030 to this additional capacity. The SSHP program also contributes to the objectives of the ECOWAS White Paper on Energy Access in Peri-Urban and Rural areas. It is expected that in 2030 around 25% of the rural population will be served either fully or partly through renewable energy powered mini-grids. The SSHP program complements the WAPP Master Plan which focuses mainly on the expansion of transmission lines and generation from large hydro power and natural gas.

The ECOWAS SSHP Program aims at four major outcomes:

a) Policy and regulatory SSHP frameworks are strengthened.
b) Capacities of different SSHP market enablers are strengthened and applied.
c) Knowledge management and awareness raising on SSHP is strengthened.
d) SSHP investments and businesses are promoted.

The program will generate the following key results by 2018:

a) By 2018, at least 35 projects (new projects or rehabilitations) in different ranges of capacity up to 30 MW are developed to feasibility stage and at least 5 are brought to financial closure. The projects will be identified through annual calls of the ECOWAS Renewable Energy Facility.
b) At least 5 SSHP projects (< 100 kW) are operating and - during their planning and implementation - have served as demonstration projects for capacity building.
c) At least 2 refurbishment/rehabilitation projects (< 200 kW) are identified and realised.
d) At least 10 companies provide various SSHP related services (planning, operation, repair etc.).
e) Bottlenecks of SSHP project implementation and operation, of current policies and legal frameworks and roles and shortcomings of relevant stakeholders are understood and recommendations for improvement are elaborated and discussed.
f) ECOWAS countries obviously improved their legal framework (poverty reduction impact of SSHP in evidence in the legal framework, feed-in tariff defined, transparent licensing procedure etc.) and SSHP has become integral part of ECOWAS/WAPP planning documents.

g) A capacity development strategy is elaborated and SSHP initiatives and projects increasingly rely on local expertise from public and private sector (with limited international support).
h) Quality guidelines are introduced during trainings and are generally applied for development and implementation of SSHP projects.
i) Facilitate open knowledge sharing on SSHP aspects through the ECOWAS Observatory for Renewable Energy and Energy Efficiency (ECOWREX) and tools provided and contents are utilised.
j) An information base on relevant SSHP resources and sites is created and helps to facilitate the development and implementation of SHP programmes and projects.
k) A communication strategy disseminating achieved progress and awareness raising about SSHP opportunities is developed and implemented.
l) ECREEE is established as centre of excellence in the SSHP sector.

The SSHP Program will be managed by the ECREEE Secretariat in close partnership with the United Nations Industrial Development Organization (UNIDO). UNIDO will create synergies to the SSHP mini-grid projects of the GEF Strategic Program for West Africa (SPWA). Other partners are invited to join. The partners will be responsible for the administration of the program (e.g. project cycle management, appraisal and quality assurance of supported projects, financial accountability). The program management team, consisting of an international program manager, local technical SSHP experts and administrative assistants, will implement the activities according to the project document and annual work plans. To stimulate the market, most of the activities will be executed by private implementers contracted through competitive tenders or calls for proposals.

FIGURE 1

OUTCOMES AND OUTPUTS OF THE ECOWAS SSHP PROGRAM

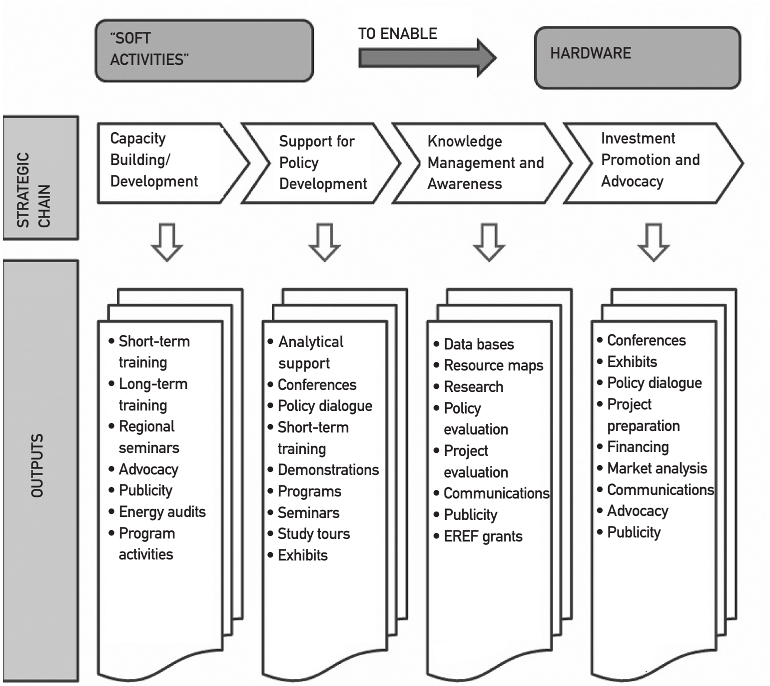
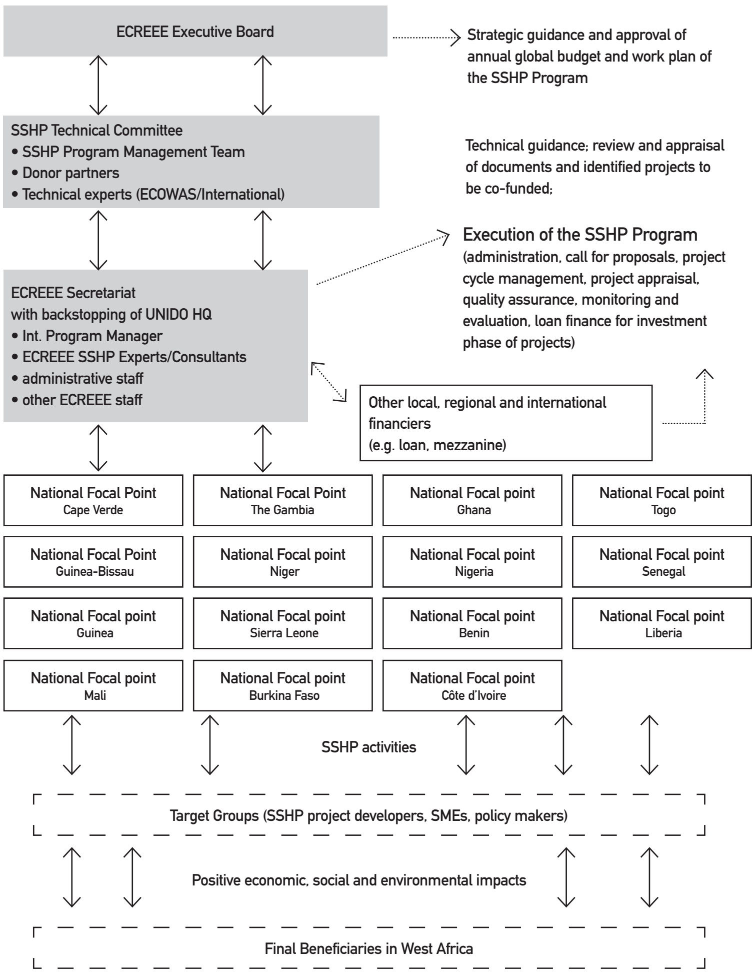


FIGURE 2

IMPLEMENTATION STRUCTURE OF THE SSHP PROGRAM



The SSHP Program is governed by the ECREEE Executive Board (EB) and a special Technical Committee (TC) comprising local and international SSHP experts. The bodies will review and approve the annual work plans, budgets, progress and financial reports of the program. Moreover, strategic steering and technical assistance for supported projects will be provided. The SSHP program will benefit fully from the established ECREEE network of National Focal Institutions (NFIs) in all ECOWAS countries and the UNIDO International Centre on Small Hydropower (IC-SHP), based in Abuja, Nigeria. The budget requirement to implement the envisaged first phase of the ECOWAS SSHP Program amounts to around 15,5 million Euro for the period 2013 to 2018.

AUTHORS

Mahama Kappiah. Executive Director at ECREEE.

Martin Lugmayr. Renewable Energy Expert at ECREEE/UNIDO.

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SANTO ANTÃO WIND PROJECT - FIRST IPP IN CAPE VERDE

DANIEL GRAÇA
ELECTRIC

ABSTRACT

The Santo Antão wind farm is the first experience of an IPP generated from renewable energies in Cape Verde, operating since April 2011. The wind farm is connected to an isolated electrical grid, creating specific problems of exploitation. The operational performance during the first 12 months was satisfactory, but could be improved. The financial performance was also good for the country, the promoter and the public utility.

1. DESIGN AND ASSEMBLY OF THE PROJECT

Since Cape Verde is a country composed of nine inhabited islands, the fundamental strategy of the promoter of the project was to implement smaller scale electrical grids that, until now, have not attracted interest from major international investors. The island of Santo Antão, which has a population of around 26,000 inhabitants, was chosen. However, in the future, this project is expected to be replicated on other islands with a similar population size. The aim of this project is to create and consolidate the technical capacity to design, implement and operate small and medium size wind farms on the national level.

The Santo Antão Wind Park project was co-financed by the Government of the Kingdom of the Netherlands within the framework of the PSOM/PSI programme. Its objective is to promote partnerships between Dutch businesses and entrepreneurs of developing countries. A joint venture company was established under Cape Verdean law between a Cape Verdean and a Dutch company for the implementation and exploitation of the ELECTRIC WIND, SA project, which was granted a license for the establishment of IPPs. Before coming into operation, a sale and purchase agreement of the electricity produced by the wind farm was signed with the national public electricity utility, setting prices below the current national rate. The wind farm does not qualify for subsidized prices, but it is exempt from income tax for a period of 3 years.

The wind farm is connected to an isolated network Santo Antão, powered by a diesel plant containing 4 small diesel generators, with an installed power of 3,800 kW. The peak registered in the power plant in 2010 (before the wind farm began to operate) was 1,700 kW. The electrical grid serves a population of about 26,000, with a total of 6,680 customers. There is another isolated network on Santo Antão, serving 3,963 customers.

The wind farm will be constructed in two phases: in this first phase 2 MICON M530-250/50 wind generators, of 250 kW each (called WT1 and WT2 in this article), were installed, plus 1 MT switching station with bi-directional energy metering and a 6.3 km section of medium voltage network. In the second stage, when the two isolated networks of the island are interconnected, 2 more 250 kW units will be installed.

2. PRODUCTION OF THE WIND FARM

The wind farm completed 12 months of operation in March 2012 and the production is illustrated in Table 1. The values are satisfactory, since it is the first year of operation.

TABLE 1
PRODUCTION AND AVAILABILITY OF THE WIND FARM

	PRODUCTION (kWh)	OPERATION (HOURS)	AVERAGE PER HOUR (kWh)	LOAD FACTOR	WIND TURBINE AND GRID AVAILABILITY
WT1	526.270	5.500	96	38% (2,105 Hours)	63%
WT2	738,740	6,812	108	43% (2,955 Hours)	78%

WT2 is not far from the expected production (850,000 kWh or 3,400 hours), but WT1 is much more distant. Several reasons have contributed to the difference in production, including stoppages caused by anomalies, as well as planned stoppages.

It was observed that even in periods of normal operation the instantaneous production of WT2 is almost always higher than WT1, probably due to better wind conditions. The production is expected to improve significantly in the second year of operations.

The technical availability seems low (about 63% for WT1 and 78% for WT2) but, as seen below, a great part of the unavailability is related with the network or the power plant. The load factor of the units is good, illustrating the potential wind of the location.

FIGURE 1
MONTHLY WIND PRODUCTION

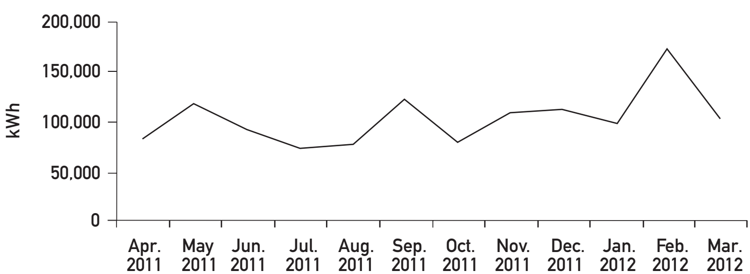
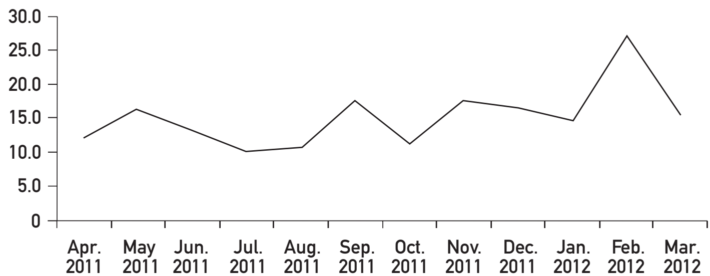


Figure 1 shows the variation in monthly production, which usually accompanies the variation of wind intensity throughout the year. In Cape Verde, there is a period of lower intensity of wind, which lasts from July to October, and a period of higher intensity of wind, from November to June. By registering an unavailability of the wind farm of about 30%, the evolution curve of the monthly production doesn't clearly explain these two distinct periods.

The contribution of wind generation to the overall production of the electrical grid to which it is connected was 15%. The months of July, August and October have a lower wind penetration (10% - 11%), while in the month of February 2012 it reaches 27% (fig. 2).

FIGURE 2
WIND PENETRATION



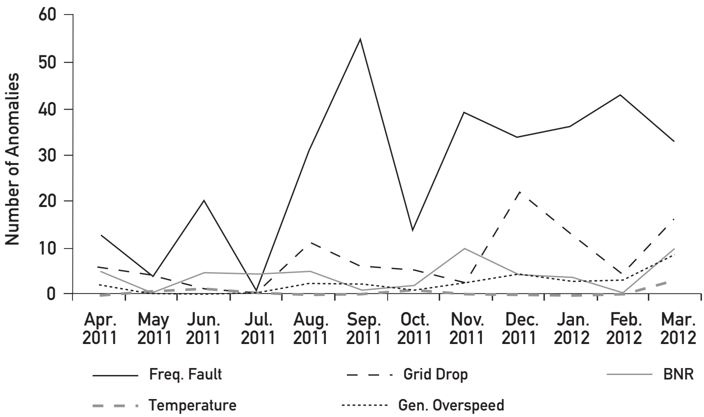
3. MALFUNCTIONS OF THE WIND TURBINES

There were 306 anomalies in unit WT1 and 211 in WT2, an average of 0.71 errors per day/unit, which seems to be very high.

The "frequency fault" malfunction was the most common (62%) and was almost always associated with strong wind intensity. The low load in the power plant from midnight to 6 AM, in conjunction with the deficient self-regulatory capacity of the frequency parameter in some of the power plant's generators, caused this type of occurrence. In fact, this is the main problem of a wind farm connected to a small electrical grid.

The "grid drop" malfunction was the second most frequent anomaly (17%) and is caused by problems in the public network, which we have no control over. It is important to emphasize that each problem in the network causes 2 simultaneous anomalies (one in WT1 and another in WT2).

FIGURE 3
MALFUNCTIONS IN THE WIND FARM



Other registered anomalies, related only to the performance of wind generators (21%), were: (i) "break not released" mainly in unit WT1, which can be related to salt deposition inside the nacelle, creating additional mechanical resistance when restarting the rotation of the blades, in situations of low wind intensity; (ii) high temperature, only in WT1, but that was overcome by setting the temperature trigger at a higher value; (iii) overspeed, which occurs in periods of high wind intensity.

4. IMPACT OF THE WIND FARM IN THE OPERATION OF THE RIBEIRA GRANDE POWER PLANT

There is always the fear that a wind farm can have a negative impact on the operation of a small power plant, particularly by increasing fuel consumption and the production of reactive energy, as well as increasing disturbances to the proper operation of the electrical grid, such as blackouts or fluctuations in frequency and voltage.

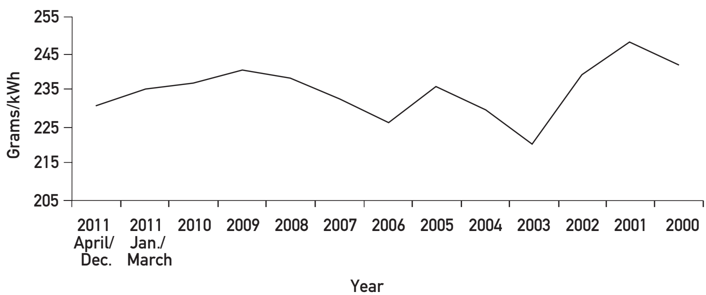
However, the Santo Antão wind farm was integrated into the electrical grid quite satisfactorily, without deteriorating the performance of the power plant.

4.1. FUEL CONSUMPTION

Figure 4 shows the evolution of the average consumption of fuel per year over the last 11 years. It verifies that the power plant's consumption from April 2011 - December 2011 was the lowest it had been in the past 5 years and the third best over the past 12 years.

FIGURE 4

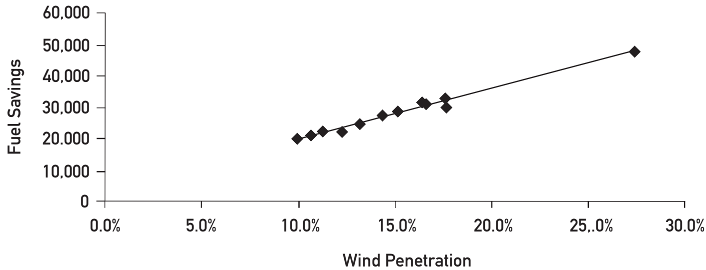
FUEL CONSUMPTION OF THE RIBEIRA GRANDE POWER PLANT



Even limiting our analysis only to 2011, it is clear that the average specific consumption from January to March, before the wind farm began operations, is higher than after starting the wind farm. Since no maintenance was carried out that could have improved the performance of the power plant generators, it can be concluded that the operation of the wind farm allowed the plant's generators to operate more efficiently.

On the other hand, Figure 5 shows that fuel savings are directly proportional to the wind contribution. Therefore, there seems to be no deterioration of specific consumption, regardless of the operating regime of the diesel generators in the power plant.

FIGURE 5



4.2. BLACKOUTS

There were 15 blackouts during the period under review, which is not very different from the number in 2010, which was 14, as shown in Table 2.

Therefore, it can be concluded that the operation of the wind farm had no negative impact to the number of blackouts.

TABLE 2
NUMBER OF BLACKOUTS

APRIL 2011 / MARCH 2012	2010	2009	2008
15	14	14	9

4.3. REACTIVE POWER AND POWER FACTOR

There was also significant variation in the power factor. Even if a lower trend of the power factor value is registered in the power plant, this does not mean there is an increased production of reactive power. It may be the result of a smaller supply of active energy by the power plant, since it is partially supplied by the wind farm. On the other hand, Cape Verdean legislation establishes that the power factor *per* wind generator must not be less than 0.85. The total value registered for the two wind turbines was 0.91.

4.4. ELECTRICAL LOSSES IN THE NETWORK

Losses (technical and non-technical) did not increase compared to previous years. It can even be considered that the wind farm has a positive impact in this sense, since it injects energy from one of the extremes of the network (Table 3).

TABLE 3
LOSSES IN THE ELECTRICAL NETWORK

YEAR	2008	2009	2010	2011
Losses	29.1%	23.7%	23.1%	22.9%

4.5. FREQUENCY AND VOLTAGE

The stability of the frequency and voltage only fluctuated slightly in the measuring devices in the power plant, in moments of turbulent wind. It was also observed that there are generators in the plant that allow a better self-regulation of these parameters. Therefore, situations of possible instability are more closely related to the performance of the generators operating in the power plant. However, the frequency and voltage of the electrical network are electrical quantities that must be monitored through network analysers, in order to be able to properly assess the impact of the wind farm at that level.

5. FINANCIAL AND ENVIRONMENTAL IMPACT OF THE SANTO ANTÃO WIND FARM

The financial and environmental balance of the first twelve months of operation of the wind farm shows positive gains at all levels, as shown in Table 4:

1. The Electric Wind company closed its 2011 operating accounts with a positive result.
2. Electra, SA (the public utility) avoided costs, since the price of fuel was higher than the purchase price of kWh of wind power.

3. the country avoided the costs in foreign currency of importing fuel.
4. the environmental benefits were avoiding carbon emissions.

TABLE 4
FINANCIAL AND ENVIRONMENTAL IMPACT IN 2011

PRODUCTION (kWh)	FUEL SAVING (LITRE)	CURRENCY SAVINGS FOR THE COUNTRY (EURO)	FINANCIAL SAVINGS FOR ELECTRA (EURO)	GAS EMISSION SAVINGS (TON)
1,265,010	340,000	335,000	186,000	960

This financial and environmental impact is significant, since it is a small park connected to a grid which serves 26,000 inhabitants. In the near future, when more wind farms are installed the impact will be much higher.

6. CONCLUSION

This project, which is the result of a joint venture between two private companies, co-financed by the Dutch Government, shows that the private sector may play an important role in the national effort to achieve a significant production of electricity from renewable sources. The first twelve months show that on a technical level the operation of the wind farm does not disturb the normal operation of a small power plant, provided that the project is properly scaled. The wind contribution in the production of electricity was 15%, but it can increase by improving the performance of the grid.

At a financial level, it is of particular importance that even without price subsidies the wind park can produce positive results for the promoters, the national utility and the country, while also having a positive impact on the environment.

AUTHOR

Daniel Graça. Manager of ELECTRIC.

THE CABEÓLICA PROJECT

ANA MONTEIRO
CABEÓLICA

ABSTRACT

Despite past renewable energy generation, Cape Verde's energy matrix has up until now been dominated by fossil fuel resources. The aim to significantly increase wind energy penetration, coupled with ideal conditions, led to the creation of the Cabeólica Project - the first commercial-scale, Public-Private-Partnership wind farm project in sub-Saharan Africa. Throughout the initial months of 2012, the project has contributed with 20%-40% monthly wind energy penetration rates in the four islands where the wind farms are implemented. The installed capacity of wind energy in comparison with total electricity capacity has placed Cape Verde as one of the countries with the highest wind energy penetration rates in the world.

Keywords: Wind energy; energy generation; Public-Private-Partnership.

1. INTRODUCTION

Cape Verde is made up of ten islands off the West coast of Africa, with a population of roughly 500,000 people and a GDP of 1.5 billion USD [1]. The country has no significant natural resources and is dependent on the outside world for most things, including energy. Throughout its existence, Cape Verde has imported its entire stock of oil products to generate almost all of its electricity requirements. This has had an immense impact on the country's fragile economy. Electricity shortages have become chronic in the last decade as demand has outstripped supply and the utility company's economic situation has not provided for appropriate investment and maintenance of generators and power grids, resulting in frequent blackouts, especially in the capital city during summer months, when the country experiences a peak in electricity demand. This situation is further compounded by the fact that Cape Verde produces roughly 92% of its potable water from the highly energy-intensive desalination of sea water [2].

In the past the power generating system has been dominated almost exclusively by foreign, non-renewable resources. This is a paradox in the country given that Cape Verde is situated in the trade wind corridor of the Atlantic Ocean and enjoys constant, mono-directional wind speeds of roughly 10 m/s for much of the year [3]. The characteristics of the wind regime found in Cape Verde translate into some of the best conditions for wind energy generation in the world.

Although some limited amount of wind and solar energy generation had previously been introduced in Cape Verde, there was a need for a project that would contribute more significantly to the country's projection into an ambitious adventure to redefine its energy matrix so as to assure a significant amount of energy produced from a cost effective renewable source.

The aspirations of the Cape Verdean Government to increase wind energy penetration, coupled with the need for foreign investment and technical and business know-how, resulted in a dynamic Public-Private-Partnership (PPP) which was established in 2008. The PPP had as its main objective the creation of a local company to develop, finance, construct, own and operate four wind farms with a total installed capacity of 25.5 MW, distributed among four islands strategically chosen as a function of their energy demand: Santiago (9.35MW), where half of the country's population resides and where most of the industrial and administrative base is located; S. Vicente (5.95MW), where the second largest population is found; Sal (7.65MW) and Boa Vista (2.55MW), the two islands that have experienced the most significant increase in tourist traffic in the country.

2. THE PPP

After many years, and several unsuccessful bidding processes in an attempt to increase wind energy penetration by roughly 4.8 MW, the Government of Cape Verde partnered with InfraCo Limited (a privately managed donor-funded infrastructure development company) for the development and promotion of the project. This was followed by detailed studies, including a demand study and grid stability study, both of which led to the conclusion that it would be possible to increase wind energy penetration by a large amount. InfraCo recommended the Government of Cape Verde on a project to increase the wind power capacity by additionally installing roughly 28 MW because it was, feasible, viable and would be more attractive to investors.

The Cabeólica PPP, the first in Cape Verde and the first of commercial scale in the wind energy sector in Sub-Saharan Africa, was initially established between InfraCo, the Government of Cape Verde (through the Ministry of Tourism, Industry and Energy) and Electra, S.A.R.L. (the local utility company). The partnership later came to include Africa Finance Corporation (a Pan-African development finance institution based in Nigeria) and Finnish Fund for Industrial Cooperation (a Finnish development institution). The PPP was a key factor in attracting investment for the project, which is based on a 30%-70% equity-debt ratio project finance scheme, in which 20 million EUR was secured by the private investors and 45 million EUR was provided through loans from the European Investment Bank and the African Development Bank.

TABLE 1

CABEÓLICA INVESTMENT PROJECT FINANCE SCHEME

TYPE	RATIO	ENTITIES	AMOUNT
Equity	30%	Private Investors	€ 20 million (approx.)
		AFC	
		Finnfund	
		InfraCo	
Loan	70%	Development Banks	€ 45 million (approx.)
		EIB	
		AfDB	
Total		€	€ 65 million (approx.)

The PPP, among other benefits, ensured participation of solid, high-profile public and private partners as well as facilitated the constitution of a long-term off-take agreement with the utility company, thus enabling predictable and transparent cash flow projections.

In order to guarantee the highest possible standards during project development, a vast array of top-level experts in different specialties were engaged, including RISØ, world leaders in wind analysis and wind energy research, and Sinclair Knight Merz, a leader in project consulting and engineering. The construction of the four wind farms was conducted through a Turn-Key Engineering

Procurement Construction (EPC) contract secured with Vestas, the global leader in wind turbine manufacturing. The EPC called for the construction of the four wind farms including the erection and installation of all 30 Vestas V52-850kW wind turbines procured; the construction and installation of roughly 30 km of transmission lines to connect each wind farm to the respective island's electricity grid; the construction of a total of roughly 15 km of external and internal access roads; and a control station building at each wind farm. To ensure appropriate maintenance and availability of the turbines, a Service Agreement was signed with Vestas for 5 years.

3. CHALLENGES

The development phase lasted five years, the time necessary to finalize all of the preliminary studies, agreements, land concessions, permit and licensing issues and other contractual and legal documentation necessary for a project of this scale.

The implementation of the project was extremely challenging due to major technical hurdles encountered during the development and construction phases. Many of these challenges were related to the fact that the country features small and isolated power grids, as is common in island nations. For this reason, a dynamic power analysis of four completely different power grids, each with its own complex issues, had to be conducted to assess the limitations and evaluate wind energy integration. Another major challenge was the transportation of 30 turbines and their distribution to four different islands with a number of port limitations. The logistical arrangements for the successful delivery of the equipment underwent an exhaustive and detailed analysis. Yet another challenge was the lack of a specialized workforce and equipment necessary for the construction and assembling of 55-meter-high turbines, as well as lack of quality certified materials and resources. As a result, the majority of the equipment, special vehicles, materials and specialized manpower had to be imported.

As could be anticipated, the initial operation phase which is still under way, has also presented many challenges. As the country has experienced a sudden transition from almost 100% diesel to a diesel-wind grid connected system, a number of challenges have arisen related to grid stability, dispatching of power generated by different sources and resource personnel. As a result, there has been a combined effort involving Cabeólica, Electra and Vestas to overcome these difficulties through the implementation of certain technical and operational measures and the training of wind farm and grid operators.

4. CURRENT ACHIEVEMENTS AND PRODUCTION EXPECTATIONS

The project was engineered so as to benefit roughly 80% of the population. The electricity system on all four islands is a single-buyer system, which constitutes a clear framework for ensuring the off-take volumes and pricing. The utility company utilizes Cabeólica's remote SCADA system to access the wind farms and control wind energy production to be sent to the distribution centers according to necessities and limitations.

In September 2011 the first wind farm (Santiago) began operation, and throughout the remainder of the year, while still in the commissioning phase contributed with a monthly average penetration of roughly 20%. The São Vicente wind farm began operation in October of the same year and contributed with a monthly average penetration under commissioning of roughly 25%. The Sal wind farm followed closely behind in November with a monthly average

penetration of roughly 21%. During the early months of 2012 until present, representing the initial commercial production period, the four wind farms contributed between 20%-40% of monthly wind energy penetration rates, with percentages varying from island to island, as per the table below. In May and June, on the island of São Vicente, the daily wind energy penetration rate frequently exceeded 50%. In other words, during such days more than half of total electricity demand was covered by wind energy.

TABLE 2

PERCENTAGE PENETRATION DURING INITIAL COMMERCIAL PRODUCTION PERIOD (2012 ESTIMATES) [4]

ISLAND	INSTALLED CAPACITY	AVERAGE MONTHLY PENETRATION
Santiago	9.35 MW	20-25%
S. Vicente	5.95 MW	35-40%
Sal	7.65 MW	30-35%
Boa Vista	2.55 MW	25%
Total	25.5 MW	20-40%

Cabeólica's ambitious target for the near future is to maximize wind energy penetration rates in order to reach 30%-50% on all four islands. Achievements within this targeted range will require further technical improvements on communication and control systems, seamless cooperation with the grid operators and high reliability of the turbines. Dispatching and spinning reserve optimization will be developed further and possibly also demand side management and electricity storage systems would be introduced. The penetration level achieved will also depend on various economic and population-related factors on the different islands, as well as on month-by-month consumption and climatic conditions.

Meanwhile, Cape Verde currently boasts one of the highest wind energy penetration rates in the world. The country has been ranked third worldwide for total installed wind power per GDP, and as the country with the highest installed wind power per total installed electricity capacity at the end of 2011. In terms of total cumulative installed wind energy in comparison to total installed electricity capacity, Cape Verde has surpassed many countries known to be leaders in wind energy installation, such as Germany, Portugal, Spain and Denmark [5].

5. CONCLUSION

The Cabeólica project has contributed significantly to the energy generating capacity of Cape Verde, which is experiencing a rapid increase in electricity demand, and has reduced pressure on the public sector, which had previously been solely responsible for financing the energy growth of the country. The project has aided the Cape Verdean Government in assuring that local power generation is 25% renewable [6].

The production of energy by the wind farms is projected to reduce tons of oil imports, which in turn translate to a significant reduction in fuel import costs that can be rechanneled by the government to more pressing social and economic needs.

Furthermore, the electricity supplied by Cabeólica is roughly 25% less expensive than other available options in the country.

The project has also aided the country in its compliance with international environmental commitments and sustainable development goals. The project's production of energy is expected to displace an average of more than 60,000 tons of CO_2 equivalent gas emissions every year [7].

The Cabeólica Project was awarded the 2011 Best Renewable Energy Project in Africa at the Africa Energy Awards in Johannesburg, having been distinguished for representing the first initiative of its kind in the region. It is currently being studied by other countries in Africa and other parts of the world for replication.

These positive factors, coupled with the continuous acquisition of know-how, place the company in a good strategic position to support the Government of Cape Verde in its target of generating 50% of total electricity demand with renewable energy by 2020 [8].

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AUTHOR

Ana Monteiro. Head of the Environmental, Social and Administrative Department at Cabeólica, S.A.

www.cabeolica.com

SAINT-LOUIS REGION WIND FARM

MOUHAMADOU LAMINE NDIAYE
C3E

ABSTRACT

The Saint-Louis wind farm project is located in the north-western part of Senegal, in the Saint-Louis region. This part of the country has considerable wind resources, with average recorded speeds above 6 m/s. The installed capacity of the wind farm will be 50 MW, and the electricity generated will mainly be supplied by Senegal's National Electricity Company (SENELEC - *Société Nationale d'Électricité du Sénégal*). Wind turbines with a power range between 850 kW and 1 MW will generate up to 94.5 GWh of electricity per year. The project is spread over two sites, with installed capacities of 15 MW at Gantour and 35 MW at Mboye. The project was developed by the *Compagnie Eau Energie Environnement* (C3E), with technical assistance provided by CEGELEC TOULOUSE, and financial assistance from the Saint-Louis region, the Midi-Pyrénées region and the *Agence Française de Dévelopmment* (AFD - French Development Agency). A national steering committee which includes all the players in the sector, and co-chaired by the Senegal Ministry of Energy and the Saint-Louis region, has approved all development work, from the choice of the site through to the calculation of

expected production. The project is one of three new renewable energy projects selected by the Senegalese government as part of their policy to develop the energy sector. The project has been presented to potential investors and/or backers, such as PROPARCO, FMO, KFW, etc., which all showed strong interest in providing financial support. The project is presently at the end of the development phase and is waiting for investors.

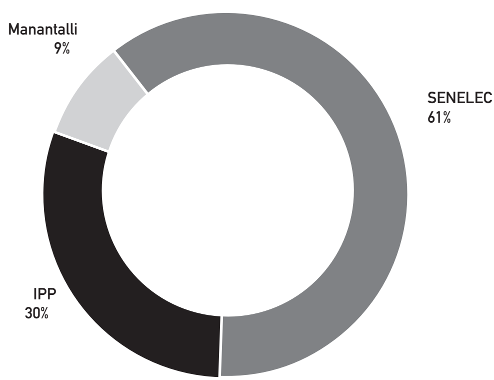
Keywords: Renewable energy, wind energy.

1. SITUATION OF THE ELECTRICITY SECTOR IN SENEGAL

1.1. GENERATION

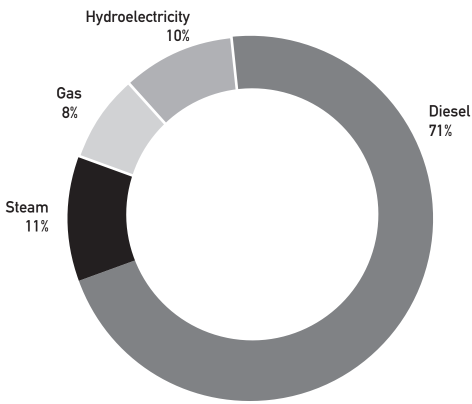
The total installed capacity of generating facilities in Senegal is over 670 MW, taking into account the "takkal" plan (renting generators to compensate for shortages, as part of the restructuring and stimulation plan for the energy sector), implemented in 2011. At present,

FIGURE 1
DISTRIBUTION OF PRODUCTION BY THE ORIGINAL



SENELEC generates 60% of this, while private companies (Independent Power Producers - IPP) generate 30%, with the remaining amount generated by the Manantali dam, a sub-regional collaboration between Mali, Mauritania and Senegal. 80% of this electricity generation is interconnected, 90% is from thermal energy sources, and just 10% is from hydroelectric sources. The "tyranny of oil" in Senegal's energy sector is therefore plain to see. Electricity generation from clean energy sources is very low, and only occurs in a few isolated sites.

FIGURE 2
DISTRIBUTION OF THE PRODUCTION OF ENERGY BY THE DEAF



1.2. TRANSMISSION

The function of the power transmission network is to transfer high-voltage electricity (90 and 225 kV) from the plants where it is generated to points of consumption. In Senegal, the transmission network comprises a national and supranational network.

The national network comprises 327.5 km of 90 kV lines and eight 90/30 transformer substations, with a total installed capacity of 1,127 MVA. The supranational network includes the 945 km of the 225 kV line linking Manantali, Matam, Dagana, Sakal and Tobene. It supplies the 225/90 kV Tobene substation (2x75 MVA) and the 225/30 kV substations.

1.3. THE DISTRIBUTION NETWORK

Distribution networks supplied by HV/MV and MV/MV substations distribute electricity to other users: individuals, government, industry and commerce. Transmission from generating plants to points of consumption is a complex process, due to the impossibility of storing electricity, and the need to cover variable demand at all times. At the heart of this process is the Hann dispatching centre, a real electricity routing centre which ensures the balance between generation and consumption is maintained 24/7. The Dispatching centre is assisted by the *Bureau Central de Conduite* (central routing office), which constantly monitors the Dakar HV network.

- Considering the above, the energy situation (and electricity in particular) in Senegal is characterised by:
- a preponderance of thermal power plants, in particular a considerable number of diesel-fuelled plants, leading to poor control over kWh generation costs;
- demand which is far higher than supply, leading to frequent shortages;
- a lack of renewable energy, even though Senegal has good wind and solar resources, to name but two sources.

Developing renewable energy has become essential to mitigate or reduce the dependence on fossil fuels, of which global stocks are continuously diminishing. Through its policy to promote renewable energy, Senegal has decided that 15% of the energy consumed in the country will be from clean sources by 2025. The Saint-Louis wind farm should be considered in light of this context.

2. THE WIND FARM PROJECT APPROACH

This document was drafted to sum up all the measures taken to enable the implementation of the wind farm in the Saint-Louis region. The following sections will provide an overview of the project, rather than lay out all the details of the work carried out. We will focus more on the constraints that delayed construction and the prospects for the implementation of this vitally important project for Senegal in general and Saint-Louis in particular. In this document, we will provide two major pieces of technical information; average recorded wind speed and the wind atlas, along with micro-sitting information for the project, which we carried out to attract potential investors.

2.1. PROJECT PURPOSE

The promotion of natural resources local to the Saint-Louis region has been part of the regional integrated development plan for a long time. Many measures have been implemented to this end, and this wind farm project is part of this wider context. The aim is to set up, within a well-marked-out area, facilities which will generate electricity from the kinetic energy of wind, for distribution on the SENELEC national grid. The facilities will therefore enable electricity to be generated from a clean, renewable and local energy source – wind – for around 22 years.

2.2. GOALS

The project plans to set up a 50 MW capacity wind farm along the western border of the region, consisting mainly of 50 to 59 turbines, with a rated power of between 850 kW and 1 MW. Other equipment and infrastructure will be set up alongside these machines: an access track, transformation substations, transmission lines to transfer the generated power to the SAKAL substation, etc. In terms of the technology, the project will feature horizontal-axis wind turbines, with a nacelle height of between 55 and 70 metres and a rotor diameter of between 55 and 62 m. According to the RETScreen renewable energy project analysis tool, the expected annual electricity generation will reach around 94,500 MWh, thereby avoiding the emission of 71,482 tonnes of CO_2.

2.3. STAKEHOLDERS

2.3.1. The development company

The project has been developed by C3E in close collaboration with CEGELEC Toulouse, which provided an expert to work on the project for over a year, as well as taking charge of quality assurance from their offices based in Toulouse, France. Other French companies (EQUITAO, ENERGIE DU VENT) specialising in specific areas directly related to the project have also been involved.

2.3.2. At the local and regional level

The Saint-Louis region, represented by the Regional Council and the rural communities of Gandon and Fass Ngom, are the local partners in the project. The region has and continues to deploy considerable lobbying efforts to promote the project, both at the national and international level, while the rural communities approved the allocation of land to the project (a land use agreement grants exclusive remit for the development of the project in the area for 25 years).

2.3.3. At the national level

Work has been carried out under the supervision of a steering committee, which validated all the milestones passed by the project during meetings organised in Dakar and Saint-Louis. This steering committee is made up of a number of players in the sector: the Senegalese Ministry of Energy, the Saint-Louis Regional Council and Regional Development Agency, the Senegalese Ministry of the Environment, SENELEC, the CRSE (*Commission de Régulation du Secteur de l'Energie* – Senegalese energy sector regulatory commission), the SPIDS (*Syndicat des Professionnels de l'Industrie et des Mines du Sénégal* – the Senegalese mining and industry professionals trade union), SOCAS, etc.

2.3.4. At international level

The project has received funding from the Midi Pyrénées region in France and the AFD, for a total sum of 130,000 euros. The project has been presented to a number of potential investors and/or backers, such as PROPARCO, FMO, KFW, etc., whom have shown strong interest in providing financial support.

The project has grown from a private and local initiative to a national project with support from abroad. As a result, the Saint-Louis wind farm project forms part of Senegal's Energy Sector Development Plan.

2.4. PROJECT COSTS AND PROFITABILITY

Estimated at 1,600 euros per installed kW, it is thought that the Saint-Louis region wind farm will cost 80 million euros, or just over 50 billion CFA francs. The RETScreen software has calculated the facility's internal rate of return to be around 29% before tax, with an eight-year (8) payback period.

The cost per kWh is 53 CFA francs (0.081 euros), and could be sold on to SENELEC at around 80 CFA francs (0.122 euros).

2.5. BENEFITS FOR THE REGION

The wind farm will provide considerable direct and/or indirect benefits to the Saint-Louis region. Financially it will generate more than 60 million CFA francs (91,600 euros) per year for the region, calculated on the basis of 1,250 CFA francs/kW, which the region will receive each year from the promoter as payment for land rental. This financial support will be used to fund local development projects. A rural electricity line could also be installed, so part of the power generated could be consumed locally. The installation of the wind farm will lead to the construction of road infrastructures which will contribute to opening up of the region. In addition to the creation of jobs during the construction phase, one or more shops could be built around the wind farm, enabling potential visitors to leave with a few souvenirs.

As a reminder, technical studies have focused on the following aspects:

- Wind studies:
  - Wind energy atlas (Image 1 and 2). The wind atlas has shown that the further one moves away from the western border (Atlantic Ocean side), the more wind speeds drop.
  - Selection of two sites.
  - Measurements over twelve months (Table 1).
  - Micro-sitting and calculation of expected production (Image 3 and 4).
- Geotechnical study:
  - Probes.
  - Pre-design for the foundations.
- Environmental risks:
  - Ornithological study.
  - Assessment of risks related to ground composition.
- Other work carried out.

IMAGE 1. AVERAGE WIND SPEED ATLAS (AT 40 m ABOVE THE GROUND).

Alongside these studies, C3E and SENELEC studied how to transfer the power generated into the electricity grid, and the electrical design of the project. All this information can be found in a document entitled "*convention de raccordement électrique*" (electrical connection agreement). An energy purchasing contract has also been drafted with SENELEC, and negotiations on the price per kWh have started. The analysis of the environmental impact of the project has also been conducted, as well as a project information memo with a view to its eligibility for the MDP (*Méchanisme pour le Développement Propre* – Senegalese clean development initiative).

All documentation pertaining to the studies above is available.

IMAGE 2. WIND POWER DENSITY ATLAS (AT 40 m ABOVE THE GROUND).

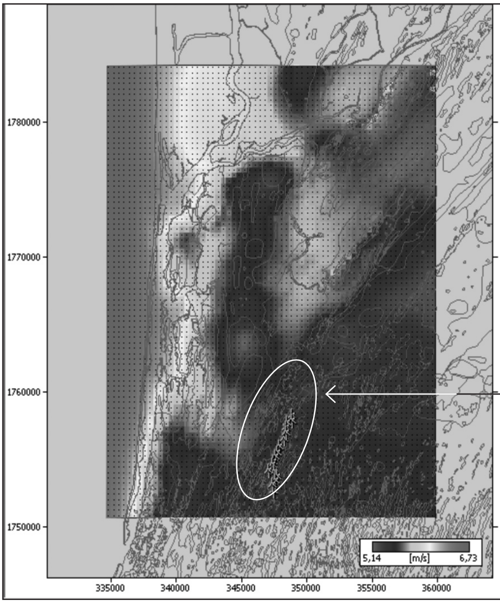


IMAGE 3. MAIN SITE.

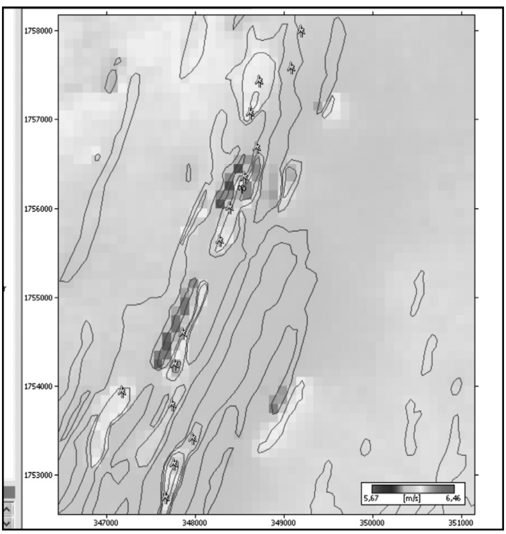


IMAGE 4. MICRO-SITTING DETAILS.

TABLE 1

AVERAGE SPEEDS MEASURED (m/s) AT 40 m ABOVE THE GROUND AT GANTOUR AND MBOYE, AND 39 m ABOVE THE GROUND AT GANDON

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Gandon 2004/2005	5.7	5.6	5.8	5.4	5.1	5	4.8	4.3	4.7	5.4	5.1	5.9
Gandon 2007/2008	/	6.4	5.7	5.5	5.2	5	4.47	3.17	4.65	5.43	5.76	6.52
Gantour 2007/2008	7.06	7.06	6.25	6 .15	5.73	5.58	4.89	4.12	5.16	6.10	6.44	7.17
Mboye 2007/2008	/	/	/	6.3	5.9	5.6	4.89	4.08	5.22	6.28	6.57	7.34

These studies show that there are no technical barriers to the Saint-Louis region wind farm project. There were constraints in other areas until 2010. From that date onwards, the circumstances surrounding the project were much more favourable, as show in the following sections.

2.6. PROJECT CONSTRAINTS BETWEEN 2003 AND 2010

Project development took longer than expected between 2003 and 2010. This was due to a number of factors:

- Lack of a benchmark: the wind farm was the first of its kind to be studied in Senegal. This situation meant that following the first round of wind measurements it was not possible to correlate our measurements with existing data. A second round was needed to validate the information collected.
- A legal framework not adapted to the initial strategy, which was "self-generation through the grid" ("You invest where you want, we transport and you consume where you want" is the slogan used by ONE in Morocco). Indeed, Senegalese law 98 29 of 14 April 1998 on the electricity sector prohibits self-generation outside the area where it will be consumed. Despite the formation of a group of Senegalese industrial companies which planned to invest in the project, transport

their own power through SENELEC lines and consume it in their production facilities in Dakar or elsewhere, the 1998 law did not allow this. Hence the return to the classic IPP format.

- Lack of regulatory framework to promote the inclusion of renewable energy in SENELEC's purchasing policy: SENELEC, as the single buyer, was not obligated to introduce a percentage of clean power into the power distributed in Senegal.
- Lack of a clearly defined development policy defining the types of renewable energy to generate (solar, wind, or biomass), where to produce it, in what quantities, the price per kWh and the timeframe.
- Lack of incentivising / attractive framework for the development of major renewable energy projects.
- Single buyer: SENELEC, currently facing financial difficulties.

This set of constraints is related to the fact that this wind farm project is pioneering, and we had to fight hard to convince the Senegalese legislators to review their position. The results of this began to manifest from 2011 onwards, providing the wind farm with more attractive prospects.

3. PROSPECTS FROM 2011 ONWARDS: A NEW REGULATORY FRAMEWORK

Considerable institutional changes occurred from December 2010.

1. *The promulgation of the law on renewable energy:* Following in the footsteps of other countries throughout the world, for a number of years Senegal has committed to an ambitious and bold renewable energy development policy. This commitment by the government is influenced by the need to take into account political, socio-economic and environmental concerns in energy development strategies. From a political point of view, the

development of renewable energy aims to implement greater security of supply for energy, and a reduced dependency on imports of fossil fuels for electricity generation. From a socio-economic standpoint, a certain number of measures must be taken to encourage the private sector to invest in renewable energy. These measures focus on awarding permits for electricity generation, sales and remuneration conditions and giving priority to connecting the network and purchasing equipment for generation, operation, self-consumption and research and development. From an environmental standpoint, renewable energy will contribute to sustainable development by its very nature, since it does not emit greenhouse gases and preserves nature and the environment. That is why Senegal will consolidate its policies by enacting law n° 2010 – 21 of 20 December 2010, containing guidelines on renewable energy, as part of the implementation of a legal and regulatory framework.

2. *Adoption of application decrees:* Two application decrees were adopted in December 2011 to implement this law. They contained the following:
   a) 21/ Decree no. 211-213 implementing the guidelines for renewable energy, and pertaining to purchasing and remuneration conditions for electricity generated by plants using renewable energy sources, and their connection to the power grid. Amongst other points, the decree clearly specifies:
      - the conditions for setting prices per kWh;
      - the calculation of the rate of return;
      - the method for selecting future electricity generation companies: calls to tender;
      - the obligation imposed on SENELEC to enable connection to the grid: "art. 9: the grid operator must give priority to connecting renewable energy plants to its grid, to collect and remunerate all the power provided by these generating plants, if grid stability conditions are preserved";
      - the electricity purchase contract: art. 13 "The grid operator and the producer shall both sign an electricity purchase contract, which specifies the rights and obligations of each party".

b) 22/ Decree 2011-2014 implementing the guidelines for renewable energy, pertaining to conditions for the purchase and remuneration of surplus electrical energy from renewable sources generated through captive power generation.
   - Article 6 specifies that for the *purchase of surplus energy*, the grid operator shall purchase and transport the surplus of electricity from renewable energy sources generated by the facility of a self-generator in compliance with article 24 of law 98-29 of April 14, 1998, within the limits of the maximum power indicated, under the condition that the grid continues to function properly.

The new regulatory framework in force has removed all the constraints holding back the wind farm project, enabling it to move forwards within a much more favourable setting, which could herald the project becoming a reality in the near future.

AUTHOR

Dr Mouhamadou Lamine Ndiaye. Director, Water Energy Company Environnment (C3E SARL).

www.compagnie3e.com

MICROGRID IN SENEGAL THROUGH PV AND MACSEN-PV PROJECT

MÓNICA ALONSO LÓPEZ
ITER

ABSTRACT

Technological Institute of Renewable Energy (ITER) is a renewable energy research centre with 20 years experience. In the past few years ITER has installed more than 45 MW of photovoltaic power plants in the Island of Tenerife, manufacturing its own panels and inverters. In view of the importance of the Canary Islands as a nexus between Africa and Europe and the need for technical cooperation of Renewable Energy Systems (RES) in African countries, ITER has been carrying out several projects in different countries and most specifically in Senegal.

On the one hand, in the field of rural electrification the Pilot Project "Microgrid in Senegal through PV in the village of Fordou (Ranerou) in the North of Senegal", with which the ASER (Senegalese Agency for Rural Electrification) froms a collaboration.

On the other hand, ITER leads the MACSEN-PV project, for the promotion of the implementation of renewable energy systems (PV) for power supply in Tenerife and Senegal, with actions addressed to improve the capacity of local authorities and technicians. This project also participates the Tenerife Energy Agency (AIET) and, as Senegalese partners, ASER and CERER (Centre d'Etudes et de Recherches sur les Energies Renouvelables). One 3 kW pilot PV plant for grid connection is going to be built in CERER facilities (Dakar).

Keywords: Photovoltaic, microgrid, Senegal, technology transfer, capacity building, renewable energies, power supply.

1. INTRODUCTION

The energy situation in Senegal, as in most African countries, is characterized by a low percentage of rural electrification and the challenge of bringing conventional generation and energy transport infrastructures into some areas. In addition, most of these countries depend largely on energy from abroad; have a large penetration of diesel generators and electricity is very expensive.

Over the past few years, most of these countries have been working on the implementation of new policies that will provide the population with general access to electricity and the long term replacement of fossil fuels from renewable energy sources. Therefore, we are at a turning point for new policies and projects that have a direct bearing on the use of local renewable energy resources, ensuring the socioeconomic development of African countries, especially in rural areas, in a sustainable way, thereby contributing to solving the challenge of climate change.

In this context, the Canary Islands are positioned to serve as a link between Africa and Europe, playing an important role in terms of technology transfer and capacity-building. ITER, a technological reference in the field of renewable energies in the Canary Islands, is actively involved in various projects based on technical cooperation, especially in Senegal.

2. MICROGRID IN SENEGAL THROUGH PV - RANEROU PROJECT

The project was launched as a result of the keen interest shown by the Government of Senegal in developing renewable systems for rural electrification and it was communicated to the Cabildo de Tenerife (insular authority). The Cabildo entrusted ITER the design and implementation of a pilot project of these features within its cooperation programme "Tenerife with Senegal", considering its extensive experience in this field.

The beneficiary village was identified and the project´s main objetives were defined once the project was commissioned. The Government of Senegal recommended the village of Fourdou, in the region of Ranerou (located in the North-eastern part of Senegal), due to its isolation and its poor economic development. The main goal of the project was to ensure the access to a power supply based on photovoltaic solar energy, giving priority to the school and community uses.

ITER´s technicians carried out a technical visit to Fordou in November 2008 in order to present the project to the local community, to elicit their perspective regarding their main needs and to decide on site the most suitable design for the installation.

In the first design, the installation was targeted to educational uses, setting the photovoltaic system on the roof of the school. This design also included the assembly of a small wind turbine and a satellite communication system together with three computers for the school. Nevertheless, this initial proposal varied significantly after several meetings held with representatives of the Government

PICTURE 1. TECHNICAL VISIT TO FORDOU. NOVEMBER 2008.

of Senegal. On the one hand, the wind turbine was discarded since it would be more difficult to ensure its maintenance and it was decided that the installation would also provide energy to the health centre and the public lighting. On the other hand, the installation of the satellite communication system was useless due to the absence of mobile network operators in the area. Nonetheless, the region had GSM phone coverage, but only allowed a very low bandwidth data transmission. This fact caused the exclusion of the communication system and the computers that without the connectivity will not be very useful for the community. Furthermore, the Government of Senegal expressed the need for the construction of a new classroom in the school of Fordou because the existing ones were damaged. Therefore, the project included this new building work.

The definitive axes of the project were the implementation of a training plan for local technicians; the construction of a new classroom for the school; the installation of a photovoltaic system of 1,150 W and the electrical wiring in the village for the power supply of community uses.

One of the first activities of the project consisted of the development of a training programme. Although this program was originally designed for the training of local technicians about installation and maintenance tasks, the Government of Senegal suggested that the training course was redirected towards ASER. This agency is the competent body in Senegal that carries out tasks regarding national rural electrification and their technicians have extended experience in the field of renewable energies. For this reason, the training programme was reoriented towards a more specialized

PICTURE 2 AND 3. ASER´S TECHNICIANS TRAINING COURSES AT ITER. OCTOBER 2009.

content, such as the grid connection of large photovoltaic systems or the regulatory and administrative photovoltaic framework. The training programme finally took place in October 2009, and both Senegalese and ITER´s technicians appointed the experience as very satisfactory and established the required links for the project´s development.

ASER´s involvement in the project, both in the conception and design of the installation, as well as in its start and validation, was crucial for its proper development. ASER contributed with its local environmental knowledge and its experience in the development of rural electrification programmes in Senegal, guaranteeing that the system was adapted to the real needs of the population, making it durable and replicable.

The first phase also included the building of the new classroom for the school. Three local companies were contacted to study their offers, finally being awarded the company Germany Senegal Cooperation (GSC). In November 2009, ITER's and ASER's technicians visited Fordou in order to check the status of the works and to hold a new meeting with the leaders of the community. Once there, the technicians found that the works were not taking place as it had been reported, and that they were being implemented by mistake in the capital, Ranerou. Despite this setback, the works started again in the correct and initial location, the village of Fourdou, now that the village of Ranerou was already connected to the grid. The classroom was finally built in Fordou in December 2009.

The visit of November 2009 was also used to designate the most suitable location for the photovoltaic installation, satisfying all the village´s needs, minimizing costs and losses of energy. ASER elaborated a general scheme of the installation and its uses. Based on this scheme and requirements detected, ITER designed the supporting structure of the photovoltaic panels and acquired the different equipment, being the structures and the photovoltaic modules of self-manufacture. The final installation is made up by the following components:

- 12 PV modules ITER type ST125P y ST130P (9 installed, 1 for tests, and 2 spare modules).

- 6 2V batteries of 731 Ah C100.
- 1 1000 W Inverter.
- 1 Charge controller.
- 5 street lamps, 25 lamps.
- Supporting structure of the photovoltaic panels and assembly instructions.

The assembly of the photovoltaic installation relied on a local company, being finally awarded the company Sol Treize. ITER developed detailed assembly instructions, in order to assure the correct assembly of the installation meeting the design specifications. The structure was entirely mounted at ITER before being sent to Senegal. This was done to mark the different components in order to make their identification easier and to ensure their assembly in the correct order. The installation was completed in October 2010, date in which technical personnel of ASER carried out a checking technical visit and reported back to ITER, indicating the correct installation and operating of the equipment.

PICTURE 4. PV INSTALLATION AND TECHNICAL ROOM. FORDOU.

PICTURE 5. INTERIOR EQUIPMENT OF THE TECHNICAL ROOM. FOURDOU.

In October 2011, after one operation year, ITER´s and ASER´s technical personnel visited Fordou once more to track the facilities. In this visit, the technicians found that the installation was working properly and was in perfect conditions, including the illumination community system and the energy supply of the health center. The technical room and its content was also checked to ensure it contained all the foreseen equipment which included batteries, charge regulator, inverter, electricity meter provided by ASER, AC 220 V electric switchboard with 4 switches and a clock for the illumination system of the square. The acid of the batteries, the good functioning of the photovoltaic panels and the electricity meter were verified, indicating 300kWh in the operative year. The school enclosure composed by five classrooms, had also been equipped with electrical system of illumination, switches, plugs and energy saving lamp bulbs.

During this visit there were also interviews with key local stakeholders to determine their level of satisfaction with the installation (the head of the village, the headmaster of the school, the President of the Management Committee of the installation, and the technician responsible for the maintenance). In general, the installation was valued very positively due to the change in the life of the village. In particular, the head of the village considered important the electricity supply in the square and in the health center; and the director of the school highlighted that now the children could continue studying until later both in the classroom and in the square.

Regarding the preventive maintenance of the installation, the technician who performs these tasks, resident in Fourdou and without previous studies was trained by ASER. Among his tasks, the person responsible for the maintenance is in charge of cleaning the photovoltaic panels and the technical room, along with verifying and completing the water level of the batteries when needed. This person also must report and contact ASER in case of failure. During the interview, this person said that until the time of the visit, the system had not had any significant failures and was very interested in extending his training to better understand the system and be able to solve future incidents.

The initial photovoltaic installation project is therefore consolidated and is part of the community, improving the living conditions of the inhabitants of the village of Fordou.

It is important to highlight that this kind of projects must be open to amendments and constantly include feedback from the local counterpart and technical visits in order to ensure that the final installation meets the real needs and solves the possible problems that may arise during the development of the project. Even though the installation is not very big and is not the first one performed in Senegal, the project includes other added values for its replicability, such as the close collaboration with the local counterpart (ASER), the hiring of local companies, the training program and the fact that the installation will be used to generate incomes to ensure its maintenance. The Management Committee of the installation offers a charging service of mobile phones at the price of 150 FCFA per charge, competitive against the 200 FCFA fee of the nearby town of Ranerou, capital of the Department. The money collected is used for the maintenance of the facility.

PICTURES 6 AND 7. OUTSIDE THE CLASSROOM BUILT IN FORDOU AND INTERVIEW TO THE MAINTENANCE TECHNICIAN. TRACKING VISIT OF THE PROJECT IN OCTOBER 2011.

3. MACSEN-PV PROJECT - PROMOTION OF RENEWABLE ENERGY SYSTEMS CONNECTED TO THE GRID IN TENERIFE AND SENEGAL

The MACSEN-PV project, launched within the frame of the PCT-MAC 2007-2013 European Programme, is conceived as a platform for technical cooperation between Tenerife and Senegal in the field of the integration of renewable energies in the power supply. Its main objective is to improve the capacity of public authorities and local technicians to support the implementation of renewable energies as part of the power supply in these regions. Its principal result foreseen will be the establishment of new laws and energy plans that will contribute to the socioeconomic development of the participant regions, reducing its dependence on foreign energy and fossil fuels, and strengthening its respective power grids. Likewise, the project will contribute to the training of local human resources to supply, design, install and maintain these installations; and will be replicable and an example for neighbouring regions. As a tangible result, a 3 kWp PV system connected to the grid in CERER facilities (Dakar) has been installed.

PICTURE 8. MACSEN-PV TRANSNATIONAL MEETING IN ASER FACILITIES. DAKAR. OCTOBER 2010.

ITER leads this project, in which the following Institutions participate as partners: AIET; ASER and CERER. The project started in October 2010 and will finish in December 2012.

Even if we are talking about two different regions, the characteristics of the electrical systems of Canary Islands and Senegal present certain similarities in terms of its isolation and its dependence on external sources, which could make them vulnerable to price rises or supply problems.

The project is divided into sequential phases that enable to control its evolution and allow its proper management:

1. Analysis of the environment. Drawing up of various reports aimed to define the main existing needs and problems regarding the integration into the grid of renewable energy systems and the possible options to deal with them. These studies will be used as a starting point for the following phases of the project.
2. Strengthening of the capacities of the competent Public Institutions in the establishment of a favourable legislative framework.
3. Strengthening of the capacities of the local human resources through technology transfer towards the training entities of the participating regions.
4. Installation of a 3 kWp pilot photovoltaic system connected to the grid in CERER facilities (Dakar).

The project also includes management and dissemination activities aimed to establish abiding links of technical cooperation between the partners and to amplify its impact and replicability.

The technical reports have already been produced jointly by the participating partners (ITER, AIET, ASER and CERER). These reports have identified the availability of resources, the forecasts of the growth in energy demand, the existing legislation, the main needs of the electricity market and the training deficiencies existing in the field in the participating regions. The reports are available for its download on the website of the project in Spanish and French.

Materials and tools aimed at technicians from relevant public institutions and teachers have been developed based on the findings of these previous reports. More specifically, MACSEN-PV has developed a "Guide for Renewable Energy Integration in electricity supply and isolated applications for Public Managers" and several "support materials for teachers of high school and college." These materials have been specifically distributed to target groups beneficiaries of the actions that took place during the celebration of the project's Technical Seminars, held both in Tenerife and Senegal. However, they are also available for download at the project´s website in Spanish and French. Moreover, this web page also counts with an online Advisory Office, which contains documents, links and tools of interest related to energy planning, teaching and training and employment opportunities in the sector.

PICTURE 9. MACSEN-PV TECHNICAL WORKSHOP FOR TEACHERS. DAKAR, 10TH NOVEMBER 2012.

PICTURE 10. TECHNICIAN OF THE LOCAL INSTALLER COMPANY WORKING ON THE 3 kWp INSTALLATION IN CERER. NOVEMBER 2012.

The project concludes with the launch of a 3 kWp photovoltaic installation connected to the grid in CERER´s headquarters in Dakar. This installation will be inaugurated on December 2012, with the presence of the Senegalese government officials and of the island of Tenerife. This photovoltaic system is a milestone in the development of renewable energies in Senegal, since this is the first facility to be connected to the conventional Senegalese electricity grid. This system will be used as a starting point to develop the future integration of distributed systems of renewable sources in the Senegalese grid, which aims to be the solution for the model-based Senegalese isolated mini-grids. In addition, the facility will be used as a demonstration platform and internship for local technicians, through CERER. For this reason, its design has been adapted by ITER specifically taking into account the peculiarities of the Senegalese network, and how to maximize its demonstrative and educational use.

The Web page http://macsen-pv.iter.es; Facebook page www.facebook/MacsenPV and the following e-mail address macsenpv@iter.es have been developed for the publication of the latest news and the main results of the project, as well as for the interaction with those persons and entities interested.

AUTHOR

Ms. Mónica Alonso López. Director of the Tenerife Energy Institute and external adviser en ITER.

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THIRD PART
FINANCING RENEWABLE ENERGY MARKETS AND BUSINESS

RENEWABLE ENERGY MARKETS FOR RURAL ELECTRIFICATION

MARKET POTENTIAL, PROVEN BUSINESS MODELS AND CURRENT CHALLENGES FOR SUSTAINABLE ELECTRIFICATION OF RURAL COMMUNITIES IN DEVELOPING COUNTRIES

SIMON ROLLAND
ARE

ABSTRACT

One fifth of the world population has no access to electricity, 500 million of those in Africa alone. Renewable energy (RE) technologies offer excellent solutions especially when increasing conventional energy prices constitute a burden for local end users and governments alike. The prevailing idea that RE projects in developing countries cannot be profitable is wrong and needs to be changed. There are already a number of successful business models that prove the economic viability of RE technologies in these locations. Unfortunately, their full potential is not yet close to being realized and many challenges need to be overcome to do so.

The ECOWAS region offers very favourable conditions for RE solutions, such as solar, hydro and wind projects. Solar Home Systems (SHS) for instance are already quite well developed in the region, whereas several hybrid forms of power generation also constitute real options for the local people. Certain bottle-necks remain, such as the lack of financing, improper regulation or insufficient local support. However, if addressed appropriately, these challenges can be overcome and local communities will be able to benefit from the electricity while the private sector will more actively be investing in these profitable markets.

Keywords: Rural electrification, renewables, off-grid, Africa, ECOWAS, solar, wind, hydro, Alliance for Rural Electrification, capacity building.

1. INTRODUCTION

The benefits of technology can take many forms, and for a small village on a small island, in a small African country it meant its first 24 hours of electricity on 9th February 2012.

The village of Monte Trigo is as far west as one can get in Africa - it is the westernmost village on the westernmost island in the continent's westernmost country, Cape Verde. The 60-family community is only reachable by boat and is completely dependent on fishing and its trade with nearby villages. The need for ice is a matter of survival for its inhabitants: they need it for preserving the fish, hence the constant and frequent five-hour boat trip (each way) to São Vicente, the nearest main island, for ice purchase. It is a process far from efficient, wasting precious time that could be used for other economic or social activities.

Their dependence on diesel was an increasing strain on the island's fragile economy, so a reliable, affordable and clean source of energy became a priority for the community. The installation of an off-grid solar system seemed to serve all these needs.

Local entities came together and, with the support from the ACP-EU Energy Facility, a micro PV power plant was installed with the capacity to produce an average of 74kWh per day. Since then, major changes are shaping the life of this community: one user has bought his first refrigerator (an A+ energy rating) and local workers brought in a welding machine from a nearby village to fix a defected structure. It was the first time local people were able to use such appliances in the village. Finally, it is expected that with two ice-making machines, capable of up to 500 kg per day production, solar power surplus generation will improve the commercial activities on which the village sustains its economy.

Until the installation of the micro PV power plant, these 60 families were just a small part of the 1.4 billion people in the world without access to electricity, 85% of which live in rural areas of developing countries. In the ECOWAS region alone, the number of people without access to electricity is nearly 200 million. Villages like Monte Trigo are proving the potential of off-grid renewables in developing countries in general and in the ECOWAS region in particular. They are also demonstrating why the technical qualities, reliability and flexibility of off-grid renewables work so well in such cases.

2. THE CASE FOR OFF-GRID RENEWABLES IN DEVELOPING COUNTRIES

There are three basic approaches to bringing electricity to remote areas. The first is simply to extend the national grid, but this is at best a long-term hope for many regions in developing countries. National utilities are often struggling with grid stabilisation and concentrate on the demand of growing populations in urban centres. Costly extensions to rural areas are down the priority list, especially in regions where terrains that are complicated to cross, dramatically increasing the costs. Grid extension can cost up to USD15.960 in Senegal or USD19.070 in Mali, for instance[1].

The second approach is based on small stand-alone off-grid technologies. The dispersed character of rural settlements is an ideal setting for these solutions, in particular with renewable energy (RE) sources which are in many cases cheaper than traditional alternatives in remote locations. Small scale renewable energy home systems, designed to power individual households, represent an ideal solution relatively easily-accessible by people with low income levels and easy to maintain.

The potential for Pico PV Systems (PPS) and SHS is especially remarkable. These small systems are often within the payment capacity of most rural people in developing countries and offer immediate, affordable solutions to these communities. Moreover, when they are out of the end users' payment capacity, mature business models (mainly based on microcredit and fee-for-service) have been developed to bridge the gap. This is why countries like Senegal and Mali, both enjoying the excellent natural conditions found in the entire ECOWAS region, take advantage of these technologies through schemes based on concession and fee for service to increase access to energy.

In Mali, the Malian Agency for the Development of Household Energy and Rural Electrification (AMADER), together with the Mali National Centre for Solar and Renewable Energy (CNESOLER), work on SHS installations in the country. Their target is to provide nearly 700 solar systems for community and institutional purposes, and more than 11.000 SHS for local households. All in all, 70.000 new people are expected to have access to electricity by 2015.

FRES, Foundation for Rural Energy Services, one of the private operators managing a concession in the same country also uses solar energy solutions to electrify remote communities. In 2012, they have already installed and managed 85 kWp of SHS and reached more than 4.000 people. For their project, FRES employs the fee-for-service model with which customers pay a monthly fee for the electricity provided, with costs equivalent to the conventional local source of energy such as candles and kerosene. The installed systems are owned by FRES, thus, the end-customers have a very low initial investment and the organisation also ensures the maintenance and efficient working of the system.[2] The initial monthly fees were between 12 to 20 EUR but after receiving a subsidy from the AMADER, the fees decreased significantly.

The third rural electrification approach is through the installation and management of mini-grids supplied by a centralised power plant or by distributed systems, which can provide electricity to both domestic appliances and local businesses.

These can be powered either by fossil fuel (often diesel), by RE, or by hybrid resources. Diesel remains the most widely used due to the persistent idea, often wrong, that it is a cheaper option. However, with a sound business model addressing the main barriers - the initial investment cost, the long-term maintenance of the

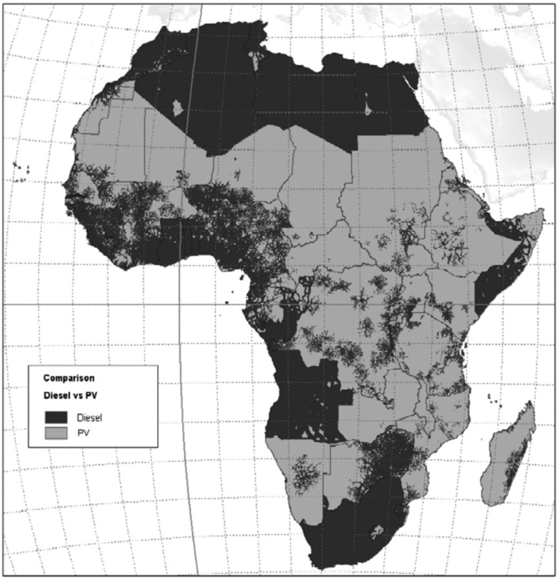

FIGURE 1. OFF-GRID OPTIONS: ECONOMIC COMPARISON OF DIESEL VERSUS PV. SOURCE: "ENERGY SOLUTIONS IN RURAL AFRICA: MAPPING ELECTRIFICATION COSTS OF DISTRIBUTED SOLAR AND DIESEL GENERATION VERSUS GRID EXTENSION", JRC 2011.

system and an intense capacity building work - RE and hybrid mini-grids could very well become mainstream solution for hundreds of thousands of villages and communities around the world. Many examples of such developments already exist in West Africa. INENSUS, a Germany-based company, has electrified more than 160 households in Senegal through an entirely commercially-driven (yet sustainable) approach. Using its Micro Power Economy model, the company, in cooperation with the German Agency for International Cooperation (GIZ), has installed wind-solar-diesel hybrid systems, and reached more than 2.000 people in the first two pilot villages. Over the next years, INENSUS aims to electrify 100 villages in Senegal using the same concept.

In general, RE and hybrid mini-grids offer an ideal solution to decrease the costs of the many installed diesel generators throughout the ECOWAS region. The simple injection of RE power in existing diesel-based mini-grids can dramatically reduce the diesel bills of many local communities and, more globally, of the countries that often heavily subsidise diesel, while avoiding important infrastructure investments. In 2010, developing countries received USD 409 billion in fossil fuel consumption subsidies, out of which only 8% reached the poorest 20% of these countries. In 2012, such subsidies are expected to reach USD 630 billion. (Oil Change International, 2012). In Nigeria for instance, the installed capacity of diesel mini-grids is larger than the national grid-connected capacity and such trends (relevant to all system sizes) are present in many countries, demonstrating again the relevance of mini-grids hybridisation.

Apart from solar, another technology widely applied in developing markets is small hydro, which is particularly relevant in areas with abundant hydro resources, such as Southeast Asia and some parts of sub-Saharan Africa. Eastern, Southern and Central Africa offer the greatest potential for small hydropower in the continent, but countries like Nigeria and Ghana also have considerable opportunities for the sector. Some years ago, and in Nigeria alone, there was a potential for nearly 300 new sites corresponding to more than 734 MW. In 2011, the total capacity of the planned small hydro projects in the ECOWAS region was about 82 MW. Compared to other technologies, a relatively high initial infrastructure investment might be required; however, the electricity is generated at a very competitive price.

Small wind, a technology that remains relatively unknown in these regions, represents another interesting option for Africa. According to a recent report published by Pike Research, the global market for small wind technologies is forecasted to more than double between 2010 and 2015, and much of this expansion will happen in developing and emerging markets. Although lower wind speeds in Western Africa do not allow installing wind turbines in all locations in the region, there are still favourable sites. Moreover, small wind is well suited for hybrid systems in which it can be combined with, for example, solar or diesel, creating even more possibilities in design and application. For instance, the Sun and Wind Factory, an ARE member from The Netherlands, recently installed a hybrid wind-solar water pumping and electrical system at an orphanage in The Gambia. A 1.5 kW capacity wind turbine was installed alongside the solar system.

Besides off-grid technologies' flexibility that allow them to adapt to different social, economic and geographical conditions, they also benefit the local communities on many other levels, with a positive impact on health, environment, gender equality and, of course, economic growth. Although the technologies are mature enough to face the challenges of electrification, the difficulty remains in attracting the private players and investors that will be central in scaling up these efforts. Most private companies are still reserved about entering these markets, the reasons varying from the perception of a low profit margin, to partially true stereotypes regarding the business and political environment of these countries.

3. BEYOND CHARITY, A PROFITABLE MARKET

The International Energy Agency (IEA), that has not always been the most enthusiastic supporter of small scale RE, recently confirmed the potential of off-grid and mini-grid renewables market and published inspiring figures. According to them, to reach universal electricity access by 2030, 949 TWh of additional generation will be needed in the developing and emerging markets. Of this, 42% (399 TWh) should be supplied through mini-grids and 18% (171 TWh) by isolated off-grids. These figures only underline a potential of course, but they are also a strong indication from one of the most influential voices on energy issues. In the same logic, The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) has identified a very impressive potential for mini-grids in the entire ECOWAS region, a prospect that only awaits courageous entrepreneurs once the necessary pre-conditions for private investments will have been implemented.

It is wrong to think that renewable energy only exists in developing countries due to subsidies. Public financing plays a fundamental role in accelerating energy access, but off-grid renewables also exist as commercially-driven markets. Several companies, many of them members of the Alliance for Rural Electrification, have developed business models involving no or very little subsidies and that have proven to be profitable for all stakeholders involved, from the technology supplier to the operators and the consumers (see our case studies), including in the ECOWAS region.

The end-users capacity to afford RE services in Africa is often underlined as one of the key barriers to renewables' development. However, in many countries, SHS or PPS are frequently paid in cash by consumers or compensated using short-term support of microfinance. Such business models – microcredit, fee-for-service and others – allow many people in developing countries to already afford RE technologies, despite the initial financing barriers.

These schemes have been developed in order to help individuals access such sustainable and cost-beneficial technologies. In Kenya, the payback period of a small PV system consisting of a solar panel, lamp and a mobile phone charger is just a few months, since this type of small system costs around USD 18 and locals already spend as much as USD 2 a week to charge their phones and purchase kerosene for lighting. Similarly, a fee-for-service approach as the one used by the FRES in Mali allows the customers to pay roughly the same monthly amount they would spend on purchasing kerosene and candles.

4. TAILORED (YET REPLICABLE) BUSINESS MODELS

Finding the right business models that allow the end users to afford the electricity and a company to be profitable will be key in the electrification process of developing countries. The private sector, governments and NGOs recognised this, hence the increasing number of innovative business models being tested and already proven effective.

The most appropriate business model depends largely on the technology and energy source used. There is no one-size-fits-all solution. At the same time, there are common characteristics that can be replicated and applied to particular cases.

In the case of SHS, as already discussed before, two main business models are currently employed to finance RE projects, namely, microfinance and microleasing. Microfinance is known for the two different approaches – the One-Hand model (Bangladesh/Grameen Shakti model) and the Two-Hand model (Sri Lanka/SEEDS model). Microleasing models, such as the fee-for-service and the lease/hire, are usually led by service providers and, in this case the energy provider owns the system and provides only a service, including maintenance and quality insurance. This differs from the microfinance approach, where the customer eventually gains the ownership over the system after repayment period. In case of the lease/hire model, the lessor remains the owner of the system and is therefore responsible for its maintenance and repair.

In the case of mini-grids, there are a number of other business models that have been successfully utilised in different continents, including Africa. If, for example, the desired mini-grid in an isolated area does not succeed in attracting private-sector or utility interest, the community-based model can be used. In such case the community becomes the owner and operator of the system, providing maintenance, collecting tariffs and being responsible for management services.

Other model types include the private sector-based and the utility-based, as well as the hybrid business model. By combining different ownership structures, such as public-private partnership, or collaboration with the local community, the latter one provides site-specific and customised solutions. It is harder to implement, but have proven to be more beneficial in the long-run in many cases.

The increasing use of these business models is leading to a clear increase of private companies in renewables markets in developing countries. More information is presented in the case study below.

5. OTHER BOTTLE-NECKS

The technological solutions are ready and with adequate business models consumers can afford it, so why are not off-grid technologies more widely-spread in developing countries?

Despite the increase of installed off-grid capacity, the overall situation in Africa is expected to worsen - the rapid population growth outpacing the slight increases in electrification rates - if the challenges existing in rural areas are not addressed properly. First of all, developing countries experience a lack of education and information on RE at all levels. National and local governments often still do not believe in renewable technologies, and banks and credit agencies do not completely understand the specific financial structures of RE technologies (high up-front costs, low operation and maintenance costs = longer return on investment).

Secondly, energy policies often remain short-sighted and unclear in many countries. In the rural electrification sector, where programmatic approach has such an influence (for instance on the areas where mini-grid or off-grid should have the priority), stability and long-term vision is central in making investment decisions. Moreover, decision-makers still tend to emphasise short-term costs and supply, rather than the long-term benefits of cheaper clean technologies. Consequently, the lion share of energy investments keeps going into grid extension, urban electrification, large hydro, gas or coal power plants and, of course, into diesel subsidies.

For these barriers, there are clear solutions: publicly available long-term rural electrification strategies, flexible and standardised regulation to encourage project development, and an industry-wide support of quality standards that will ensure confidence in technologies. Suitable policies supporting RE projects are still rare and often not applied. As in other economic sectors, uncertainties tend to delay projects, especially in a sector where investments need to be made over long periods of time.

Also, the question of financing must be addressed to scale up the generation of electricity from RE sources. Beyond micro-finance, entrepreneurial finance (debt or equity) still remains the most important – and the most difficult – financing segment to push market development. Access to affordable finance, along with sound and replicable business models to ensure project sustainability, are the key economic triggers of rural electrification. Capacity building in the banking sector, as well as supporting instruments such as risk guarantee schemes, will therefore be important to ensure increased access to financing at the local level.

Finally, it has to be recognised that rural electrification alone does not lead to poverty alleviation and overall development of the countries. In fact, if rural electrification is an absolute pre requisite to economic growth and sustainable development, it should be first and foremost seen as a tool to enhancing it. Only economic growth will make rural electrification truly sustainable and vice versa. Therefore, rural electrification should always be integrated in a wider prospect of rural development build around and with access to electricity.

6. A POLITICAL NOD AND GLOBAL COOPERATION

Yes, one of the most important lessons learned since the beginning of off-grid renewable technologies back in the 1970s, is that access to energy alone is not enough to achieve global development and progress. It is, though, a fundamental and unavoidable step towards social, economic and environmental change, fighting diseases, enhancing literacy, women's empowerment, and improving basic living conditions.

Projects implemented in Africa, Asia and Latin America can be profitable and at the same time improve the lives of millions of people living in these regions and striving for a better future. As the UN Secretary General has put it: "Let us not stand and curse the darkness. Let us eliminate it, and in so doing provide opportunity and hope for all".

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AUTHOR

Simon Rolland. Secretary General, Alliance for Rural Electrification (ARE).

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RENEWABLE ENERGY FINANCING IN WEST AFRICA: AN OVERVIEW OF THE CURRENT STATUS AND CHALLENGES

PUNJANIT LEAGNAVAR
UNEP

ABSTRACT

This article presents an overview of renewable energy finance in the Economic Community of West African States (ECOWAS). Currently, the lack of available data presents a barrier for private investment to the region, as it can affect investor confidence and increase perceived risk. This is one barrier that the region must overcome in order to drive and increase financial investment in renewable technologies.

Keywords: finance, ECOWAS, renewables, policy.

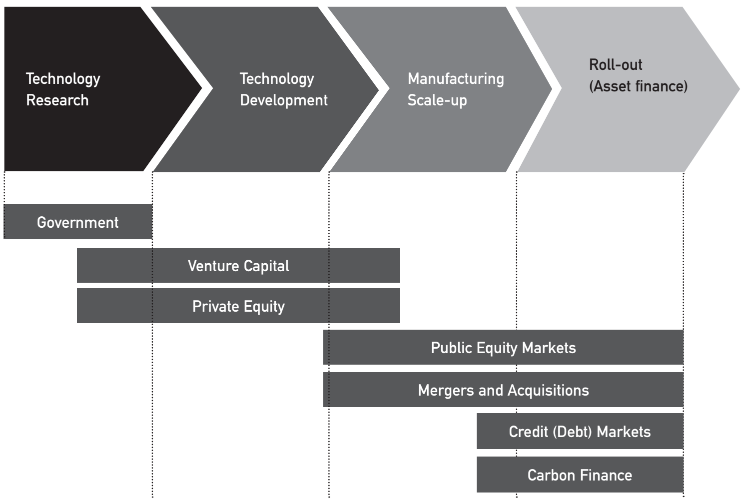
1. PROFILE OF THE ECOWAS REGION: FINANCIAL INVESTMENT IN RENEWABLE ENERGY

The provision of renewable energy in the ECOWAS countries offers the opportunity not only for climate change mitigation, but also for local socio-economic development. Although the subregion has considerable resource availability for many renewables, in particular for bioenergy, solar, and wind, there are still significant barriers to self-sustaining renewable energy markets.

The subregion faces a significant challenge to meet current and future new power capacity, with an energy demand/supply gap greater than 40%. This is coupled with specific barriers to investment that are particularly pronounced in the subregion, including the cost competitiveness of clean technologies, lack of policy drivers and lack of available renewable energy data for investors. [1]

FIGURE 1

FUNDING OF RENEWABLE ENERGY (UNEP, 2011)



In order to identify and deliver the opportunities for renewable energy, thereby offering support for MDGs and catalyzing a path towards a green economy, critical financial investment is needed across the renewable energy finance continuum. This chapter will briefly review the current outlook of financial investment in the ECOWAS subregion and present turnkey solutions for securing future investment.

Traditionally, energy infrastructure in the subregion has been financed through public sector sources of finance. However, trends show that this is changing incrementally with increased private financing of large energy infrastructure initiatives. There remains an urgent need to address the uncertainty and associated risk perceived by potential investors in relation to renewable energy. In order to encourage these investment trends, the African region has developed a framework guide for investment. This framework, defined by the African Development Bank, has outlined the main objectives for its clean energy investment platform: [2]

- Accelerating the reduction of energy poverty and vulnerability, by increasing the access of households and of small economic operators to reliable and affordable energy supplies;
- Facilitating sustained high rates of economic growth, by providing operators in the productive sectors with realistically priced energy supplies;
- Contributing to world-wide energy security, by sustaining significant exports of energy resources to the rest of the world, while increasing African countries' collective self-sufficiency and strengthening regional inter-dependence in energy services and products; and
- Promoting clean development and contributing to global emissions reduction efforts, by steadily improving energy efficiency on the supply side and encouraging a culture of energy saving on the demand side, increasing the contribution of renewable energy sources, and paying close attention to environmental and social externalities of energy production.

A literature review reveals that although information exists on financial investment in the renewable energy sector for the African region, data on the sub-regional and country level is difficult to obtain. This lack of available data presents a barrier for private investment to the region, as it can affect investor confidence and increase perceived risk. Although figures for West Africa are difficult to quantify, total investment for the entire African region in 2010 was roughly 3.6 billion USD. Among all developing regions, Africa gained the largest investment increase in renewables (excluding China, India and Brazil). In the whole region total investment rose 384% in the years 2009 – 2010. This number can be largely attributed to the strong investments in Egypt and Kenya in technologies such as geothermal, solar and wind. Among ECOWAS countries, Cape Verde gained the biggest investment in renewables in 2010 totaling 0.16 billion USD from wind energy. All other countries saw less than 0.1 billion USD of investment in the same year. [3]

TABLE 1

TRENDS IN RENEWABLE ENERGY INVESTMENT IN AFRICA (BILLION USD)

2005	2006	2007	2008	2009	2010
0.1	0.6	0.7	1.1	0.7	3.6

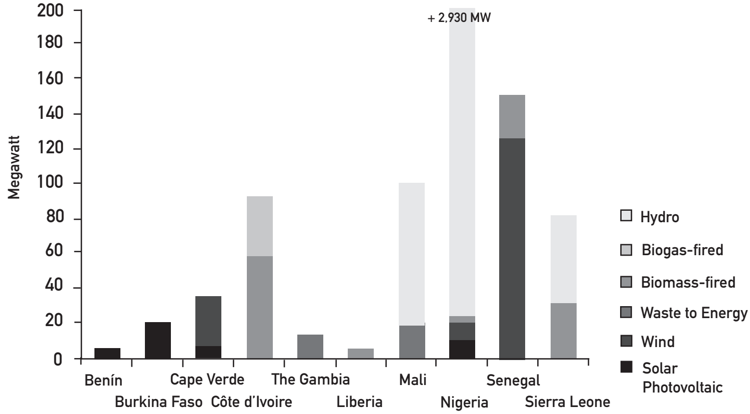
2. INVESTMENT IN TECHNOLOGIES

Investments differ by type of investment and renewable energy technology. In the ECOWAS subregion, financial investments were concentrated in specific clean technologies with a focus on solar, wind, and bioenergy. The following table gives an indication of large scale renewable energy projects, financed through both government and private sector investment, which were undertaken in ECOWAS countries. A majority of the clean energy investments were directed towards bioenergy-based technologies such as biomass firing and waste-to-energy projects.

The data shown is not exhaustive and reflects a few of the large scale investment projects in the subregion. Complementing these investments, decentralized and distributed small-scale generation (less than 1 MW) is also prevalent in ECOWAS countries. Although it is difficult to obtain actual figures, an assumption can be made that sub-regional investments followed the upward trend in world markets. With a global 91% increase in 2010, small-scale distributed energy constituted an equivalent of 60 billion USD in outlays, which covers over 25% of the total global investment in renewable energy.

FIGURE 2

FINANCIAL INVESTMENT IN RENEWABLE ENERGY PROJECTS IN ECOWAS COUNTRIES (GOVERNMENT AND PRIVATE SECTOR FUNDING)

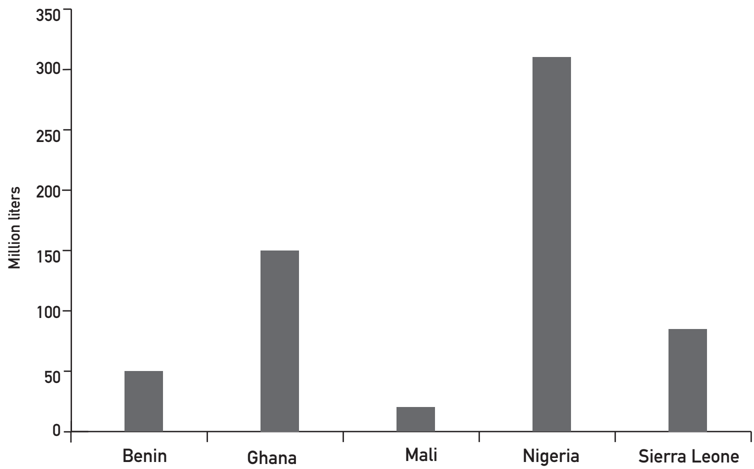


**Data presented here refer to years between 2008 and 2012. Information on projects should be taken as an indication only. It refers to a general trend of available resources, and does not prejudge the feasibility of individual projects. There was no information available for Guinea-Bissau, and Togo.

ADAPTED FROM: INTERNATIONAL RENEWABLE ENERGY AGENCY, 2011. RENEWABLE ENERGY COUNTRY PROFILES AFRICA.

FIGURE 3

FINANCIAL INVESTMENT IN RENEWABLE ENERGY PROJECTS IN ECOWAS COUNTRIES (GOVERNMENT AND PRIVATE SECTOR FUNDING)



ADAPTED FROM: INTERNATIONAL RENEWABLE ENERGY AGENCY, 2011. RENEWABLE ENERGY COUNTRY PROFILES AFRICA.

3. BARRIERS TO INVESTMENT FINANCE

Barriers to finance need to be overcome in order to promote an investment climate for renewables. Some of the impediments that the ECOWAS subregion faces include: lack of local skilled technological experts, weak institutional structures for rural and peri-urban areas, lack of national objectives/incentives for renewables and high perceived investment risk due to uncertainties over the likely returns from investment in renewable energy in ECOWAS. A significant cause of such uncertainty, which urgently needs to be addressed, is the lack of available data on investment in renewables in the subregion. This data can help define priorities for governments in order for them to better characterize their investment priorities. It can also raise investor confidence as it helps elaborate trends, and outlooks of the current renewable energy market in the various ECOWAS countries.

4. POLICY DRIVERS FOR INVESTMENT

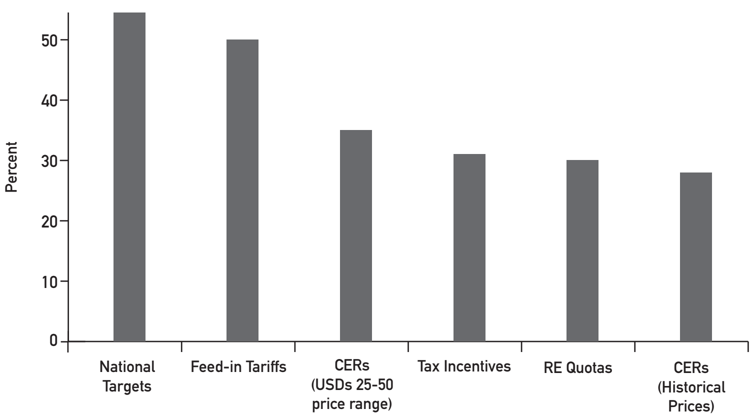
Key factors that determine the level of investment are regulation, policies and incentives. In order to encourage greater private investment mobilization in ECOWAS countries, there are some critical steps that need to be achieved, which will require the dedication of governments and policymakers:

- Create a level playing field in terms of profitability between innovative renewable energy technologies and conventional fossil fuel based technologies.
- Provide easy market access to private sector actors on a competitive basis.
- Mitigate political and regulatory investment risk for renewable energy technologies in order to increase the return expectations of private investors.

In several ECOWAS countries, drivers/incentives have improved the investment climate and so increased the level of support to the renewable energy sector. Countries such as Côte d'Ivoire, *Cameroon*, *Cape Verde*, *Ghana*, Nigeria, Mali and Senegal, have developed regulatory support mechanisms for renewables or renewable energy targets. Ghana, for example, has adopted tradable Renewable Energy Certificates (RECs); and along with the Gambia and Mali have also developed fiscal incentives (carbon finance, tax reductions, etc.). These reforms have made it possible to establish independent power producers through different grid-access models, and have also attracted private finance into the region. [4] According to a study conducted by the UNEP's Finance Initiative, national targets and feed-in tariffs are the most influential to private financiers in order to mobilize investment. This is followed by certified emission reductions, and tax incentives (figure below).

FIGURE 4

WHICH TYPES OF INCENTIVE MECHANISMS ARE THE MOST POWERFUL IN MOBILIZING PRIVATE FINANCE FOR RE DEPLOYMENT IN DEVELOPING COUNTRIES?



SOURCE: UNITED NATIONS ENVIRONMENT PROGRAMME FINANCE INITIATIVE, 2012.

Recognizing access to renewable energy as a precursor to sustainable development, the UN General Assembly has launched the *Sustainable Energy for All Initiative*, stating that "…access to modern affordable energy services in developing countries is essential for the achievement of the internationally agreed development goals, including the Millennium Development Goals, and sustainable development, which would help to reduce poverty and to improve the conditions and standard of living for the majority of the world's population". [5] In order to capitalize on the opportunities that renewable energy can bring, it is paramount that ECOWAS countries foster an enabling environment for financial investment. Currently, exact investment figures are difficult to obtain; this lack of available data, coupled with weak policy drivers for investment significantly affect the overall investment climate in the subregion. Case studies and best practices should be shared within the ECOWAS countries in order to better understand what incentives have been successful for investment, and to what extent those can be replicated in other countries.

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AUTHOR

Punjanit Leagnavar is currently working with the climate change mitigation program at the United Nations Environment Programme.

www.unep.org

FINANCING OPPORTUNITIES FOR RENEWABLE ENERGY IN AFRICA[1]

AFRICAN DEVELOPMENT BANK[2]

ABSTRACT

Africa's power sector faces major infrastructure challenges and a huge financing gap. To address these problems, the continent should shift to making greater use of its vast renewable resources, putting it on a sustainable path that meets countries' fast-growing energy needs while mitigating the effects of climate change, which has a particularly large impact on Africa. Countries' public sectors can play a key role in this development by putting the needed regulatory support in place, which will in turn attract private-sector investors. Both public-private partnerships (PPPs) and purely private projects can be attracted to the renewable-energy sector if governments provide incentives in the form of good policymaking. Development banks and other multilateral and bilateral organizations are key sources of funding. Likewise are newer, innovative methods of climate financing, including carbon finance, the Climate Investment Funds (CIF), continent-specific sources, and the nascent Green Climate Fund. A mix of funds from all these sources can help close the financing gap and scale-up renewable energy in Africa, which will contribute to transition the continent towards a more inclusive and green growth.

Keywords: Renewable energy potential, resources mobilization, policy and regulatory incentives, climate finance, public-private partnerships, green growth.

1. INTRODUCTION

Africa's strong economic performance over the past two decades, as well as its projected economic growth, mean ever-increasing energy demands across the continent. It has become imperative to take definite steps to address energy insecurity and to set Africa on a sustainable energy path, building on the huge renewable energy potential of its countries. Africa has the opportunity to embark on a low-carbon, clean energy path that not only bridges its energy gap, but also attracts significant private investment to the energy sector in support of strong growth, job creation, and poverty reduction on the continent.

The key challenges facing Africa's power sector are inadequate generation capacity, limited electrification, unreliable services, high costs, and a huge financing gap. These challenges call for a paradigm shift in the development of the power sector that seeks to use the vast renewable resources of the continent, including hydro potential – ranging from large-scale to small scale, geothermal, wind, and solar. Some of these sources of energy are well positioned to respond to the access needs of Africa's large rural population, which can only be reached in the medium term by a combination of grid, mini-grid, and off-grid technologies. They can also be built at the necessary scale to avoid relying on costly small-scale, fossil-fuel-based power systems.

Adequately financing the development of the energy sector in sub-Saharan Africa is expected to require the mobilization of funds in the order of USD 41 billion per year, which represents 6.4 percent of the region's GDP [1]. A large financing gap exists because the focus of much of the current spending is on maintenance and operation of the existing power infrastructure, with little remaining to fund long-term investments essential to address the energy access deficit. Given the significant financing gap and the relatively high capital costs of clean energy solutions, a portfolio of financing sources will have to be considered and sustained to meet current and future demand. The mix of financing required by project could depend on the maturity of the underlying technology, with newer technologies e.g. concentrated solar power generally requiring greater concessional financing compared with more established technologies such as hydropower.

This paper outlines the various sources that can be mobilized in order to finance renewable energy projects in Africa. It discusses the role of the national public sector in setting the stage for renewable energy investments, the opportunities for financing renewables through private investment, the contribution of ODA to co-financing clean energy projects and catalyzing other resources, and other innovative financing mechanisms designed to raise additional funds.

2. THE ROLE OF THE NATIONAL PUBLIC SECTOR

African governments should play a key role both in providing and mobilizing the resources needed to finance renewable energy projects on the continent. While private sources play an increasingly important role in financing clean energy projects, support from public sources will be required to ensure that the returns are sufficient to attract private sector investors. Over the longer term, domestic revenue mobilization, in particular though better tax policies and strengthening tax administration, is the most viable financing basis for development expenditures, including those on sustainable energy.

The key role of the national public sector lies in putting in place an adequate strategic and regulatory framework that provides the right incentives for long-term RE investments. In addition to aspects of the overall enabling environment, such as high levels of political stability, that encourage domestic and foreign investment in general, the private sector has repeatedly cited the establishment of clear national targets for renewable energy generation and the introduction of feed-in tariffs as major drivers for private sector involvement [2]. Setting the stage through appropriate regulations and policies that will allow the scaling up of RE investments is where national governments can make the difference.

3. MOBILIZING THE PRIVATE SECTOR

Considering the existing gap between the capital investments required in the energy sector and the public financing capacity, the participation of the private sector is critical. Private sector cannot only provide financing but also transfer knowledge on most recent technologies as well as more efficient work practices. While the bulk of infrastructure in Africa, including power, has historically been financed by the public sector, there is increasing interest from the private sector, especially in energy generation.

Private-sector participation in the energy sector takes many forms: independent power producers (IPPs) that supply the grid, merchant power producers that serve industrial clients, and even captive investments in energy-intensive industries such as cement or mining. The IPPs could be classified as public-private partnerships (PPPs), which are broadly defined as long-term contracts between a private party and a government agency, for providing a public asset or service, in which the private party bears significant risk and management responsibility [3]. IPPs fit this definition given that they enter into long-term power purchase agreements with public entities, such as utilities or municipalities. The other two types of investments are purely private-sector transactions, although merchant power producers are likely to require access to the grid, which is usually publicly owned.

If properly used, a PPP has the potential to unlock funding from private sources. For this to occur, interventions must maximize public utility while minimizing long-term public fiscal commitments. Governments should invest resources to build transactional capacity within official bodies, so they can negotiate contractual agreements that reflect appropriate risk allocation and reward-sharing between stakeholders. For renewable energy in particular, technical capacity is required to properly price and reflect the economic and financial value of environmental and natural resources. Bankable project documentation that suitably allocates costs and risks to appropriate parties is essential to boost private investor confidence. This can be achieved when concession and off-take agreements are negotiated within a transparent framework governed by an independent regulatory authority [4].

South Africa, which has the largest installed generation capacity on the continent, provides an interesting example of engaging the private sector in renewable energy investment. In view of significant pressure to keep up with energy demand over the last decade, South Africa's Department of Energy endorsed in early 2011 the Integrated Resource Plan, which sets out the country's energy requirements until 2030 and the contribution of RE to those requirements. The table below presents the outcomes of the bidding process that catalyzed the involvement of the private sector.

TABLE 1

OUTCOMES OF THE BIDDING PROCESS IN SOUTH AFRICA

PROCUREMENT ROUNDS	OUTCOMES OF THE BIDDING PROCESS	REMARKS
First round in late 2011	28 preferred bidders emerge with projects totaling 1,416 MW across a range of technologies, including state-of-the-art concentrating solar power	Financial close in 2012.
Second round in early 2012	79 proposals of which 19, amounting to 1,044 MW of capacity, were selected as preferred bidders in May 2012.	Financial close is planned for early 2013. The average bid prices dropped by around 20% for wind and 40% for photovoltaic projects.

The significant interest from domestic and international private sector players—encompassing energy companies, private equity investors and financial institutions—in South Africa's RE program shows the impact of a well-defined procurement process undertaken in the context of national energy targets.

4. MOBILIZING MULTILATERAL AND BILATERAL PUBLIC FINANCING

Multilateral and bilateral public financing can play an important role in addressing the financing gap for renewable energy projects in Africa and in acting as a catalyst for stronger private sector involvement.

Multilateral public financing in Africa can distinguish between three types of multilateral institutions:

- International and regional financial Institutions, including the World Bank, the African Development Bank, the West African Development Bank, the European Investment Bank, and the European Bank for Reconstruction and Development (for North Africa only). Multilateral development banks have the experience and capacity to catalyze public and private funds for clean energy. In addition to their mandate to support country-led development processes, Multilateral Development Banks (MDBs) have the capacity to mobilize additional concessional and innovative finance; facilitate the development and utilization of market-based financing mechanisms; leverage private sector resources; support the deployment of new technologies; and support policy research, knowledge, and capacity building. Their comparative advantage is the capacity to use a wide array of instruments to support simultaneously the development and strengthening of institutional and regulatory capacity and frameworks, as well as finance for investments. These institutions generally provide a range of financial products tailored for energy, especially renewable energy, and as a consequence are all involved in the RE sector.

MDB FINANCING FOR CLEAN ENERGY INCREASES

In 2010, the World Bank Group's lending for low-carbon energy projects and programs reached 42 percent of all energy financing, and financing of renewable energy and energy efficiency projects and programs in developing countries rose to a record USD 3.6 billion.

In 2011, the African Development approved 625 million USD in financing for renewable energy in Africa. This represents a threefold increase since 2005.

GREEN BONDS: A NEW POLICY APPROACH
(ADAPTED FROM POLICY BRIEF ON RENEWABLE ENERGY FINANCE – RETD)

- Bonds are a mechanism to borrow against future economic benefits. This is particularly relevant for RE deployment, in which the assets have high upfront costs.
- Green bonds or climate bonds are tied to specific climate change mitigation or adaptation investments and allow governments and companies to raise capital to: (i) build RE generation and its enabling infrastructure, and (ii) support RE economic development opportunities.
- Some USD 400 billion of bonds outstanding have been assessed to be tied to climate change investments. But the level of transactions in bonds actively labeled green or climate has been so far limited.
- As of today, the AfDB has issued about 261 million USD in green/clean energy bonds for Africa.

The United Nations System and the European Union predominantly provide grants to co-finance renewable energy projects. This helps bring down the upfront investment costs, thus contributing to the bankability of the project and reducing end-user tariffs. Such grants also catalyze lending.

- Entities such as Multilateral Investment Guarantee Agency (MIGA) and the African Trade Insurance Agency provide insurance against *force majeure* items, such as major political or commercial incidents. Although these institutions do not provide direct financing, they catalyze investment because they reduce the risks in investing in a project or a company benefitting from such cover. They work like insurance, with the subscriber paying a premium to access the service if the project and/or the company qualify. Also, as a means of stimulating additional private sector investments in low-income countries, the AfDB has introduced partial risk guarantees (PRGs) to the Bank's suite of financial instruments. PRGs complement existing instruments through which the AfDB supports private sector development and crowds in private financing for development. By securing a PRG, governments can make their program more attractive to private investors and insure private lenders against unpredictable political risks related to the failure of a government or a government-related entity to honor certain specified commitments. Such risks could include political force majeure, currency inconvertibility, regulatory risks (adverse changes in the law) and various forms of breach of contract. The AfDB estimates that about 80% of PRGs offered over the next five years will go to the power sector.

There are generally two types of bilateral partners. The first one is standard bilateral lending agencies, such as KfW, AFD, USAID, DFID, JICA, etc. They are governed by a single country shareholder, which allows for more flexibility in terms of use of financial instruments. The second are export credit agencies (ECAs), such as Hermes, COFACE, ECGD, and US EXIM, which promote exports from the lending country. Their terms are regulated so as to avoid "dumping" between countries over the export of the same sort of goods or materials. When a project is accepted by an ECA, usually a commercial bank will be able to lend to the project and in case of the borrower's default, the loan will become the ECA's liability. For instance, it is common to see ECAs heavily involved in the wind sector, because not many countries are able to manufacture wind turbines. This creates ties between countries (for example, South Africa and Denmark).

Bilateral lending entities have the ability to lend/provide grants to a country. They complement well multilateral financing for co-financing renewable energy projects. ECAs, for their part, offer an excellent tool to enter new territories for an entity able to use their guarantees. This benefits the ultimate borrower and the lending country, the latter by way of increased exports, but also by way of attracting ancillary services around those exports.

MDBs and bilateral agencies are mobilized through a combination of upstream project scanning and downstream project identification resulting from a dialogue with project developers/sponsors and/or country authorities. They can finance projects' preparation, (feasibility studies, costs-benefits analyses, etc.) and the infrastructure. In practice, projects (particularly large renewable projects) are usually financed by a combination of multilateral and bilateral agencies. Some of the multilateral and bilateral entities listed above have the ability to contribute directly to the private sector via dedicated subsidiaries, thereby reinforcing the cooperation between both types of lending institutions. Also, these types of institutions are usually solicited when financing RE programs, not only because of their attractive financing terms and conditions, but also because their financing helps crowding-in other financing.

5. MOBILIZING CLIMATE FINANCE AND OTHER INNOVATIVE FINANCING SOURCES

A combination of financing options is required to offset the high generation cost associated with renewable energy technologies, some of which are still new and untested and ensure that power is competitively priced. A blend of concessional and commercial financing can play a key role in subsidizing generation tariffs, which would otherwise be too high and make renewable energy too expensive for off-takers to purchase.

5.1. CLIMATE INVESTMENT FUNDS

The Climate Investment Funds (CIF) aim to help developing countries pilot low-emissions and climate-resilient development. With CIF support, 46 developing countries are piloting transformations in clean technology, sustainable management of forests, increased energy access through renewable energy, and climate-resilient development.

CTF MOROCCO: OUARZAZATE CONCENTRATED SOLAR POWER PROJECT

The Ouarzazate Concentrated Solar Power Plant in Morocco, with a capacity of 500 MW and an estimated output of 1,150 GWh per year, is the first of a series of five solar complexes expected to reach a combined installed capacity of 2,000 MW by

2020. The project is expected to generate savings of 1 million tons of CO^2 per year.

The project forms part of the CIF's Regional MENA CSP Investment Plan, and will be partially financed by a USD 240 million loan from AfDB non-concessional window (for Phase 1 generating 125-160 MW) and a CTF concessional loan of USD 100 million.

SREP KENYA: MENENGAI GEOTHERMAL PROJECT

The Geothermal Development Company (GDC), a state-owned company, is the owner of the Menengai Geothermal Project, which will be designed to produce electricity for 500,000 households and displace 2 million tons of CO_2 per year.

Located in the African Rift Valley, the Menengai project is expected to set the stage for investments to help meet Kenya's rapidly increasing demand for power and transform the country into a competitive clean energy economy. In addition to supplying households, the project will cater to 300,000 small businesses and provide a further 1,000 GWh to other businesses and industries on completion.

The loans will be critical in affording Kenya an opportunity towards energy sustainability and independence. In December 2011, AfDB approved the financing for the project, consisting of a loan of USD 125 million from the AfDB concessional window and a combined loan and grant of USD 25 million from the SREP under the CIF, hosted by AfDB.

The Menengai project was the first of its kind to be approved by a multilateral development bank under the CIF for a low-income African country.

Africa has been able to obtain a large share of funding from the CIF, especially for the Clean Technology Fund (CTF) and Scaling up Renewable Energy Program (SREP). Currently, 42% of CTF funding and 58% of SREP funding is spent in Africa. CIF activities are currently ongoing in 15 African countries and one region (MENA). So far, the CTF has funded projects in Morocco, Egypt, and South Africa.

Out of the seven pilot countries benefiting from the SREP Program, four are in Africa: Ethiopia, Kenya, Mali, and Tanzania which represents a total of USD 190 million in SREP financing dedicated to renewable energy (mostly in grants and very low concessional loans). Liberia is the next pilot country that is currently entering the SREP program. In Ethiopia, Kenya and Mali, for which the investment plans have been approved, these funds are expected to catalyze a large amount of additional financing from MDBs, bilaterals and private sponsors, bringing the total investment amount to an estimated USD 1.2 billion.

The value of these programs also lies in the methodology they bring to develop investment plans that help mobilize additional financing from various sources. This example can be followed by many countries in Africa, with support from the existing pilot countries[3].

5.2. GLOBAL ENVIRONMENT FUND

For climate change mitigation, the Global Environment Facility (GEF) provides grant and concessional co-financing that is incremental to baseline projects in developing countries and economies in transition for producing global environmental benefits while contributing to the overall objective of the United Nations Framework Convention on Climate Change (UNFCCC).

Climate Change mitigation is one of the six focal areas supported by the GEF Trust Fund. Under the GEF-5 funding cycle, covering the period 2010-2014, the climate change focal area is divided into five strategic objectives. Promoting investment in renewable energy technologies is one of those objectives and a key component of the GEF climate change strategy. Under this objective, the GEF goes beyond the creation of an enabling policy and regulatory environment to promoting investment in renewable energy technologies. It seeks projects focused on the deployment and diffusion of reliable, least-cost renewable energy technologies that take into account the natural resource endowments of countries.

Under the GEF country allocation, known as STAR (System for Transparent Allocation of Resources), ECOWAS countries' allocation for climate change mitigation is USD 210 million. In addition to the countries' STAR allocations, the GEF disposes of set-aside funds, such as non-grant instruments for the private sector. Under those funds, a USD 20 million program was submitted by the AfDB to the GEF Council in June 2012 and approved to provide non-grant co-financing to private-sector RE projects[4].

5.3. DEDICATED FUNDS FOR RENEWABLE ENERGY IN AFRICA

Various instruments have been developed to support the scaling up of private-sector-driven renewable energy in developing countries by financing the demonstration of new concepts, preparing bankable projects, and providing venture or equity capital.

The Energy and Environment Partnership (EEP) is a programme that promotes renewable energy (RE), energy efficiency (EE), and clean technology investments, with implementation in southern and eastern Africa ongoing since March 2010, jointly funded by the governments of Finland, Austria, and the United Kingdom. The EEP Programme supports projects that aim to provide sustainable energy services to the poor while combating climate change. To qualify for EEP support, projects should also demonstrate high levels of innovation in delivering energy services, facilitating technology transfer, and encouraging cooperation and local stakeholders' participation in projects. EEP provides seed financing to cover part of the project costs necessary to start and develop a business (such as pilot and demonstration activities) or that can ensure the value of an investment (such as pre-feasibility and bankable feasibility studies). Funding at this stage helps businesses to sustain themselves for a period of development until they reach a state when they are able to secure investment to continue funding themselves.

Hosted by the AfDB and established in 2011 in partnership with the Government of Denmark, the Sustainable Energy Fund for Africa (SEFA) is a dedicated set of financial instruments that aim to enhance the commercial viability, as well as bankability, of smaller, private sector-driven projects in renewable energy and energy efficiency. This is expected to increase provision of productive energy, thereby increasing direct employment at the project site and indirect/induced employment through increased access of businesses and households to reliable, clean and affordable energy. SEFA provides grants for preparation of meso-scale projects (in the USD 30-75 million range) covering a broad range of activities up to financial close. Such support should allow the project to leverage debt finance from players such as AfDB, other development finance institutions, and local commercial banks. SEFA also has a seed/growth capital window for smaller emerging businesses (under 30 million USD) in the energy value chain, to be channeled through at least one private equity vehicle.

Unlike other developing regions, namely Latin America and Asia, Africa's private equity (PE) landscape operating in the renewable energy space is still in its early days, with only a few PE funds currently operational on the continent. Among these is Evolution One, currently investing in a portfolio of clean tech companies in the South African Development Community (SADC) region. There are a few more at fund-raising stage, namely the DI Frontier Fund and Investia, both with a strong preference for East African projects and companies. PE provides an avenue to strengthen the project sponsor's balance sheet while also enhancing the managerial capacity and injecting know-how. In addition to PE funds, there are also "funds of funds," which pool and invest in several of these newer PE funds. The Global Energy Efficiency and Renewable Energy Fund (GEEREF) is an example, providing risk capital through private investment in energy efficiency and renewable energy projects in developing countries and economies in transition. GEEREF is both a sustainable development tool and a tool that supports global efforts to combat climate change[5].

For more information on SEFA at the African Development Bank, please contact Joao CUNHA: j.cunha@afdb.org

Information is available on line at: http://www.afdb.org/fr/topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa/

5.4. CARBON FINANCE

The deployment of renewable energy technologies can offer opportunities for African countries to benefit from carbon finance through international carbon markets. As a market-based (and legally enforceable) mechanism, it can help generate efficiency gains, improve internal rate of returns through new carbon revenue stream during the credit period and hence bring down cost of renewable energy. RE projects qualify for the generation of carbon credits on both voluntary as well as compliance carbon markets underpinned by the clean development mechanism of the Kyoto Protocol.

So far, though, Africa has benefited little from carbon finance. As of June 2012, more than 10,000 projects are in the CDM pipeline of which 4,170 have been registered. They are expected to generate 2.7 billion CERs by 2012, but only 2.9 percent of all CDM projects originate from the African continent. One of the main reasons for this is the complexity of the CDM process and the shortage of technical capacity in African countries. In order to address such skills shortage, many technical assistance programs have been put in place, including the African Carbon Support Program initiated by the AfDB to provide support to African countries in preparing projects that can be registered under the CDM or voluntary carbon market. Other constraints preventing Africa from tapping further into the CDM relate to the high transaction costs for registering a project - a barrier for RE projects that already have high upfront transaction costs - and the volatility of carbon credit prices, which does not secure revenues for the projects' sponsors.

ESSAOUIRA WIND POWER PROJECT, MOROCCO

This project constructed 60 MW of wind power generation, increasing the country's use of renewable energy and improving the environment by reducing a significant volume of greenhouse gas emissions that would have occurred in the national grid.

The project will result in greenhouse gas emission reductions of 156,026 tCO_2 / year, which is equivalent to 780 million USD per year, assuming the price is USD 5/tCO_2. As of June 2012 the project has issued 244,000 CERs.

Agreement was reached at the UNFCCC conference in Durban (2011) on a second commitment period under the Kyoto Protocol. The details of this agreement are expected to be clarified before the end of 2012. At the same time, the European Union has decided that only CDM carbon credits from less developed countries will be allowed to be imported into the EU. These developments along with the newly set up "Programme of Activities" and "Standardized Baselines" are positive for CDM project development in Africa. This is expected to give an impetus to the generation of African CDM carbon credits[6].

5.5. TOWARD THE GREEN CLIMATE FUND

In the coming years, the deployment of renewable energy in Africa should benefit from the new generation of international climate finance. During COP 16 in Cancun, a new operating entity, the Green Climate Fund, was created to serve as the financial mechanism of the UNFCCC. The GFC is expected to support projects, programs, policies and other activities in developing countries while achieving the ultimate objective of the UNFCCC, promoting a paradigm shift towards low-emission and climate-resilient pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions. The assets of the GCF will be administered by a trustee, in accordance with the decisions of the GFC Board currently being set up. At COP 17 in Durban, the COP adopted a governing instrument for the GFC [5] and an interim secretariat was created. All pending arrangements between the COP and the Fund are expected to be concluded at COP 18 in November 2012, and the GFC should be fully operational thereafter.

In this context, African countries should position themselves to quickly benefit from such financial flows. Some have already undertaken some important steps, such as Ethiopia and Mali's creation of dedicated national climate finance basket funds. Multilateral development banks, including the AfDB, are getting organized to provide the necessary support to African countries in accessing these funds.

6. CONCLUSION

Financing renewable energy deployment in Africa is costly, and no single source can close the entire financing gap. A variety of sources, private and public, bilateral and multilateral, including some innovative forms, will be needed to generate sufficient funding and maximize strengths of each, while offsetting weaknesses.

The financing requirements should not prevent African countries from engaging in the promotion of renewable energy. Considering the challenges Africa is facing in terms of infrastructure deficit, food security, management of natural resources, natural disasters, and climate change, it is worth putting the continent on a green growth pathway. Such a pathway can create new jobs, provide energy security, make the best use of natural resources and ensure a climate resilient growth of the continent. Promoting renewable energy will definitely help achieve this broader development goal.

NOTES

1. The results, interpretations and conclusions expressed in this article correspond entirely to the author or authors and do not necessarily represent the point of view of the African Development Bank (AfDB), its Board of Directors or the countries it represents. The AfDB does not guarantee the data included in this publication and does not take any responsibility for the consequences of their use.
2. This article was written by the Department of Energy, Environment and Climate Change of the African Development Bank. It was prepared under the direction of HelaCheikhrouhou, Director, and Kurt Lonsway, Division Head, by Florence Richard, Specialist in Climate Change, with contributions by MonojeetPaj, Head of Investments, Leandro Azevedo, Expert in the Private Sector, Jao Cunha, Head of Socioeconomics, Bertrand Belben, Specialist in Energy, Daniel Schroth, Head Specialist in Energy, Ignacio Tourino, Specialist in the Environment, FaouziSenhaji, Expert in Carbon financing, Mafalda Duarte, Head Specialist in Climate Change, and Youssef Arfaoui, Head Specialist in Renewable Energy, who contributed useful comments to complete the article.
3. For more information on CIF in the African Development Bank, please contact Mafalda DUARTE. There is also information available on the internet at http://climateinvestmentfunds.org/cif
4. For more information on the GEF in the African Development Bank, please contact Ignacio TOURINO. There is also information available on the internet at http://www.thegef.org/gef/
5. For more information on SEFA in the African Development Bank, please contact Jao CUNHA. There is also information available at http://www.afdb.org/fr/

topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa/

6. For more information on Carbon Financing in the African Development Bank, please contact Uche DURU. There is also information available at http://www.afdb.org/

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INCLUSIVE BUSINESS MODELS: AN OPPORTUNITY TO ACCELERATE SUSTAINABLE ENERGY FOR ALL IN WEST AFRICA?

WILLEM ADRIANUS BRON
SNV

ABSTRACT

Traditional sources of fuel are used to meet the daily energy needs of most people in the Economic Community of West African States (ECOWAS) region. The collection of wood, dried manure and charcoal is exhausting natural resources and degrading productive land, while their availability is declining against a growing demand of the population. Currently, millions of people are confronted with challenges on access to energy, reliability and cost. Enterprises are also challenged by this 'energy poverty'. Renewable Energy development in West Africa has largely focussed on large-scale infrastructure has mainly been the entry point for policy development. As a result, domestic/small scale renewable energy supply for cooking, heating and small and medium enterprises (SMEs), especially targeting rural and peri-urban areas, has received little attention and support. Inclusive business models, in simple words including the poor in the business process, be it as producers or consumers, could help in tackling the "lack of universal access to renewable energy", especially rural populations, while giving business the opportunity to step into new markets through the delivery of products and services for the vast majority of poor people in West Africa.

Keywords: inclusive business, Bottom of the Pyramid (BOP), renewable energy, energy poverty, sustainable energy for all, West Africa, ECOWAS, capacity building, private sector.

1. INTRODUCTION

Besides being strongly dependent on fossil fuels imports, traditional biomass is currently a vital part of the primary energy consumption accounting for 80% within the Economic Community of West African States (ECOWAS). Less than 10% of the rural population has access to electricity. Availability of sustainable, clean and reliable sources of energy is an essential driver for development: no country in modern times has substantially reduced poverty without a massive increase in its use of energy. Therefore it is necessary to utilize local and renewable energy sources with contextualised solutions in order to enhance energy access within the ECOWAS region.

The collection of wood, dried manure and charcoal is exhausting natural resources and degrading productive land, while their availability is declining against a growing demand from the population. Currently, millions of people are confronted with challenges on access to energy, reliability and high costs. Enterprises are also challenged by this 'energy poverty'. Renewable Energy development in West Africa has largely focussed on large-scale infrastructure and the urban population and energy poverty has rarely been the entry point for policy development. As a result, domestic/small scale renewable energy supply for cooking, heating and small and medium enterprises (SMEs), especially targeting rural and peri-urban areas, has received little attention and support.

The ECOWAS region, as clearly described in its "White Paper for a Regional Policy[1]", has much renewable energy potential, mainly through solar, hydro and naturally biomass. The ECOWAS region has the opportunity to tackle this energy poverty by coherently looking into the use of renewable energies, leapfrogging fossil energy as this is more and more expensive and inaccessible due to increasing demand and by using the many renewable energy and climate funds focussing on Sub-Saharan Africa.

Prerequisites for the realisation of these changes include the formulation and implementation of effective policies; capacity to design and implement innovative but proven approaches; and availability of new financing mechanisms in combination with market-based approaches. This can only be effectively achieved with a long-term systemic approach. Such an approach implies the intimate involvement of government bodies, the civil society and above all the engine of the economy, the private sector.

In recent years many West African countries have grown economically but evidence shows, however, that economic growth alone does not reduce inequity. It is important that poor households and small enterprises can benefit from economic development and the availability of appropriate clean energy solutions and services in rural areas facilitates inclusive development and helps to boost highly needed rural electrification.

As such, business as usual is not an option in West Africa. Meeting the basic needs of a quickly growing population will exponentially increase the demand for energy and natural resources, thereby further intensifying the pressure on our ecosystems.

2. INCLUSIVE BUSINESS DEVELOPMENT

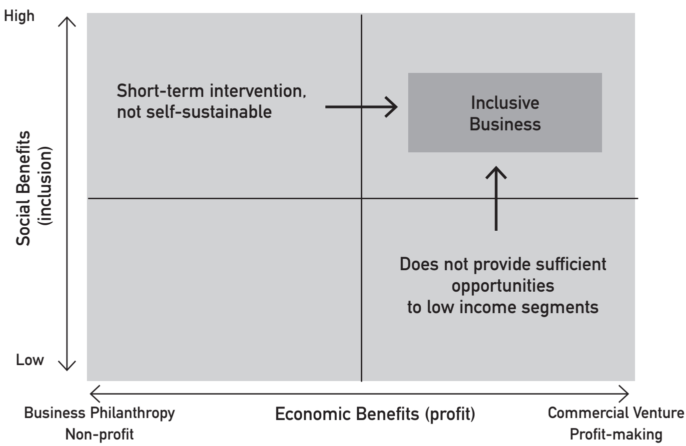
Tomorrow's leading private sector will be those that anticipate these trends and align profitable business ventures with the needs of societ[2]. In its efforts to promote business solutions for a sustainable future of developing countries, the World Business Council for Sustainable Development (WBCSD) together with the Netherlands Development Organisation SNV developed the concept of *inclusive business* to address sustainable poverty alleviation through business-led initiatives.

It builds on the work of the late CK Prahalad and Stuart Hart on Base of the Pyramid (BOP) business models, to identify commercially viable business solutions with high socio-economic impact.

The BOP constitutes the market made up of the world's poorest people, those with incomes living on less than $2 per day or the equivalent of $3,000 per year in local purchasing power[3]. This portrayal has helped envision a meaningful role for business in poverty alleviation through a market-based and profit-making approach. Nowadays there are many terms that characterize the concept of doing business with the BOP. The Inclusive Business Guide by *endeva*[4] clearly mentions the most important terms. Two of these include "*opportunities for the majority*" by the IADB and "*Making markets work for the poor/MMW4P*" by DFID, SDC and SIDA.

FIGURE 1

MAXIMISING SOCIAL AND ECONOMIC VALUE. SOURCE: SNV, ADAPTED BY AUTHOR



SOURCE: SNV, ADAPTED BY THE AUTHOR.

As defined by the WBCSD and SNV, *Inclusive business*[5] refers to the inclusion of people living in poverty into business processes along the value chain. Inclusive businesses may engage low-income communities through, among other things, directly employing low-income people; targeting development of suppliers and service providers from low-income communities; or providing affordable goods and services targeted at low-income communities. In simple words inclusive business is all about including the poor in the business process, be it as producers or consumers[6].

The Asian Development Bank's (ADB) Inclusive Business initiative, co-implemented by the Netherlands Development Organisation (SNV), stipulates that Inclusive Business differs from social enterprises and corporate social responsibility activities in its realized profit making motive, as well as its social impact in scale and systemic contribution to poverty reduction, and consequently also the larger size of investment needs. It also differs from the original base of the pyramid approach that sees the poor mainly as market for private ventures and assumes automatic benefit for the poor through the provision of any consumption good. Expanding private sector growth through inclusive business ventures on the other side would provide the poor with new jobs and access to quality and affordable goods and services, helping them improve their lives and reducing poverty.

In the ECOWAS region, the private sector has barely explored its potential at the BOP although economic growth is rising and poverty in many nations continues to be massive, with GDP per capita at less than USD$200 per year and the vast majority of the population living on much less. In order to facilitate inclusive development, inexpensive and clean energy solutions for rural areas is a must, and it can result in sustained growth benefitting the entire population of West Africa.

3. ECOWAS ENERGY MARKETS

The Economic Community of West African States (ECOWAS), established in 1975, in Lagos, Nigeria, has a population of about 300 million[7], and will grow to 325 million people by 2015. The region accounts for 4.6% of the world population and over 40% of that of sub-Saharan Africa, making it the most populated regional community on the African Continent.

As the region is faced with substantial deficiencies in the energy sector, the ECOWAS countries have adopted ambitious regional policies, committing themselves to harmonize national energy legislation, to increase the autonomy of energy supply and to significantly raise the level of access to modern energy services. Most policy initiatives and programs, like the Common Energy Policy and the West African Power Pool (WAPP), address these energy deficiencies mainly by focussing on grid extension and interlinked systems using large scale thermic and hydro projects which tend to look only at electricity access. Lack of clean, affordable energy is part of the poverty trap. Pollution from indoor use of harmful fuels for cooking and lighting leads to significant health problems. Gathering biomass fuels takes time that could be better spent - in school or at work. And the higher cost of inefficient energy-using devices and the lack of access to modern energy sources such as electricity become part of the BOP penalty - the added cost of being poor[8]. Targeting the BOP in rural and peri-urban areas remains very fragmented and has till date not really been the main objective of these policies and programs.

Some key examples exist in Africa, as mentioned in table 1 on page 5, where empowering this low-income market segment with clean and reliable energy services directly means increased health and labour conditions, increased savings on energy expenditures, increased economic output and return, less environmental degradation and more time to invest in education and social activities. It is commonly known that next to food and housing, energy is the biggest expense for low-income households accounting for an average of 9% of overall BOP household expenditure[9].

PICTURE 1. SOLAR THERMAL PARABOLA FOR SHEA NUT PROCESSING, MADE BY ISOMET IN DABARÉ, BURKINA FASO. PHOTO BY GREGORY MILLER, SNV.

Picture 1 shows a solar thermal solution giving a women's Shea nut cooperative in Burkina Faso access to an inexpensive reliable energy source for processing Shea butter. This highly important agricultural activity for rural women is still heavily dependent upon wood or diesel engines for processing. The up-scaling of this renewable energy solution would add much value to the Shea butter sector by saving on wood expenses, lowering processing time and increasing revenue for rural communities involved in the processing and commercialisation.

The ECOWAS' "White Paper for a Regional Policy"[10], endorsed by ECOWAS Heads of State and Government in January 2006 in Niamey, was a turning point in the acknowledgement of the need to address the issue of universal access to energy. Based on the context of ECOWAS, this white paper concludes that through increased supply of energy and increased access to modern energy services, ECOWAS could boost its GDP, reduce extreme poverty and achieve the MDGs by 2015. It's three fold specific objectives are: (i) the reinforcement of regional integration, (ii) the promotion of coherent, institutional and political frameworks for improved access to energy services in the ECOWAS region, and (iii) the development of coherent energy programs with a focus on poverty reduction. Within its specific objectives, the White Paper focuses on capacity building of private and public actors; the enhanced availability of soft loans, grants and private sector funds for energy services in rural or peri-urban areas; the improved exchange, promotion and dissemination of sub-regional experiences in view of energy services; and the promotion of local energy production and energy services[11].

Currently, seven years after the endorsement of the ECOWAS White Paper and three years away from its 2015 goal, the region continues to suffer from a huge demand / supply gap in modern energy services. As GIZ suitably affirms in its Energy-policy Framework paper[12] on the ECOWAS renewable energy sector, 64% of the total energy supply is covered by thermal power plants, 31% are generated with Hydropower and the remaining 5% comes from imports and other energy resources such as renewable energies.

How can we accelerate the pace and scale to make universal access to clean energy happen? How can private sector and local entrepreneurship play a more prominent role?

For the renewable energy sector to be able to flourish many things will have to change, but leapfrogging and decoupling from fossil fuels through the elimination of the continued fossil fuels subsidies is crucial. At the 4th International African Renewable Energy Alliance (AREA)[13] conference last May 2012, and the first International Off-Grid Renewable Energy Conference (IOREC) organised in Accra during the 29-31 October 2012 by ECREEE, International Renewable Energy Agency (IRENA) and Alliance for Rural Electrification (ARE), the outcomes show that once the market faces a level playing field for all types of energy, including fossil fuels – renewable energy will simply be the cheapest and most sustainable option. It therefore called on African leaders in power to redirect fossil fuel subsidies into renewable energy market development. Together with clear renewable energy and energy efficiency policies and regulatory frameworks focussing on energy services for low-income segments, business needs to take the lead in building the renewable energy sector while tackling energy access for the BOP. This obviously needs boldness, courage, commitment and urgency from the public and private sector together.

Many interesting initiatives are being undertaken in Africa. A first step is the creation of the ECOWAS Business Council, a regional private sector advisory body to ECOWAS policy makers, in order to put entrepreneurship and inclusive business models fighting poverty more explicitly on the West African political and economic agenda.

UNDP is moving ahead with the African Inclusive Market Facility (AFIM), which is a regional programme that is working to accelerate progress toward the Millennium Development Goals (MDGs) by supporting the development of inclusive, pro-poor markets across Africa. By bringing all relevant players together and building capacity of regional institutions to bridge the gap between public and private sectors as well as between policy and practical project implementation.

Another UNDP initiative called Growing Inclusive Markets (GIM)[14] highlights examples and cases of successful "*inclusive business models*". The following table shows a small selection of inspiring African best practices taken from GIM, WBCSD and Endeva which are ready for replication and upscale.

TABLE 1

SELECTION OF KEY AFRICAN INCLUSIVE BUSINESS CASES ON ENERGY ACCESS

AFRICAN INCLUSIVE BUSINESS CASES ON ENERGY ACCESS
Toyola Charcoal Stove: Improving the Environmental and Health of the Poor in Ghana (2010 - GMI)
TEMASOL: Providing Energy Access (solar) to Remote Rural Households in Morocco (2011 - GMI)
Maison Energy: Micro Enterprise for Rural Energy Access (wind, solar and hydroelectric power) in Morocco (2011 - GMI)
Rural Electrification in Mali: Improving Energy Accessibility to the Rural Poor (2007 - GMI)
Kuyasa CDM Project: Renewable energy efficient technology for the poor in South Africa (2010-GMI)
INENSUS in Senegal: Hybrid system (consisting of a small wind turbine, solar panels and a diesel aggregate) in Senegal selling electricity to the inhabitants of a village (2010 - Endeva)
Novozymes & CleanStar Mozambique: An integrated model for providing clean cooking fuels (ethanol from cassava) in Sub-Saharan Africa (2012 - WBCSD)

The African Development Bank (AfDB) has recently launched the African Guarantee Fund (AGF) and the Sustainable Energy Fund for Africa (SEFA), schemes aimed at easing access to finance among Small and Medium Enterprises (SMEs) in order to unlock their potential to deliver inclusive growth in the region. This public-private partnership is comprised of donors, development finance institutions and private investors expected to provide additional capital and scale up operations.

It is clear that the concept of inclusive business has tremendous potential in West Africa. While the rest of the world has to deal with contraction, Sub-Saharan economic growth has continued largely unabated. The International Monetary Fund (IMF) projects in its recent "World Economic Outlook" that growth in Sub-Saharan Africa is expected to increase from 5.1% to 5.4%, meaning more demand for energy and as such a growing need for innovative clean energy products and services.

The following table 2 describes the main key conclusions of three leading reports which deserve some special attention to boost inclusive business models in the energy sector in the ECOWAS region.

TABLE 2

LEADING REPORTS ON INCLUDING BUSINESS AND ENERGY ACCESS

KEY CONCLUSIONS/RECOMMENDATIONS[15] OF 3 LEADING REPORTS ON IB RELATED TO ENERGY ACCESS	
Hystra and Ashoka's Access to Energy for the BOP (2009)	• it appears that the gap between the social and the economic realms is not unbridgeable, as it is possible to both take into account social-related issues (in our case, access to energy) and create economically sustainable companies that meet with the demand of those "markets", that are sometimes seen as insolvent prior to examination. • the adequate response to the needs of underprivileged sections of the population can be elaborated not only by developing products and services that are cost and need efficient, but also through the optimization of the "human capital" of the above-mentioned sections— i.e. their organization skills, the existing solidarities between them, and their social networks. • the most successful social entrepreneurs are also the ones who tried harder to get the users who were implied in the value-added processes involved. Indeed, viewing users as agents and including them in the production, transformation and distribution processes, does seem to be a key condition to the development of promising social businesses.
Endeva's Energize the BOP! (2011)	This report is a comprehensive guide on "inclusive business" as producers and consumers. It brings together existing knowledge, presents several practical examples and provides information about contacts and further reading.
WBCSD's Business Solutions to Enable Energy Access for All (2012)	• lack of access to clean, reliable and affordable energy services must be overcome to achieve MDGs. • business a primary provider to expand access to energy. • business model innovation. • enabling policy frameworks. • financing mechanisms. • public and development finance should leverage private investment. • cross sector approaches. • effective public partner partnerships.

As Business Fights Poverty[16] rightly mentions, all three reports describe the need for access to energy at the base of the pyramid. All three describe business drivers like new markets, the opportunity for innovation, and competitive advantage. And all three examine three primary business models: electricity grid extension, distributed energy systems (which Endeva labels mini-grids and Hystra discusses within the category of rural cooperatives), and off-grid systems and devices such as solar home systems, solar lanterns, and biomass cook stoves. For each business model, common business challenges and success factors are identified. At the same time, all three reports emphasize the need for a broader enabling environment for the energy sector inclusive business models to succeed and scale – discussing the regulatory, policy, and financing requirements in varying degrees of detail. A common theme is that collaboration among business, government, civil society, and the donor community is crucial.

4. CONCLUDING REMARKS

It is clear that much can be done on inclusive business models in West Africa. Given the market structure, West African entrepreneurs have excellent skills in adapting their business models to cater to low-income consumers.

Inclusive business models are just one example of the multiple ways in which the private sector can contribute to tackle the "lack of universal access to (renewable) energy" and "energy poverty". It can help build holistic and contextual energy solutions to support West African sustainable development efforts and an energy and resource-constrained environment.

Effective public-private partnerships are therefore urgently required to create the appropriate frameworks, the capacity and the incentives to fully leverage and promote inclusive business. This cooperation will help ensure that West Africa will build what is needed for the future – a sustainable region within an emerging continent in which 325 million people live well and within the limits of our rapidly changing world.

NOTES

1. Officially named "*White Paper for a Regional Policy geared towards increasing access towards increasing access to energy services for rural and periurban populations in order to achieve the MDGs*", 2005, ECOWAS.
2. *The business of inclusion: sustainable and equitable solutions*, by Marcel Engel and Filippo Veglio, in Trade and Investment for Prosperity, Australia, 28 – 30 October 2011.
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4. www.endeva.org, Enterprise solutions for Development, endeva's mission is to inspire and support enterprise solutions to the world's most pressing problems: making poverty a thing of the past and preserving ecosystems for the future.
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14. http://www.growinginclusivemarkets.org/
15. Phrasing taken from the reports itself
16. http://www.businessfightspoverty.org/profiles/blogs/resources-for-practitioners-inclusive-business-models-in-the; Resources for practitioners: inclusive business models in the energy sector, posted by BFP Editor on February 27, 2012 at 10:30

AUTHOR

Willem Adrianus Bron. Head of the RE country of programmes, in Burkina Faso, SNV.

www.snvworld.org

ECREEE INVESTMENT PROMOTION INITIATIVES (EREF, EREI)

DAVID VILAR, MARTIN LUGMAYR,
AMINATA FALL Y MAHAMA KAPPIAH
ECREEE

ABSTRACT

This article presents the mechanisms ECREEE has already established to promote financing and investment on RE&EE in the ECOWAS region. The ECOWAS RE&EE Facility (EREF) is a small-grant fund targeting rural and peri-urban business models and to improve the energy access in the region. The ECOWAS RE Investment Initiative (EREI) is a multi-activity strategy to attract and promote investments for medium and large scale RE infrastructures in the region.

Keywords: finance, investment, ECOWAS, renewable energy.

1. INTRODUCTION

The energy sector in West Africa is facing many challenges, among which:

- lack of modern energy access for about 60% of the population;
- growing electricity demand, particularly in peri-urban and rural areas;
- problems in the generation systems because of reliance on fossil fuels and aging facilities;
- expensive energy cost;
- Climate change impacts calling for the need for GHG mitigation and adaptation of energy systems.

Notwithstanding the abundant RE resources within the ECOWAS region, it is generally acknowledged that without major investments in sustainable energy frameworks and infrastructure in West Africa, the regions energy access, energy security and climate objectives cannot be achieved simultaneously in the forthcoming decades. Major investments are required to enhance the development of renewable energy markets in the ECOWAS region.

Experience has also shown that the successful implementation of renewable energy programmes does not only depend on sound project management, but to a large extent, on political will, sound market regulation, and the technical and human capacities available. Whereas the investment funds for renewable energy activities are increasing globally, the ECOWAS region has only succeeded in attracting a fraction of these investments. There is therefore a clear need for increased and urgent efforts to enhance the policy and investment environment for renewable energy in the ECOWAS member countries.

Globally and also in developing countries, investment in renewable energies is increasing. Although, there are few players and investors in West Africa, there is a nascent interest from the private sector. The ECOWAS Commission will capitalise on this interest by putting in place appropriate policy and enabling regulatory frameworks that boost investor confidence.

2. WEST AFRICA RE SECTOR AS AN INVESTMENT OPPORTUNITY

The RE sector in West Africa shows good investment opportunities for the following reasons:

- The energy market is continuously growing in the ECOWAS Member States. However, the capacity installed increases at a lower rate than the demand growth. The difference in supply and demand pattern results to deficit in supply. Hence, there is a demand to be met and power generation needs to be drastically increased.
- The global fossil fuel markets have been characterized by high prices and volatility since 2003. Therefore, the former model for providing energy services using fuels may not be able to meet growing demands for energy in the region, as it is neither sufficient nor affordable. At the same time, RE technology costs decreased continuously in recent years and are expected to drop further.
- New regulatory frameworks are under elaboration at regional level as well as national level in many countries. Countries such as Cape Verde, Ghana and Senegal have adopted RE Law.

Some examples and enabling actions to promote RE Investments in the ECOWAS region:

- The Government of Senegal passed an RE legistation in 2010 and is managing a portfolio of projects which includes, amongst other forms of RE, the exploitation of wind resources in the northern part of the country.
- The Government of Cape Verde passed a RE legistation in 2011 and has approved an investment plan to reach 50% of RE penetration by 2020.

- The Government of Ghana passed a RE legistation in 2011 with a RE Quota Obligation of 10% and is currently defining the Feed-in-Tariff Decree.
- The Government of The Gambia is currently drafting a RE policy and regulatory framework to attract RE investors to the country.
- Several ECOWAS countries are identifying various RE micro-grids in rural areas and also establishing the regulatory framework to attract investors and promoters of these types of projects.
- In 2008, ADDAX initiated The Makeni ethanol power project (MEPP) in Sierra Leone to be operational in 2013. The project aims at production of bio-ethanol for domestic use, power to the grid and energy exports.
- In 2010, Cape Verde commissioned the firs Wind IPP of 0.5 MW
- In 2010, Cape Verde commissioned two grid-connected PV parks, 2.5 and 5 MW.
- In 2011, Cape Verde, through CABEOLICA project, inaugurated the largest wind farm of the region (25 MW).
- The European Union Delegation in Burkina Faso is financing a major PV investment of 20 MW.
- In 2012, VRA and the Public Utility and Regulatory Committee (PURC) of Ghana agreed on purchase of electricity from a 2 MW solar PV power plant. VRA is also pursuing the installation of 10 MW PV plants and 100 to 150 MW wind farms in the country.

3. MAIN CHALLENGES TO INVESTMENTS IN WEST AFRICA RE SECTOR

3.1. CAPITAL COSTS IMPACTING ON THE ELECTRICITY PURCHASE PRICE

The energy price target of the ECOWAS White Paper strategy is of particular importance when it comes to RE. For energy services to be provided at *affordable prices* there is a need for production at competitive cost. For renewable projects, this means to get access to finance up-front costs such as feasibility studies etc. and further lower cost of capital as that is a major part of the project's economic viability. The structure of capital is basically a mix of Equity, Debt and Grants. The misperceptions of risk on those capital components are impacting capital cost and could be lowered with reliable information on risk mitigation tools, such as partial risk guaranties and innovative project finance mechanisms. By creating a link between project promoters and its financial partners and potential investors in the renewable energy projects of the region, ECREEE's aim is to mobilize financial support for these projects.

3.2. THE PUBLIC SECTOR CONTRIBUTION TO RE FINANCE

Governments and public institutions have a crucial role to play for RE deployment in West Africa. There are still misperceptions on cost of RE technologies and related risk factors which influence that cost. According to the IEA, the deployment of large scale RE projects need support from public institutions, namely governments and development and investment banks. The contribution of public sector should include the following:

- Awareness raising by governments to disseminate reliable information on RE technologies, costs and related risks and demonstration that investment on RE can be advantageous in the long term. The Government can also lead by example to facilitate public and corporate acceptance of RE technologies by installing RE technologies on public buildings.
- Several African countries have boosted RE deployment by exempting RE equipment from taxes and import duties. Consequently, RE becomes a more attractive option for private households and enterprises to meet their energy needs.
- Governments have influential place in Boards and Committees of investment and development Banks that they can use on RE favourable orientation lending policies (obligation of commercial banks to a certain share of their portfolio is comprised of RE and Energy Efficiency investments).

- Tailored Policies on strategic parts of RE technologies value chain and green growth: Since RE technologies are still in the process of innovation, there should be tailored policies on local manufacturing in the value chain which can promote green growth, a strategic deployment of RE technologies taking into account the inverse evolution of value on product and services that the product allows to access.

3.3. THE PRIVATE SECTOR CONTRIBUTION TO RE FINANCE

The amount of investment needed for RE deployment in the region justifies implication of private sector which can be leveraged by public contribution. Private sector can be commercial banks, Energy Services Corporate (ESCOs) and pension funds. The latter are of particular interest in the context of financial crisis where many soft service sectors loose much attractiveness. The RE infrastructure projects need high upfront investment which is easy to mobilize by those funds and long term return of the investment can satisfy those organizations.

Therefore, the private sector encouraged by public sector involvement can contribute to invest in the regions RE sector.

4. ECREEE ACTIONS TO ATTRACT INVESTMENTS IN RE IN WEST AFRICA

The ECOWAS Commission, within its mandate to contribute to a sustainable development for the region, is committed to overcome challenges in the energy sector in order to ensure access to modern and reliable energy at affordable prices. To this end:

- In 2006, ECOWAS adopted the White Paper on improving access to energy services for population in the region, with a focus on rural and peri-urban areas. The White Paper specifies that 20% of new investment in the energy sector should be from local RE resources.
- In 2010, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) was established by the ECOWAS

Council of Ministers with support from the Governments of Austria and Spain and the United Nations Industrial Development Organization (UNIDO). The specific objective of ECREEE is to create favorable framework conditions and an enabling environment for renewable energy and energy efficiency markets, by supporting activities aimed at mitigating existing barriers. Those activities include policy development, capacity building, awareness raising, knowledge management as well as business and investment promotion.

- In October 2012, the ECOWAS Energy Ministers adopted the regional RE and EE policy establishing ambitious targets for the region in the next 10 and 15 years. These regional policies will serve to guide the region's efforts to employ sustainable energy technologies and resources, notably in our efforts to attain universal energy access. The execution of these policies at the regional and national levels will facilitate RE investments by removing the existing related barriers to the deployment of these technologies in the ECOWAS region.
- In October 2012, ECREEE launched the ECOWAS Observatory for RE&EE (ECOWREX) to boost knowledge management, networking, advocacy and strengthening of capacities on renewable energy and energy efficiency (RE&EE) addressing the existing knowledge and information barriers for RE&EE investments in the ECOWAS region.

To promote investment in the RE sector, ECREEE initiated in 2011 two actions:

1. A first call for proposals under the framework of the ECOWAS RE Facility (EREF). The EREF is awarding grants to small scale RE projects identified in the region. The 41 projects selected by EREF are being implemented with the assistance of ECREEE.
2. For medium and large scale projects ECREEE established the ECOWAS RE Initiative (EREI) with the main objective to facilitate communication between promoters and financiers interested in the RE sector of West Africa.

Both initiatives are part of an effort by the Centre to execute the investments on Renewable Energy (RE) laid out in the ECOWAS white paper on improving access to energy services for population in the region, with a focus on rural and peri-urban areas.

4.1. ECOWAS RE AND EE FACILITY (EREF)

The implementation of an ECOWAS Renewable Energy Facility (EREF) is undertaken within the execution of the action line Number 2 of the ECOWAS/UEMOA White paper which calls for an innovative investment fund for RE and EE projects to raise funding for at least 200 projects and support to local manufacturing and service companies. The Facility contributes to respond to the urgent need of investment for rural and peri-urban areas of West Africa where access to energy services is still a challenge. The EREF focus on small and medium scale RE and EE projects, mainly in rural and peri-urban areas. A first call for proposals was launched on 2011 and 166 proposals were received from promoters across the 15 member countries. 41 of those projects were approved for grant award after two stage appraisal process and an external evaluation. The selected projects are from different promoters across, figure 1 shows type of applicant in percentage of approved projects.

The projects approved focus on different thematic areas related to RE and EE. Figure 1 shows thematic are of the 41 approved projects.

The implementation of the approved projects started on November 2012 and the following results are expected.

Increase modern energy access in disadvantaged areas through the use of local resources and reduction of energy related negative externalities:

- Strengthen capacities of small and medium project developers and promoters by support from ECREEE to improve quality of proposals during the second stage of the evaluation process.
- Contribution to strengthen capacity of project beneficiaries with an important training component in activities of approved projects.

- Contribution to development of local economy.
- Knowledge transfer by dissemination of lessons learned through the ECOWAS RE and EE Observatory (ECOWREX) and publication from promoters of funded projects.
- High visibility of ECREEE and its NFIs on the ground and by the private sector.
- Strengthen knowledge base and capacities of the ECREEE secretariat.

FIGURE 1

TYPE OF APPLICANT IN % OF APPROVED PROJECTS

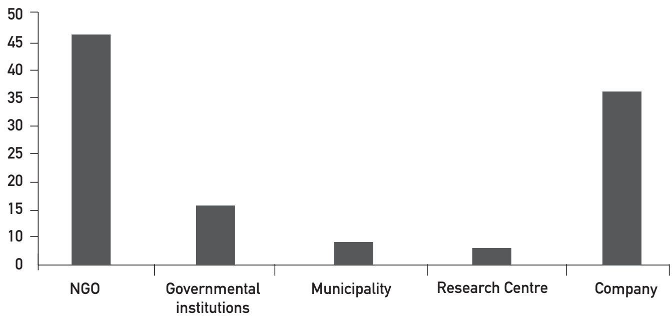


FIGURE 2

THEMATIC OF EREF OF APPROVED PROJECTS

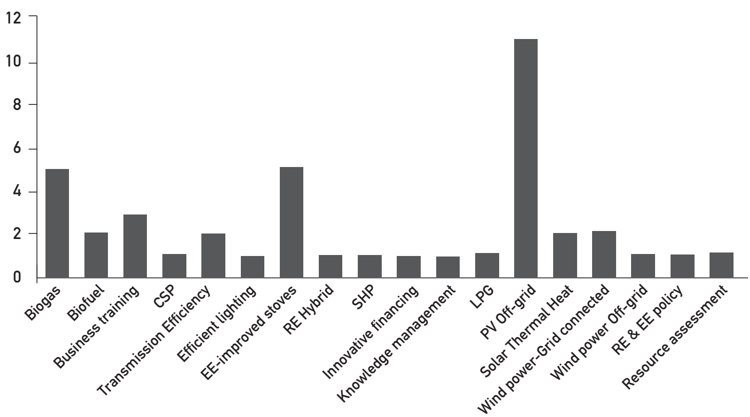
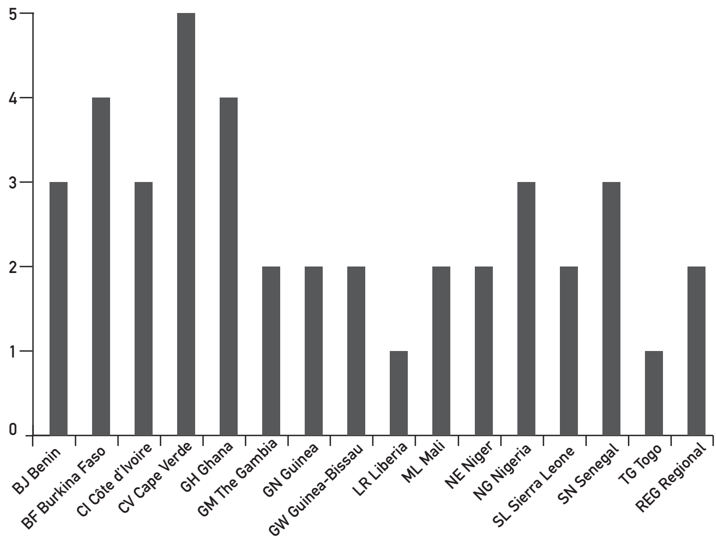


FIGURE 3
DISTRIBUTION OF APPROVED EREF PROJECTS PER ECOWAS COUNTRY

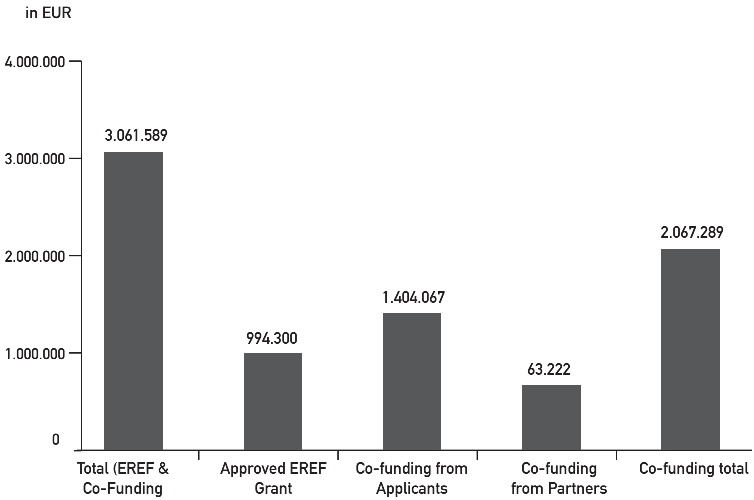


The EREF initiative is implemented with support from the Governments of Austria and Spain, it is in alignment with the Paris Declaration on Aid Effectiveness which calls for a strengthening of local ownership, capacities and increased use of local systems to implement development aid. The Facility design is based on a proven concept already implemented in Central America, Mekong, Andean region and Southern Africa.

With the finalization of the first EREF call, a major mile-stone was achieved by the ECREEE staff. The Technical Committee of the ECOWAS Renewable Energy Facility (EREF) for rural and peri-urban areas approved 41 projects with an overall volume of 3 million EUR. ECREEE is co-funding with around 1 million EUR (see report attached - around 25% of received concept notes approved). The facility will be managed by ECREEE with technical assistance from UNIDO and will co-fund the selected projects with 1 million EUR from the Spanish Agency for International Development (AECID) and the Austrian Development Cooperation (ADC). The projects will be implemented throughout the next two years.

FIGURE 4

APPROVED EREF GRANTS AND CO-FUNDING. AVERAGE EREF GRANT LEVERAGE OF 68%



4.2. ECOWAS RE INITIATIVE (EREI)

The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) launched the ECOWAS Renewable Energy Investment Initiative (EREI) as part of its mandate to attract investment on RE projects in the West Africa region. The EREI is planned as a commitment of ECOWAS to promote implementation of medium and large scale RE power plants, in order to overcome the energy challenges faced by the region.

The objective of EREI is to provide support to the implementation of RE projects by creating a platform which link-up promoters and interested financiers.

The mid-term objectives of the EREI are:

- To foster and endorse investment to promote RE infrastructure projects in West Africa.

- To facilitate the execution of RE investment projects in the region.
- To link up different stakeholders involved in the finance and development of RE infrastructure projects in West Africa.
- To decrease the misperceptions on investment-cost of RE projects in West Africa through the appraisal from ECREEE, a specialized agency of the ECOWAS Regional Government.
- To create a link between project promoters and financial partners and potential investors of these infrastructure projects.
- To become a focal point for stakeholders interested by the RE sector of West Africa.
- To finance preparatory and feasibility activities of RE Infrastructure Projects in the region
- To make the RE power sector in West Africa more attractive for Foreign Direct Investment (FDI).
- To provide reliable and updated information about existing and identified RE projects in the region.

Within the context of the EREI initiative, ECREEE initiated the inventory of all medium to large scale RE Infrastructure projects in the region, with support of its network of national focal institutions (NFI). At the end of the process, 156 projects are accounted for in the region, at different stages of development. From those 128 projects, 64 projects have reached an advanced stage of development (and available information) in order to be considered identified projects, the rest are still in a very early stage of maturity. Of the 64 projects, some have reached the financial close or are in a very advanced stage of development. ECREEE collected the remaining 41 projects in order to provide direct support to their development. The 41 projects were given to the British cabinet, Sinclair Knight Merz Limited (SKM) for a high level review, to support meeting discussions between promoters and financiers.

The characteristics of these projects are:

- Capacity installed from 1 to 100 MW.
- RET: Solar PV, Wind, Small Hydro, Waste to Power and Biomass.
- Type of power plant: grid-connected and isolated grid.
- Location: in the 15 ECOWAS countries.

FIGURE 6

CHART WITH THE IDENTIFIED CAPACITY TO INSTALL IN THE ECOWAS RE INVESTMENT INITIATIVE PIPELINE PER TECHNOLOGY

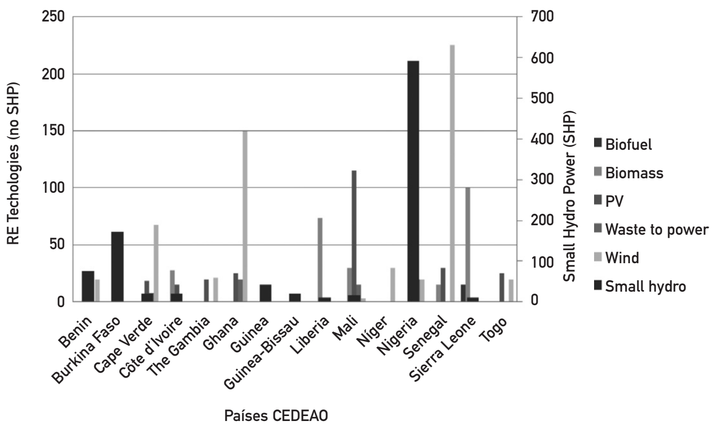


TABLE 1

NUMBER OF PROJECTS IN THE ECOWAS RE INVESTMENT INITIATIVE PIPELINE

ECOWAS COUNTRY	BIOFUEL	BIOMASS	PV	SMALL HYDRO	WASTE TO POWER	WIND	TOTAL
Benin			1	3		1	5
Burkina Faso			3	29			32
Cape Verde			6	1	2	11	20
Côte d'Ivoire		2	1	1			4
The Gambia			1			3	4
Ghana			2		1	2	5
Guinea				3			3
Guinea-Bissau			1	1			2

TABLE 1

NUMBER OF PROJECTS IN THE ECOWAS RE INVESTMENT INITIATIVE PIPELINE (CONT.)

ECOWAS COUNTRY	BIOFUEL	BIOMASS	PV	SMALL HYDRO	WASTE TO POWER	WIND	TOTAL
Liberia		3		2			5
Mali		1	13	7	1	2	24
Niger						1	1
Nigeria			2	7	1	1	11
Senegal		1	2			3	6
Sierra Leone	1	1		1			3
Togo			2			1	3
Grand Total	1	8	34	55	5	25	128

TABLE 2

IDENTIFIED CAPACITY TO INSTALL IN THE ECOWAS RE INVESTMENT INITIATIVE PIPELINE

ROW LABELS	BIOFUEL	BIOMASS	PV	SMALL HYDRO	WASTE TO POWER	WIND	GRAND TOTAL
Benin			6	75		20	101
Burkina Faso			43	171			215
Cape Verde			19	20	8	68	114
Côte d'Ivoire		28	15	20			63
The Gambia			20			21	41
Ghana			25		20	150	195
Guinea				43			43
Guinea-Bissau			5	20			25
Liberia		73		12			85
Mali		30	115	16	15	3	180
Niger						30	30
Nigeria			40	591	20	20	671
Senegal		15	30			225	270

TABLE 2

IDENTIFIED CAPACITY TO INSTALL IN THE ECOWAS RE INVESTMENT INITIATIVE PIPELINE (CONT.)

ROW LABELS	BIOFUEL	BIOMASS	PV	SMALL HYDRO	WASTE TO POWER	WIND	GRAND TOTAL
Sierra Leone	15	100		10			125
Togo			25			20	45
Grand Total	15	246	343	978	63	557	2,201

4.3. ECOWAS RE INVESTMENT FORUM

The ECOWAS RE Investment and Business Forum is the showcase of the EREI, where periodically; investors, lenders and promoters of RE projects in West Africa will meet under the umbrella and sponsorship of ECOWAS Governments, through its specialized agency ECREEE. The main objective of the Forum is to create a permanent framework where financiers and project promoters could meet to discuss the existing opportunities in the West Africa RE industry and the main issues to tackle, with ECREEE as facilitator.

The first Edition of the Forum, held on the 27th and 28th of September in Dakar, was attended by approximately 90 participants coming from Senegal, other ECOWAS member States, Europe and USA. The participants were mainly financiers, project promoters, donors and market analysts who are interested in knowing more about the investment opportunities in the West Africa RE market.

The activities to be undertaken during the meeting should provide the following results:

- The communication bridge between promoters of RE projects and financial partners is established.
- Awareness raising on the change of paradigm in the Power Sector for RE in urban and Rural Electrification is done.
- Financial partners interested in providing capital to RE projects in West Africa are listed.

ECREEE is already committed to organize the second edition of this Forum, in mid 2013. The EREI Initiative should become a platform for stakeholders to exchange project and investments on RE.

The key actions for the deployment of the EREI, will focus on the following axis:

1. To include the EREI Forum in the agenda of major RE finance events.
2. Establishment of a steering committee for selection of projects to be presented during annual meetings; objective criteria need to define the member institutions/organizations of this committee.
3. The communication on activities of the EREI Initiative: the design of an investment portal in the new ECREEE website, conception of communication products and follow-up on social media as well as to include an EREI contacts database to facilitate personal communications with stakeholders.
4. The identification of additional partners and sponsors, inside and outside West Africa financiers' community.

5. CONCLUSION

With the EREI Initiative, ECREEE is starting an exciting and ambitious process to facilitate the realization of RE infrastructures in West Africa which participants to the first edition of the Forum gave support. Indeed, the important opportunities in the West Africa RE sector call for urgent actions in order to decrease the number of existing barriers to their exploitation, the mobilization of funds for existent projects among others. Many of these projects have conclusive feasibility studies and some of these funds are being mobilized but gaps still remain to be filled. ECREEE is committed to the task of developing innovative mechanisms and actions to fill these gaps. In the coming years ECREEE will continue to organize and implement an efficient multi-year program to promote RE

Investments aimed at benefiting the RE industry and the population of West Africa.

AUTHORS

David Vilar. Technical assistance of AECID in ECREEE.

Martin Lugmayr. Renewable Energy Expert at ECREEE/UNIDO

Aminata Fall. Project assistant in ECREEE.

Mahama Kappiah. Executive Director in ECREEE.

www.ecreee.org

The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), the Instituto Tecnológico de Canarias (ITC) and Casa África have prepared this publication on the state of renewable energy in Western Africa. It is a compilation of articles written by various authors and important regional and international institutions.

The objective is to present the current situation and latest trends in renewable energy in West Africa in the international context. This book is also a contribution to the UN International Year of Sustainable Energy for All, and complements the efforts of the ECREEE in managing and disseminating as well as those of the RENOW project (MAC/3/1982), led by the ITC, which seeks to elaborate strategies in developing renewable energy in the Euro-African Atlantic Area, led by the ITC.

This publication includes articles on the legal framework and State-of-the-Art renewable energy technology, both in the West African and International regions including experiences shared in the renewable energy sector.

2012 INTERNATIONAL YEAR OF SUSTAINABLE ENERGY FOR ALL

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IBIC: KNBT/1HFD

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ISBN: 978-84-8198-880-2