MAURITANIA

Renewables Readiness Assessment

September 2015

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a future of sustainable energy, and serves as the principal platform for international co-operation, a centre of excellence, and a pool of renewable energy policy, technology, resources and financial knowledge. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.
www.irena.org

About UNDP

The United Nations Development Programme (UNDP) is the United Nations' global development network – an organisation advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. On the ground in 166 countries, UNDP works to assist national counterparts on their own solutions to global and national development challenges, considering rule of law an indispensable factor for the enhancement of human development and the reduction of conflict, poverty and insecurity.

About RRA

A Renewables Readiness Assessment (RRA) offers a holistic assessment of the situation in a given country and identifies the actions required to overcome barriers to renewable energy deployment. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders. While the RRA helps to shape appropriate policy and regulatory choices, each country determines which renewable energy sources and technologies are relevant and consistent with national priorities. The RRA is a dynamic process that can be adapted to each country's circumstances and needs. Experience in a growing range of countries and regions has allowed IRENA to continue refining the basic RRA methodology. In June 2013, IRENA published a guide for countries looking to speed up their renewable energy deployment. For more information, visit www.irena.org/rra.

Acknowledgement

This report was commissioned by IRENA in collaboration with UNDP, with valuable input from Laurent Dittrick (international consultant) and Ahmedou Hamed (national consultant).

IRENA and the UNDP would like to acknowledge the valuable comments and guidance offered by Cheikh Moctar (APAUS), Dah Ould Sidi Bouna (Director and RRA Focal point, MPEM) and Cherif Kane (UNDP, Mauritania)

IRENA wishes to thank the following experts for their insights and constructive comments during the peer review process: Ashraf Kraidy (League of Arab States – LAS), Chingiz Orujov (Islamic Development Bank), Habib El Andaloussi (United Nations Economic and Social Development Commission in Western Asia – UN ESCWA), Maged Mahmoud (Regional Centre for Renewable Energy and Energy Efficiency – RCREEE), Linus Mofor (IRENA) and the Country Support and Partnerships team at IRENA (Ilham Talab, Juan Martinez and Kavita Rai).

Authors: Mustapha Taoumi, Gauri Singh and Gürbüz Gönül (IRENA)

Disclaimer

Mauritania

Renewables
Readiness
Assessment

FOREWORD

from the Minister of Petroleum, Energy and Mines

Over the past five years, the electricity sector of Mauritania has experienced steady growth in all of its segments: generation, transport and distribution. An ambitious programme, based on a series of appropriate reforms and major investment, is being led by the public authorities to carry out a recovery plan for the sector to ensure universal access to sustainable energy services at a lower cost and to ensure the availability of reliable and secure electricity for economic operators. The programme places great emphasis on reducing energy costs through the enhancement of national energy resources, including less-polluting resources such as thermal (natural gas) and renewables (solar and wind).

After establishing a clear diagnosis of the situation of the sector in 2009, the Government has undertaken to develop a clear strategic vision structured around the following main axes:

- Add production capacity from local resources, mainly natural gas and hydroelectricity.
- Develop national and regional grid and interconnection networks.
- Enhance the role of renewable energy in the energy mix.
- Implement decentralised solutions in remote and isolated areas.

Thus, a Master Plan for the Production and Transport of Electricity was adopted in 2012, intended to provide guidance and technical, economic and financial recommendations for developing the means of production and transportation to cover energy demand in the interconnected network, reduce the number of isolated centres and develop rural distribution networks. It is in this context that the authorities decided in 2011 to launch a project to generate electricity from offshore natural gas deposits discovered in Banda in 2001. The natural gas extracted from this project will feed several electric generating units interconnected with domestic and industrial demand centres.

It should be noted that renewable energy already dominates the sustainable development programme initiated by the authorities in Mauritania. The Poverty Reduction Strategy Paper (PRSP) has set a target of raising the share of renewable energy in the national energy mix to 15% by 2015 and 20% in 2020. Following the commissioning in 2013 of the Sheikh Zayed 15 MW solar photovoltaic (PV) plant in Nouakchott, and after completion of the construction of a 30 MW wind power plant and a 30 MW solar PV plant in Nouakchott, this goal will be greatly exceeded. With the contribution made by hydropower, the share of renewable energy in the national energy mix will reach 34% in 2015. Furthermore, a feasibility study is under way for the construction of a 100 MW wind farm in Boulenouar in the northern part of the country.

The authorities have sought the support of the United Nations Development Programme and the International Renewable Energy Agency, with a view to integrating renewable energies into a long-term vision, highlighting the contribution of these resources in structuring interventions by key stakeholders, and encouraging the use of renewables in all sectors of the economy, as well as creating the optimum conditions for achieving the country's national objectives. The authorities are very grateful to IRENA and UNDP for their support in the implementation of the Renewable Readiness Assessment as a principal component of a comprehensive renewable energy strategy in Mauritania.

In conclusion, I would like, on behalf of the Government of Mauritania, to thank IRENA for its support for the country, and I remain convinced that with the support of technical and financial partners in general development actions, and especially that of IRENA, Mauritania will achieve its goals in promoting renewable energies.

Mohamed Salem Bechir
Minister of Petroleum, Energy and Mines of Mauritania

An ambitious programme, based on a series of appropriate reforms and major investment, is being led by the public authorities to carry out a recovery plan for the sector to ensure universal access to sustainable energy services at a lower cost and to ensure the availability of reliable and secure electricity for economic operators.

FOREWORD

From the Resident Representative, UNDP Mauritania

Energy is one of the key elements of human sustainable development. Fossil fuels are among the most used energy sources in the world, even if their import weighs heavily on national budgets. They are also partly responsible for climate change, as the Intergovernmental Panel on Climate Change recently confirmed. Finally, these resources are finite, underlining the need for humanity to think of other, cleaner, energy sources to support sustainable and inclusive development.

This is why the United Nations Secretary-General, Ban Ki-moon, launched the Sustainable Energy for All (SE4ALL) initiative in 2011. It has three interlinked objectives to be achieved by 2030: 1) ensure universal access to modern energy services, 2) double the global rate of improvement in energy efficiency and 3) double the share of renewable energy in the global energy mix. As Mr Ban Ki-moon said: "Energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive. Sustainable Development is not possible without sustainable energy."

Mauritania joined the SE4ALL initiative in 2014. This global priority has been included in the United Nations Development Assistance Framework 2012-2016 of the United Nations System in Mauritania. The United Nations Development Programme (UNDP) ensures the leadership in this area in Mauritania. It is in this context that UNDP initiated the elaboration of a "National Strategy for Renewable Energy" in 2012, at the request of the Ministry of Petroleum, Energy and Mines, to help Mauritania optimise its use of an abundant renewable energy resource.

In 2013, UNDP mobilised the International Renewable Energy Agency (IRENA) to join the initiative. The final objective of this initiative is to improve the population's access to clean and sustainable energy resources, namely in rural areas, where access to electricity remains low (approximately 5%). These renewable energy sources can also be used by the productive sector, including mining, as well as for production, transformation and conservation of agricultural and fishing activities.

These efforts are illustrated by the inauguration in 2013 of the 15 MW solar photovoltaic power plant. A 30 MW wind farm is also being installed, while hydropower continues to be pursued through recent OMVS installations. This does not account for numerous smaller-scale initiatives already operational or planned by SOMELEC, SNIM, APAUS, ADER and others.

M. Mario Samaja
Resident Representative
UNDP Mauritania

Renewable energy can be used by the productive sector, including mining, as well as for production, transformation and conservation of agricultural and fishing activities.

FOREWORD
from the IRENA Director-General

Like much of the Middle East and North Africa, Mauritania enjoys an abundance of sunshine and also considerable wind resources. The transition to making large-scale use of these clean, renewable energy sources entails considerable challenges on the policy, infrastructure and investment fronts.

The Renewables Readiness Assessment (RRA) process provides a holistic evaluation of a country's conditions, identifying actions to overcome the barriers to renewable energy deployment. The process is country-led, with the International Renewable Energy Agency (IRENA) offering technical support and expertise to facilitate consultations among different national stakeholders.

Since 2011, more than 14 countries in Africa, the Middle East, Latin America and the Caribbean, Asia and the Pacific Islands have undertaken the RRA process, which generates knowledge of best practices and supports international co-operation to enable the accelerated deployment of renewable technologies. Mauritania, in keeping with its strong and consistent support of IRENA's mission, is one of the countries pioneering the RRA process in the Middle East and North Africa region.

As the RRA highlights, the country has already taken steps towards large-scale use of renewable energy for on-grid and off-grid applications. The 15 megawatt-peak Sheikh Zayed solar photovoltaic plant, commissioned in 2013, now provides 7% of the power supply of Nouakchott. The same city is also set to benefit from a new 30 megawatt commercial wind farm, a project financed by the Mauritanian government and the Arab Fund for Economic and Social Development.

With an electricity network consisting of mini-grids, Mauritania is well positioned to integrate solutions and business models based on renewable energy. Meanwhile, the United Nations Development Programme (UNDP), within the Sustainable Energy for All initiative, is helping tackle the gaps the country faces regarding access to energy.

By supporting the RRA process, IRENA and UNDP aim to demonstrate the viability of renewable energy solutions for Mauritania and thereby attract investment in the sector. This report provides the foundation for a concrete and visible strategy for doing so, along with a related action plan.

IRENA would like to thank Minister Mohamed Salem Bechir, former minister Mohamed Ould Khouna and their teams for their generosity in hosting this study. We are grateful for their important contributions, which have resulted in valuable insights for RRAs in other countries. Additionally, this report will feed into IRENA regional work, including modelling and analysis on integration and planning for renewable energy across North Africa.

We sincerely hope that the outcomes of these RRA consultations will help Mauritania in its pursuit of the transition to an energy system driven by renewables. IRENA stands ready to provide continuing support to the country in implementing the actions identified.

Adnan Z. Amin
Director-General
IRENA

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF BOXES

ABBREVIATIONS

ACP/EU-EF	African Caribbean and Pacific/ European Union Energy Facility
ADER	Rural Electrification Development Agency
AFD	Agence Française de Développement
AMU	Arab Maghreb Union
ANADER	National Agency for the Development of Renewable Energy
APAUS	Agency for the Promotion of Universal Access to Basic Services
ARM	Multisectoral Regulation Authority
ASP	Authorised service provider
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
CNRADA	National Research Centre for Agronomy and Agricultural Development
COMELEC	Maghreb Electricity Committee
CRAER	Centre for Applied Research in Renewable Energy (University of Nouakchott)
CSP	Concentrated solar power
DEME	Directorate of Electricity and Energy Control
ECOWAS	ECOWAS Economic Community of West African States
ECREEE	Centre for Renewable Energy and Energy Efficiency
EDF	European Development Fund
ENFVA	School of Education and Agricultural Extension
ESMAP	Energy Sector Management Assistance Program
FADES	Arab Fund for Economic and Social Development
FAUS	Fund for Universal Access to Services
GDP	Gross domestic product
GIS	Geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GNP	Gross national product
GRET	Group for Research and Technological Exchanges
HFO	Heavy fuel oil
IDB	Islamic Development Bank
IPP	Independent power producer
IRENA	International Renewable Energy Agency
ISET	Higher Institute of Technological Education: Institut Supérieur d'Enseignement Technologique
ITC	Canary Islands Institute of Technology
kWh	Kilowatt-hour
MPEM	Ministry of Petroleum, Energy and Mines
MW	Megawatt
MWp	Megawatt-peak
NGO	Non-governmental organisation
OFID	OPEC Fund for International Development
OMVS	Senegal River Basin Development Authority
PPA	Power purchase agreement
ProCEAO	Programme for Efficient Cooking Energy in West Africa
PRS	Regional Solar Programme
PRSP	Poverty Reduction Strategy Paper
MFSP	Multifunctional Solar Platform
SE4ALL	United Nations Sustainable Energy for All initiative
SPEG	Company for the Production of Electricity from Gas
SNIM	National Company for Industry and Mining
UNDP	United Nations Development Programme
WAPP	West African Power Pool

EXECUTIVE SUMMARY

The Renewable Readiness Assessment (RRA) is a wide-ranging tool initiated by the International Renewable Energy Agency (IRENA) aimed at assessing national conditions for the development and deployment of renewable energy and, more specifically, the actions required to improve those conditions. The RRA process was initiated at the request of Mauritania in collaboration with the United Nations Development Programme (UNDP) country office. The official launch of the RRA process was held on 12-13 November 2013 in Nouakchott with strong participation and engaged discussions. The final report validation workshop was organised on 28 May 2014 in Nouakchott.

ECONOMIC OVERVIEW

Mauritania is a large, semi-arid country with a population of 3.4 million people, 60% of whom are under the age of 25. Just over 41% of the population lives in urban areas, and urbanisation is increasing at a rate of 2.9% per year. Gross Domestic Product (GDP) per person was USD 1 247 in 2012, and overall GDP grew 6.7% between 2012 and 2013.

The main economic activities are extractive industries (83% mining, with the remainder oil and gas), fishing and agriculture. Industrial activities represent 54.6% of GDP, while services represent 28.5% and agriculture (including fishing) represents 16.9%. In terms of employment, the balance is inverted, with 50% of the active population working in the more labour-intensive agriculture and fisheries sector, 40% in the services sector and 10% in the industrial sector.

Although resource exports boost the national economy, they also expose it to external fluctuations in commodity prices. Extractive industries provided approximately 38% of national revenues (excluding foreign development aid) in 2011, up from 24% in 2010. In 2008, exports of crude oil brought in USD 326 million, whereas fossil fuel imports cost the country USD 546 million.

Although the Mauritanian economy will remain exposed to commodity price variations for its export revenues, it can help to reduce price risks by increasing its use of domestic energy resources. The country has acknowledged this situation in its national policies by, among other solutions, supporting the use of offshore natural gas for electricity production as well as promoting renewable energy.

ENERGY AND DEVELOPMENT

Energy is explicitly acknowledged as a development priority of the country and is a key element of several of the main themes of the government's Poverty Reduction Strategy Paper (PRSP) (IRM, 2000, 2006, 2011). These include aims to: 1) accelerate economic growth to improve the economy's competitiveness and reduce its dependence on external factors, 2) develop the growth potential and productivity of the poor by promoting the sectors that directly benefit them and the areas in which they are concentrated, 3) develop human resources and improve access to services, and 4) promote institutional development and governance, a goal that can be linked to efforts to reform the energy sector.

Access to energy services remains limited in Mauritania due to various geographical factors, including widely spread large urban population centres (Nouakchott and Nouadhibou) and significant rural populations distributed throughout the country. The share of households connected to the grid has increased from 18% in 2000 to 34% in 2013 (MPEM, 2014).

Electricity demand is growing by 10% per year, led primarily by industry needs and fuelled in part by rising domestic demand. The current installed generation capacity is around 350 megawatts (MW), of which 75% is based on heavy fuel oil (HFO). In a "high-growth" scenario for the electricity sector, grid-connected demand (excluding mining activities) is projected to grow

by 450% between 2010 and 2030 (INTEC, 2012). This underlines the need for sound policies to lead future capacity expansion.

Planned investments in national electricity capacity, including several new wind and solar projects, would increase the contribution of renewables to 36% of capacity by 2020 and 41% by 2030. However, these numbers do not include demand from the mining sector, which is mostly off-grid (due to the remote location of production sites) and is expected to represent nearly three - quarters of total electricity demand by 2025. If mining activities are included, the overall demand growth could near 600% by 2030.

Mauritania has significant renewable energy resources. The estimated solar photovoltaic (PV) potential is 2 000-2 300 kilowatt-hours per square metre per year (kWh/m^2/year), with the lowest radiation measurements being on par with the highest solar resources in southern Europe. For wind, the values are similarly high but are more localised around coastal areas, with peak wind speeds of more than 9 metres per second (m/s) in the Nouadhibou region.

These resource potentials indicate that renewable energy sources can be competitive with HFO-generated electricity in most regions, to be balanced via load adjustment to account for variability in production. In addition, significant hydropower resources have begun to be tapped through the Senegal River Basin Development Authority (OMVS), although the potential for small hydropower still needs to be assessed in the country's south. Biomass, while still used primarily in a traditional form, has the potential to meet many energy needs if managed carefully in a context of local desertification.

RENEWABLE ENERGY STRATEGY

Thus far, renewable energy options in Mauritania have been developed on an ad hoc basis. This has resulted in a project-led renewable energy policy that has encouraged the development of two large projects in the country: a 15 MW solar PV plant, inaugurated in 2013, and a 30 MW wind project in Nouakchott, which began construction in 2014. This project-led policy has helped to jumpstart renewables deployment in the country, both for on- and off-grid uses. The challenge now is to capitalise on this experience and to further develop these nascent solutions while maximising the country's capacity to boost employment while cutting costs.

Mauritania has a unique opportunity to develop its local economy and industry while addressing some of the economic challenges it faces today, including the need to generate local employment and to reduce the economy's exposure to commodity-related price shocks. In this vein, the country may wish to further develop regional co-operation with both the Maghreb region and West Africa, with the aim of becoming an exporter of renewable electricity.

Based on its economic development priorities, Mauritania has identified three key "service-resource pairs" – priority pairings of energy-demanding services with relevant renewable energy resources (IRENA, 2013a) – within the RRA process. These are:

- Access to renewable energy services for rural and off-grid applications – including services based on solar, small hydropower, biomass and wind energy;
- Productive activities for economic development – such as industry and mining applications and fishery transformation activities – based on solar and wind energy; and
- Centralised electricity production for grid-based power, based on solar and wind energy.

Yet despite the significant renewable resources at the country's disposal and recent project installations, several recurring challenges have been identified. To capitalise on recent and historical experience in the renewable energy sector, the country should address the following key issues:

- The lack of a clear strategy for renewable energy deployment, which has resulted in overlap among programmes and agencies and in a lack of co-ordination of actions in the field of renewables.

- The lack of legislative and regulatory stability, including an electricity tariff structure that fails to accurately reflect costs and a regulatory authority that remains limited in its scope. The lack of legal and regulatory stability impedes necessary investment in the electricity system.

- A range of capacity-building issues, including the need to better capitalise on national experience in the renewable energy sector to increase knowledge and understanding of renewable resources, technologies and their potential. These needs are widespread within the economy, ranging from public actors to the private sector.

To address these and other issues identified during the RRA process, country stakeholders defined an initial plan of five actions, covering all three key service-resource pairs:

ACTION 1: DEVELOP A NATIONAL POLICY ON RENEWABLE ENERGY

Mauritania needs to develop a comprehensive national renewable energy policy that embraces renewable technologies within a long-term vision that recognises the benefits of large-scale renewables development. This policy should confirm the current renewable generation targets of 15% by 2015, 20% by 2020 and 35% by 2030. However, the country may consider increasing these targets, as it already has exceeded the target set for 2015.

The policy should also confirm the current targets for electrification of 108 villages in nine of the poorest provinces (wilayas), as well as support for current collective and private electrification initiatives in 192 local areas (IRM, 2011). The policy document also needs to reflect the existing PRSP and Millennium Development Goal (MDG) targets for urban and rural electrification (80% and 40%, respectively, by 2015). For the country to meet these targets, however, the policy also needs to include equalisation (pérequation) and tariff principles in order to enable sufficient revenue generation to facilitate new project development, including off-grid. Finally, the policy should outline regulatory and institutional frameworks that are needed to ensure better co-ordination of national programmes and projects.

ACTION 2: UPDATE THE ELECTRICITY CODE AND ITS ASSOCIATED IMPLEMENTING DECREES

To be effective, the renewable energy strategy and related targets need to be reflected in future decrees and legislation. The new electricity code under development should specify these objectives as well as the underlying rules for promoting renewables in each sector. The electricity code also needs to help level the playing field in terms of generation costs. Current on-grid generation costs need to be better reflected in the power pricing structure to allow for a competitive comparison of generation solutions (*i.e.* renewable energy). In addition, because the country may become an exporter of renewable power, the electricity code should reflect this option for potential regional co-operation.

ACTION 3: CREATE THE INSTITUTIONAL AND REGULATORY FRAMEWORK TO FACILITATE DEPLOYMENT OF RENEWABLES

Beyond the electricity code itself, Mauritania needs to create a favourable institutional and regulatory framework for the deployment of renewables. A first step is to optimise current interventions in the energy sector by clearly addressing the overlap among agency, state and non-governmental (NGO) activities in the renewable energy area. The country could reinforce this message through the following actions:

- Revise the legal framework to enhance the role of regulatory agencies in the renewable energy area and to cover all actors in the sector (including the national electric utility, SOMELEC).

- Create a renewable energy unit (pole des energies renouvelables) dedicated to these resources within the Directorate of Electricity under the Ministry of Petroleum, Energy and Mines (MPEM).

- Encourage off-grid industrial Independent Power Producers (IPPs), which represent a large majority of the national electricity generation capacity, to mix their current capacity with renewable sources. On a large scale, renewable energy can contribute to the production of electricity in Mauritania through IPPs and other private producers. In general, Mauritania should modernise its legislative and regulatory frameworks to enable private investment in energy production in order to meet industrial needs. The economies of scale might bring savings to off-grid consumers, while eliminating the administrative and technical investments and responsibilities that are attached to electricity generation.

All stakeholders in the RRA process identified the need to create a dedicated renewable energy "monitoring centre". This entity could be in charge of capitalising on previous experiences within the country as well as centralising all renewable energy-related data, including renewable resource assessments.

ACTION 4: PROMOTE CAPACITY BUILDING AND RESEARCH PROGRAMMES, DEDICATED TRAINING AND EDUCATION

Considering the breadth of renewable power capacity being installed both on- and off-grid, Mauritania needs to develop capacity-building and education programmes that are specific to renewables. To create sufficient local capacity for maintaining and installing renewable energy projects, the country also needs to reinforce vocational training (formation professionelle) and education programmes. Although some resources and infrastructure already exist, these could be exploited more broadly. Finally, the local human resources that have been developed to implement and maintain existing projects should be better deployed to help reduce the overall national costs for maintaining on- and off-grid renewable projects.

With regard to research and development (R&D), the creation of a renewable energy monitoring centre and training resources, among other actions, could help to develop national competencies. The country should also consider the development, verification and dissemination of a wind and solar atlas, with the collected information then integrated into a public database on renewable energy resources. Applied research related to nationally specific solutions and needs should be developed within existing universities and engineering schools. This would necessitate a dialogue with all stakeholders from the public and private sectors to ensure relevance of the research topics to the country needs.

ACTION 5: DEVELOP A FINANCIAL FRAMEWORK AND INCENTIVE SCHEMES

A key barrier for renewable energy development is the cost and availability of financing. The government of Mauritania may be able to provide the most effective support to renewables in this area, by promoting stable legislative rules that would lessen inherent country risks and help to greatly reduce the cost of financing projects. Technology risks could be reduced through the promotion of a national human resources capacity for installation and maintenance, and by developing technical guidelines that consider the harsh climate

conditions of the country and its impact on the operating efficiency of equipment. In addition, the government could create a specific national fund dedicated to promoting renewable energy for off-grid access, to further encourage these solutions.

Wind power generation in Mauritania
Photo: Tractebel Engineering

Mauritania needs to find alternative sources of employment to balance the structural lack of jobs in the extractive industries. Extreme poverty is not declining as much as overall poverty in the country, indicating the lack of decent employment opportunities, particularly in rural areas.

I. Economic and energy background

INTRODUCTION

The Islamic Republic of Mauritania is a Saharo-Sahelian country in West Africa, covering 1 030 000 square kilometres (km^2) and with an Atlantic coastline of 700 km. In 2013, the population was 3 461 041, with a total of 557 248 households and an average household size of 6.1 persons. A large majority of the population is concentrated in the capital city of Nouakchott (with 809 360 inhabitants) and in the northern city of Nouadhibou, as well as in a strip running between the Route de l'Espoir and the southern border. Just over half (51%) of the population lives in urban areas, and the urban population is growing by 2.9% annually (UN, 2014).

GDP per person in Mauritania was USD 1 247 in 2012, and overall GDP grew 6.7% between 2012 and 2013. The economy is based mainly around mining and quarrying activities, with the country exporting primarily iron ore, copper and gold, in addition to crude oil. Oil production from the Chinguetti field totalled 2 242 358 barrels (or 6 143 barrels per day [/day]) in 2013, and the country soon will extract natural gas, to be used exclusively for electricity production. Overall, industrial activities account for 48% of GDP, ahead of the service sector at 37% and agriculture (including fisheries) at 10%.

In terms of employment, these figures are reversed, with 50% of the workforce employed in agriculture, 40% in the service sector and 10% in industrial activities. Despite the importance of mining and other extractive industries to the economy, these industries are not as labour-intensive and thus employ far less of the active population. The country's unemployment rate is estimated at 10% of the workforce, down from 30% in 2008.

Extractive industries accounted for roughly 38% of total government revenue in 2011 (excluding official development assistance), up from 24% in 2010. The mining sector represents 83% of the extractive sector revenue, compared with 17% for oil. Notably, Mauritania spent nearly USD 546 million on petroleum product imports in 2008, compared to total export revenue of USD 1 627 million, of which USD 326 million came from crude oil exports. (Although the country's fishing industry is highly developed, making it a net exporter in this sector, this is not necessarily reflected in the balance of payments, as fisheries exports do not bring in as much foreign currency as mining, and the country exports most of its fishery products unprocessed.)

This shows how dependent Mauritania is on commodity prices, both for its exports and for its import costs. This leaves the economy exposed to external economic shocks. A 2013 report from the International Monetary Fund notes: "Several potential risks that may adversely affect [the country's] growth outlook are still very real threats, and the economy remains vulnerable to adverse changes to terms of trade. The top priorities remain reducing the economy's vulnerability to external shocks" (IMF, 2013). In terms of exports, mining will continue to be vulnerable to fluctuations in world commodity prices. However, it is possible to reduce the country's dependence on imported resources (including petroleum products) through greater use of renewable energy in all sectors of the economy.

Mauritania also needs to find alternative sources of employment to balance the structural lack of jobs in the extractive industries. Extreme poverty is not declining as much as overall poverty in the country, indicating the lack of decent employment opportunities, particularly in rural areas. In a country like Mauritania, the decentralised nature of renewable energy can have enormous benefits, particularly for poorer rural areas, as renewable energy technologies can often offer a secure and reliable energy alternative that is able to increase the standard of living of rural and less developed communities. Further, local authorities can invest in local renewable energy infrastructure and services, allowing for significant local added value creation in terms of job creation and boosting local economic growth (IRENA, 2014)

ENERGY IN THE SOCIO-ECONOMIC CONTEXT

Energy has been explicitly identified as one of the priorities for Mauritania's development. The country's Poverty Reduction Strategy Paper (PRSP) covers four main themes, which are summarised as follows (IRM, 2000, 2006, 2011):

- The first theme is aimed at accelerating economic growth to improve the competitiveness of the economy and to reduce its dependence on external factors.

- The second theme is aimed at enhancing the growth potential and productivity of the poor. This involves the promotion of sectors that directly benefit the poor and areas with a high concentration of poverty. This focus, based on the implementation of public investment programmes, will help reduce inequalities and improve the poor's resource base.

- The third theme focuses on developing human resources and access to basic services. This area will, in the long run, have the most significant effect on poverty through its impact on productivity and by improving living conditions for the poor. Access to education and health, in particular, significantly reduces the poor's vulnerability.

- The fourth theme aims to promote genuine institutional development based on good governance and on the full participation of all poverty-reduction stakeholders.

The four themes of the PRSP can be linked indirectly or even directly to energy policy, including the promotion of renewables in the country. The current system of access to energy services, focused primarily on diesel generators, barely mobilises the resources required to pay for fuel and, by extension, renewal costs. In addition, the PRSP includes a target to increase the renewable share of on-grid electricity generation to 15% in 2015 (IRM, 2011) and 20% in 2020[1] (IRM, 2006).

Renewable energy sources present a significant opportunity, among other things, to:

- help secure the country's energy supply;

- reduce its dependence on imported oil and stabilise the cost of electricity generation; and

- contribute to the energy supply in areas not covered by the national grid.

In addition, the use of renewables could reduce the overall expense of efforts to provide basic services to off-grid populations. Moreover, deploying renewable energy to a level that goes beyond domestic needs could allow the country to become an exporter of clean energy to neighbouring countries in the region and beyond, thereby accelerating its development.

To take advantage of these potential contributions, however, Mauritania must better integrate and appropriate the benefits of concerted development of renewable energy. This would require implementing a national policy that fosters the development of these

resources, but it especially requires reducing the barriers to renewables development. This in turn necessitates implementing adequate and effective economic policies, creating a framework for effective regulation, and developing strong and dynamic institutions as well as a sustained capacity-building programme.

[1] The renewable share of capacity is 19.8% today and is expected to increase to 26% following construction of the new 30 MW wind farm in Nouakchott. Planned dual-fuel plant investments would change this share to 25% in 2016 and 23% in 2018, and planned investments in combined-cycle natural gas power plants from 2022 would reduce this share further.

REGIONAL CONTEXT

Mauritania straddles two distinct regions and cultures. To the north, it is a member of North Africa and the Arab Maghreb Union (AMU), and to the south and west, it is an "observer" in the Economic Community of West African States (ECOWAS).

The AMU, a Pan-Arab trade agreement formally established in 1989, includes a Ministerial Committee on Infrastructure, and the General Secretariat of the AMU includes an Infrastructure Directorate. There is now also a Maghreb Charter on Environmental Protection and Sustainable Development and a strategy for renewable energy.

Mauritania was a founding member of ECOWAS but withdrew from the organisation in 2000; however, it continues to participate as an observer and to engage in a number of projects, including those related to regional electrical interconnection. Moreover, the Banda gas field project, an offshore project being planned for electricity production, would not be economically viable without the possibility of exporting power to ECOWAS countries (in this case, Guinea, Mali and Senegal). The project includes several planned transmission lines, either as an extension to the 225 kilovolt (kV) transport network to Nouadhibou, or via a proposed new 225 kV transport line between Nouakchott and Tobène, Senegal.

In 2012, ECOWAS adopted a regional renewable energy policy, which includes a plan for increasing the share of renewables in order to support the development policy of the West African Power Pool (WAPP) and to contribute significantly to energy access goals (ECOWAS, 2012). The mandate of the WAPP (a specialised institution of ECOWAS) is to ensure regional power system integration and the realisation of a regional electricity market. WAPP comprises public and private generation, transmission and distribution companies involved in electricity operations in West Africa. ECOWAS has also established a Centre for Renewable Energy and Energy Efficiency (ECREEE) to help countries develop renewable energy support policies and to provide related decision-support tools.

Mauritania has also been a member of the Senegal River Basin Development Authority (OMVS) since that organisation's inception in 1972. The mission of the OMVS is to:

- achieve food self-sufficiency for the people of the basin and sub-region,
- secure and improve people's incomes,
- preserve the balance of ecosystems in the basin,
- reduce the vulnerability of member state economies to climate and external factors, and
- accelerate the economic development of the member states.

Within the OMVS, Mauritania has participated in the construction and development of the Manantali dam (which began producing electricity in 2001) and the Félou dam (which began producing electricity in 2013), for which it has drawing rights of 15% and 30%, respectively. The country's allocation of projected OMVS dams has increased to 25%, on par with the other three OMVS countries (Guinea, Mali and Senegal).

Mauritania is also part of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), which brings together nine countries in the Sudano-Sahelian region for discussions about food security and the fight against the effects of drought and desertification. In addition, the country is an active member of the Maghreb Committee for Electricity (COMELEC), via the national utility SOMELEC. For now, the country is not interconnected to the COMELEC network, but a connection is planned from Nouadhibou to Morocco, which would strengthen Mauritania's position and open up export prospects to North Africa and Europe, given the high wind potential in the Nouadhibou region.

Because it is no longer an ECOWAS member, Mauritania does not, as such, have an integrated regional approach for energy issues. However, with some elements of its national policy directly touching on energy policy in West Africa, it is still indirectly linked, for example through OMVS hydropower activities and the Banda gas project.

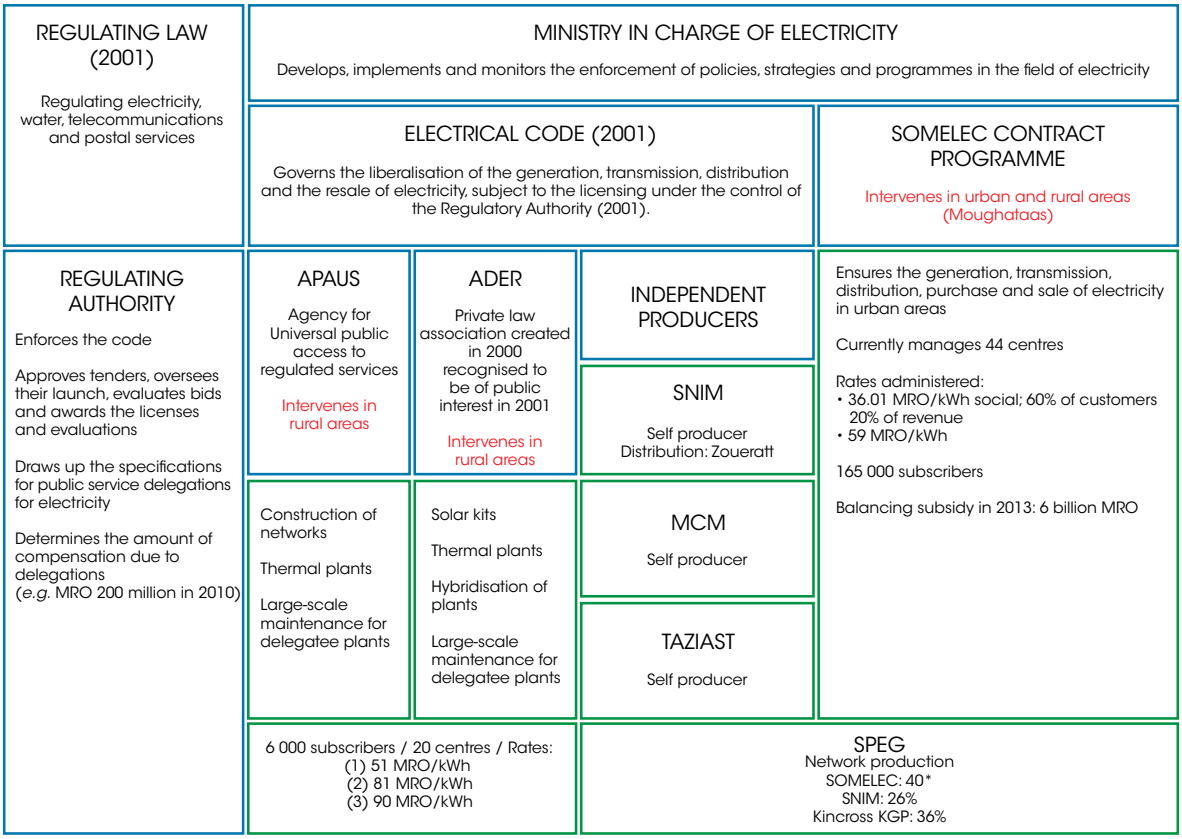
Additionally, in 2013, Mauritania joined the United Nations Sustainable Energy for All initiative, and it also recently joined RCREEE, which includes as members 15 other Arab countries, including all North-African Arab countries aside from Sudan and Djibouti, as well as other West-African Arab countries.

It is clear that anchoring national policy in regional policies, as a reflection of Mauritania's pivotal position between North and West Africa, would add visibility to the country's objectives and could allow it to benefit from effects of scale, especially in the field of renewable energy.

ENERGY SECTOR INSTITUTIONS

The key renewable energy stakeholders in Mauritania are government ministries, national agencies, non-governmental organisations (NGOs) and the private sector. The roles of several of these players are outlined in figure 1 and summarised briefly below.

Figure 1: Organisation of the energy sector



Note: Conversion rate is 1 Ouguiya (MRO)= EUR 0.00250428 = USD 0.00343770

Ministry of Petroleum, Energy and Mines (MPEM):

MPEM oversees the main governance structures for energy, including the Department of Electricity and Energy Management (DEME) for the fields of electricity (under the supervision of SOMELEC) and operators on- and off-grid. The Directorate General of Hydrocarbons (DGH) is responsible for granting and monitoring operating licences and distributing petroleum products.

These governance authorities, among others, aim to supervise operational structures, such as SOMELEC and the Rural Electrification Development Agency (ADER) for DEME (with the Agency for the Promotion of Universal Access to Basic Services, APAUS, falling under the Ministry of Economic Affairs and Development, MAED); and SOMIR (Mauritanian Refining Industries Company), SMH (the national hydrocarbon company), SOMAGAZ (Mauritanian Gas Company) and GIP (Petroleum Facilities Management Company) for the DGH.

Multisectoral Regulation Authority (ARM):

Established in 2001 under Law 2001-18, the ARM is responsible for regulating activities in the areas for which it is responsible, including the water, electricity, telecommunications and postal services sectors (IRM, 2001a). For now, in the area of electricity, the ARM is in charge of regulating only authorised service providers (ASPs); SOMELEC is not yet included in its scope of action.

Agency for the Promotion of Universal Access to Basic Services (APAUS):

Created in 2001 under ORD 2001-06 (IRM, 2001b), APAUS is a multi-sectoral public entity in the areas of water, energy and telecommunications. As an independent body, it receives independent funding. Its mission is to promote universal access to services through: advocacy actions, some of which are specific to the private sector; resource mobilisation; ensuring coherence and convergence between the strategies of external partners interested in universal access; and the design and implementation of pilot projects that aim to demonstrate the viability of guidelines and disseminate lessons learned.

APAUS also manages the government's Fund for Universal Access to Services (FAUS), which aims to gradually consolidate most of the resources used for expanding and operating regulated services. APAUS conducts electrification and infrastructure development actions in some villages, while being responsible for heavy equipment maintenance for ASPs.

Agency for the Development of Rural Electrification (ADER):

ADER is a non-governmental and not-for-profit association that carries out rural electrification actions under the supervision of MPEM. Previously invested mainly in the distribution of PV kits, ADER now operates more to complement the projects run by APAUS.

Mauritanian Electricity Company (SOMELEC):

SOMELEC was set up in 2001 following the split of SONELEC (the National Company of Water and Electricity), with a view to liberalising the electricity market. It is responsible for the generation, transport, distribution and sale of electricity in urban and suburban areas across the country. It is also in charge of managing remote networks in the regional capitals (moughataas) and for managing solar and wind power plants connected to the grid, including the 15 MW solar PV plant and the 30 MW wind plant in Nouakchott.

Company for the Production of Energy from Gas (SPEG):

SPEG was founded in 2012 by its shareholders (SOMELEC 40%, SNIM (the National Company for Industry and Mining) 26% and Kinross Gold Power 34%) to develop, finance and operate energy projects. The primary purpose of SPEG is to capitalise on the natural gas resources of the Banda offshore field, in particular developing them for electricity production.

Mining companies:

Some of the mining companies run village electrification operations on which many villages depend. The companies are considering the possibility of reducing their operating costs through the increased use of renewable energy to meet off-grid needs.

NGOs:

A number of NGOs, including international ones, are involved in the energy sector, providing both awareness and demonstration projects on the possible use of renewables, especially in rural areas.

ENERGY SUPPLY AND DEMAND

Production

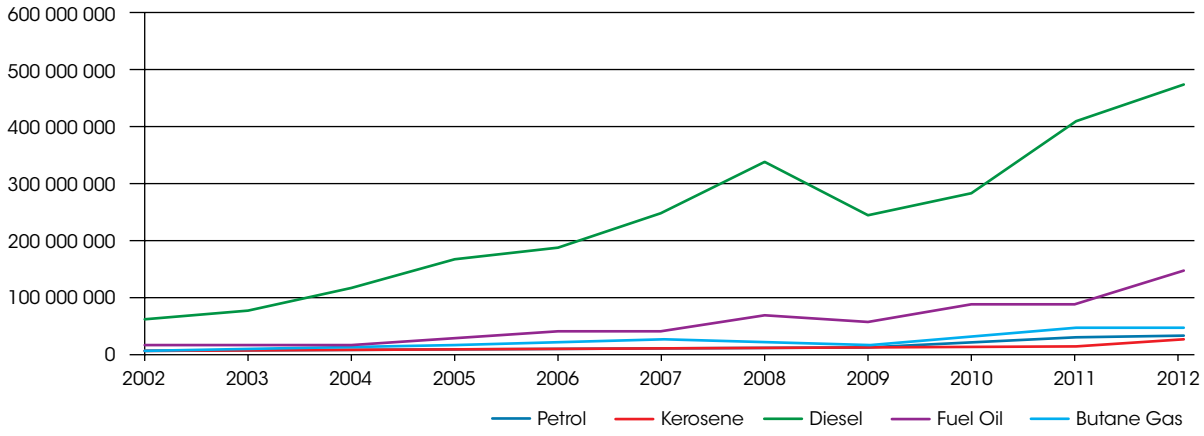
The full extent of Mauritania's oil and gas reserves remains unknown; however, these resources are large enough to be commercially exploited. The Regional Atlas on West Africa (OECD, 2009) has estimated the country's oil reserves at 1 billion barrels, which would put it just behind Nigeria in total reserves. But investors have sometimes been disappointed with the results of operations. Oil fields such as Chinguetti, used exclusively for export, saw output fall from 70 000 barrels a day in 2006 to 6 143 barrels a day in 2013. This uncertainty in production may be due in part to the lack of knowledge about the full extent of these resources. To date, the country remains under-explored, with just 1.7 wells per 10 000 km^2 in the licensed areas, compared to a worldwide average of 50 wells per 10 000 km^2 (Zawya, 2013).

The Banda gas field, with an estimated 1.2 trillion cubic feet of reserves (MPEM, 2014), is expected to enter into production by 2017. The start of operations will depend on the finalisation of negotiations on gas use initiated as part of the SPEG framework. The gas reserves of the Banda field do not justify activities such as building gas liquefication facilities to enable export on a global scale, building a pipeline to connect to the West African Gas Pipeline, or even exporting gas to Morocco. The decision was made to use the gas to produce electricity for domestic use by mining companies, with the surplus then exported to the OMVS area.

Demand

Oil consumption in Mauritania was estimated at 13 000 barrels a day in 2012 (MPEM, 2014). This level of demand corresponds to a net import of 7 000 barrels a day. Despite its domestic production of crude oil, the country is a net oil importer because it must import all of its refined oil resources. This situation affects oil import costs as well. Figure 2 shows the increase of these costs during 2002-2012, with net predominance of diesel, which is used mainly in the transportation sector and in off-grid power stations.

Figure 2: Cost of hydrocarbon imports, by source, 2002-2012 (in USD)



Source: APAUS, 2014b

Annual primary energy consumption in the country was estimated at 4.8 million barrels of oil equivalent (0.7 million tonnes of oil equivalent, or toe) in 2010 (EIA, 2013). Annual consumption per capita is 0.3 toe (GTZ, 2009), or 0.17 toe if traditional biomass is excluded. Mauritania's energy mix comprises approximately 67% biomass (wood and charcoal), followed by petroleum products, which account for the vast majority of commercial energy used in the country. Electricity consumption is increasing by more than 10% per year, yet less than 5% of the rural population has access to electricity (EIA, 2013).

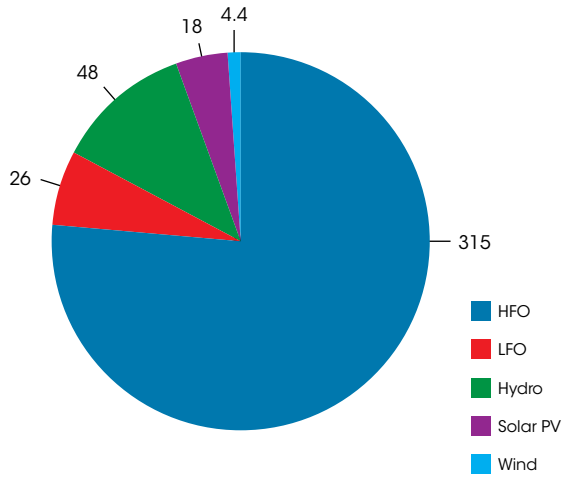
Overall, access to energy services is limited in the country. Major efforts are focused on rural electrification, but the bulk of the population remains dependent on non-commercial energy resources for its needs (traditional biomass provides 64% of primary energy consumption). The main resources used to generate electricity are imported, and all petroleum products are imported due to the lack of local refining capacity. Although domestic natural gas exploitation will reduce the country's dependence on imports, any lag in the extraction timeline could have a significant effect on the economy.

ELECTRICITY SYSTEM OVERVIEW

Generation

The main resource used in the country for electricity production is heavy fuel oil (HFO), which accounts for 75% of the installed generation capacity (just over 315 MW total in 2013; see figure 3). Under the "high-growth" scenario, excluding demand projections for capacity, electricity demand (both on the grid and from mining) is expected to increase from 220 MW in 2013 to nearly 1400 MW in 2025, multiplying the current installed capacity by six (INTEC, 2012). Notably, 75% of this projected capacity is related to mining sector demand (1050 MW in 2025).

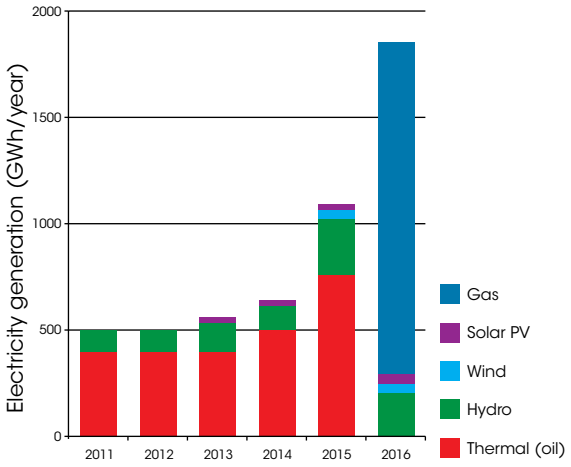
Figure 3: Installed electricity capacity, by source, 2013 (in MW) (SOMELEC, ASPs, mining)



Source: MPEM, 2014

The new gas project in Banda for electricity production is expected to change the trends of electricity generation. As figure 4 illustrates, a significant drop in the contribution of thermal power plants in the electricity mix is expected in 2016 with the commissioning of the 30 MW wind power plant and the 120 MW dual-fuel plant (mixed HFO / natural gas), as well as the completion of the upgrade and additions to the distribution networks in Nouakchott and within major cities, which will be commissioned in 2015.

Figure 4: Electricity generation by source, 2011-2016 (in GWh/year)



Source: APAUS, 2014b

With the country's planned network capacity additions, total generation capacity would reach 752 MW by 2030, with 280 MW from HFO and mixed power, 217 MW from hydropower and 75 MW from solar and wind (see table 1), for a total of 39% renewable capacity connected to the grid. However, these figures do not include additional planned capacity in the mining sector, are not correlated in terms of planned electricity generation, and do not account for the systems used for rural electrification. Moreover, in the event of a delay in planned gas operations, the country will become even more heavily exposed to volatile oil prices and security of supply issues.

Table 1: Overview of grid-connected electricity generation plants under the high-growth scenario

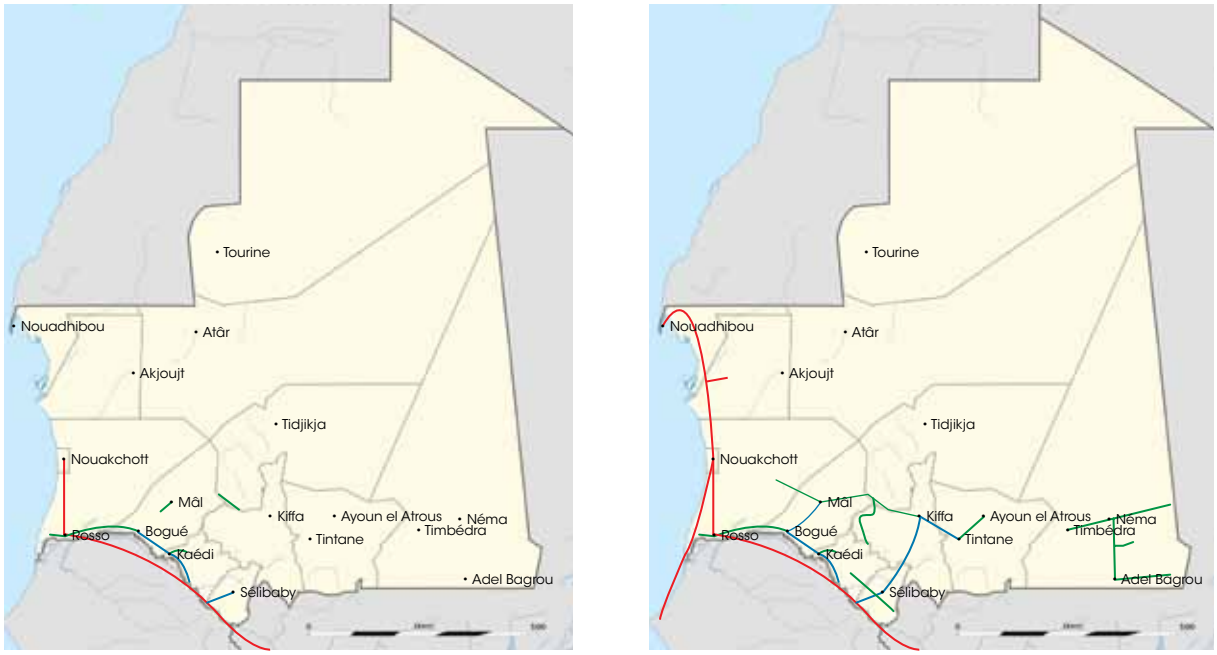
Name	Plant Type	Power available (MW)	Year of commissioning	Last year planned
Manantali	Hydropower (Available power to Mauritania)	30	2002	2030
Félou		18	2013	2030
Gouina		35	2016	2030
Gourbassi		6.25	2017	2030
Bouréya		40.25	2021	2030
Koukoutamba		70.25	2023	2030
Badoumbé		17.5	2025	2030
Total Hydropower		**217.25**		
Total Natural Gas	Combined-cycle natural gas	**180**		
Dual 1	Mixed HFO / natural gas (114)	120	2015	2030
Dual 2		54	2018	2030
Total Mixed		**174**		
Arafat 1 rehabilitated	HFO	39	2014	2023
Arafat 2		8.75	2011	2020
Wharf		36	2011	2014
Nouadhibou		22	2013	2030
Total HFO		**105.75**		
Wind Farm Nouakchott	Wind	30	2014	2030
Solar Nouakchott	Solar PV	15	2013	2030
Solar 2 Nouakchott		30	2015	2030
Total Non-Hydro Renewables		**75**		
TOTAL		**752**		

Source: INTEC, 2012; MPEM, 2014

Transmission and distribution

The Mauritanian transmission network is built around the main centres of demand (see figure 5). A 225 kV line (red line) runs south along the coast to Rosso, then along the border on the Senegal side before joining the OMVS network at Dagana. Transmission along the border is provided by a 33 kV line (green SOMELEC line) from Rosso to Boghé and a 90 kV line (blue OMVS line) from Boghé to Matam.

Figure 5: Electricity network in Mauritania, 2013 and plans for 2018



Source: MPEM, 2014
The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

As figure 5 illustrates, the network is expected to expand greatly by 2018. Two new 225 kV line projects (red lines) are planned as part of the Banda gas field operations, one extending the transport network to Nouadhibou in the north (and extending to the mining areas within the country), and the other running south to Senegal, allowing for cross-border export. Additional 90 kV and 33 kV network extensions are planned in the country's south to increase population access.

The rate of access to electricity is low in Mauritania, due in part to the difficulty of extending the network and to the scattered nature of demand, which makes interconnection difficult. Overall, it is estimated that the number of households connected to the network increased from 22% in 2000, to 24% in 2004, and to 34% in 2013 (see table 2).

[2] The rate of electricity access is the ratio between the number of households covered and the total number of households in the area or district.

Table 2: Rate of access to electricity, 2013

National access rate	34%
Urban	58%
Rural	5%
Nouakchott	70%
Nouadhibou	68%

Source: MPEM, 2014

To overcome these disadvantages, the Master Plan for the Production and Transport of Electricity considers extending the network from the main consumption centres. Connection areas within a radius of 120 km from the point of generation/interconnection are defined to measure the potential of connection to the network/mini-grid. Some of these areas could be connected directly to the national grid, and others could be powered by solar hybrid/diesel power (Kiffa would be one of the first areas covered by hybrid production and a 33 kV network).

Costs and tariffs

Despite growing diversification, Mauritania's energy system remains heavily oil-dependent, both on- and off-grid. Moreover, the country's geography and the distribution of population and activity centres are not conducive to development of the domestic energy market. All of this affects electricity production costs and tariffs.

As in many West African countries, electricity tariffs in Mauritania are established by government decree, with the monthly residential rate set relatively high at just above USD 0.20 per 100 kWh (see table 3). Currently, two sets of tariffs co-exist in the country: the SOMELEC tariffs that are applied on- and off-grid in the regional capitals (moughataas), and the off-grid tariffs proposed by the authorised service providers (ASPs) (see tables 4 and 5).

Table 3: Comparison of residential electricity rates in West Africa

Name	Effective monthly residential rate (USD per 100 kWh)	2009* monthly GNP per capita (USD)	Share of GNP per capita spent for 100 kWh of electricity (%)
Gambia	0.280	98	21.7
Senegal	0.238	139	17.2
Mauritania	0.203	104	19.5
Burkina Faso	0.200	103	19.5
Côte d'Ivoire	0.119	134	8.9
Ghana	0.820	128	6.4

Source: IRENA, 2013b; Mauritania from SOMELEC, 2013 and INTEC, 2012
* 2013 GDP was used for Mauritania

Table 4: Existing and proposed fee schedule for customers on and off the network

On- and off-grid tariffs (SOMELEC)		Off-grid tariffs (ASPs/subcontractors)		
Current rate	Proposed monthly rate	Domestic rate <25 kWh per month	Middle rate 25-120 kWh per month	Higher rate >120 kWh per month
Fixed premium: MRO 329 (USD 1.12)	Energy prices:	Fixed premium: MRO 600 (USD 2.06)	Fixed premium: MRO 1 625 (USD 5.58)	Fixed premium: MRO 7 513 (USD 25.77)
Energy prices:	Domestic: MRO 36.01/kWh (USD 0.12/kWh)	Energy price: MRO 51/kWh (USD 0.18/kWh)	Energy price: MRO 81/kWh (USD 0.27/kWh)	Energy price: MRO 90/kWh (USD 0.32/kWh)
<2 kVA: MRO 30.74/kWh (USD 0.11/kWh)	Higher voltage: MRO 59/kWh (USD 0.21/kWh)			
>2 kVA: MRO 59.03/kWh (USD 0.21/kWh)	Medium voltage: MRO 37/kWh (USD 0.12/kWh)			

Source: SNC Lavalin, 2013
Note: Conversion rate is 1 Ouguiya (MRO)= EUR 0.00250428 = USD 0.00343770

Table 5: SOMELEC electricity tariffs

Voltage	Category	Current rate	
		Energy price (USD/kWh)	Monthly fixed premium (USD)
Low Voltage (LV)	Domestic	0.12 0.19 0.19	11.37 49.59 151.66
	Street lights	0.18	144.95
	Industries, crafts and commerce	0.19 0.18 0.19	11.37 49.59 151.66
	Administration	0.18 0.19	49.59 248.24
Medium Voltage	1st Category	0.12	13.97
	2nd Category	0.08	252.90

Source: SOMELEC, 2014

The off-grid ASP tariffs are maximum tariffs set by the ARM under MPEM decree. The operators –ASPs – apply these prices for each service area. The ARM assesses the subsidy granted to each ASP on a quarterly basis, using a grant taken from the Fund for Universal Access to Services (FAUS) managed by APAUS. Thus, the state, through the ARM and via APAUS (FAUS), issues the quarterly operating subsidies required to ensure the economic sustainability of the ASPs.

Both on- and off-grid rates are subsidised and currently do not allow the state to recover the operating costs on either market. Furthermore, the country's average electricity generation costs are higher than currently applied tariffs. Because of the high share of oil-fired generation, average generation costs are increasing, reaching USD 0.36/kWh in June 2012 (AFD, 2013), compared with USD 0.34/kWh in 2011 and USD 0.32/kWh in 2010. The updated generation costs for a medium-sized (1-5 MW) diesel power plant are estimated at USD 0.38/kWh (INTEC, 2012). These cost variations indicate how difficult it is to compare conventional power generation costs to renewable energy generation costs, and point to the need to standardise the different approaches and methods for estimating costs to avoid creating confusion among decision makers, investors and developers.

These low electricity tariffs are one of the reasons for SOMELEC's strong deficits and the slow progress in access to energy services. To respond to these constraints, SOMELEC, with the support of the state, has launched a recovery plan and emergency measures. In 2013, the ASP's operating subsidy was MRO 430 million (USD 1.37 million) for 6 000 subscribers, while SOMELEC's balancing subsidy was MRO 6 billion (USD 20.5 million) for 180 000 subscribers (MPEM, 2014). However, the state is still obliged to pay annual operating subsidies every year. In 2013, the grant allocated to SOMELEC was USD 20.5 million.

Emergency measures to balance SOMELEC's accounts focus largely on recapitalising the company through capital injection and tariff adjustments (IMF, 2012). But longer-term actions have not been implemented. The Banda gas project is expected to improve SOMELEC's financial situation by generating electricity at low prices. Further, the average cost of production is projected to drop significantly starting in 2015, with the commissioning of the 30 MW wind plant and the 120 MW dual-fuel plant, as well as completion of the upgrades and additions to distribution networks in Nouakchott and within major cities.

The country's electricity price projections are influenced in large part by the planned use of natural gas for electricity generation via the Banda project. However, given that the gas is not yet available (with the production and transportation facilities not yet built), it is difficult to predict when the planned dual-fuel plant will actually switch from oil to gas. Through the Banda project, the country hopes to reduce electricity supply costs sufficiently to enable reductions in the annual operating grants for SOMELEC and to maintain current electricity prices. Shrinking SOMELEC grant budgets would ease pressure on the state's budget and free up additional resources for rural electrification. In essence, the current tariff structure focuses available grants on the most well-off, grid-connected population, without addressing the development needs of the poorest populations.

THE RENEWABLES READINESS ASSESSMENT METHODOLOGY

The Renewables Readiness Assessment (RRA) process, developed by IRENA, is a comprehensive assessment tool for the promotion and deployment of renewable energy. The present RRA process was configured to assist Mauritania in the necessary transition to a renewables-based energy future.

IRENA became a full-fledged international organisation in April 2011, with a mandate to promote increased adoption and sustainable use of all forms of renewable energy. With its 138 members and 33 countries in the process of accession, IRENA has the global reach to act as the focal point for international co-operation and to underpin the effort to increase the inclusion of renewables within the energy mix of countries around the world. Through its work programme, IRENA aims to position itself as a platform for stimulating policy dialogue and developing strategies to assist countries in their renewable energy transitions.

RRAs are now an integral component of the IRENA Work Programme and are included in "Promotion of regional consensus to adopt renewable energy through strategic intervention". The RRA process is designed to provide inputs to national and regional renewable energy action plans and to bring together partners who can support the implementation of action plans

RAPID

The RRA highlights the requirements for the installation and on-going operation of renewable energy facilities in a country

COMPREHENSIVE

It covers all renewable energy sources and services

NATIONAL

The RRA report, along with the insights and recommended actions therein, arise from a country-led process

THE RRA PROCESS IN MAURITANIA

The Directorate of Electricity and Energy Efficiency, within the Ministry of Petroleum Energy and Mines, was the RRA representative for Mauritania.

The process itself was initiated in collaboration with the UNDP country office, which played a historic role in this area in the country. Initial preparations were funded by the UNDP Mauritania Office, which chose to launch an advisory mission, "Performing a national strategy for renewable energy development in Mauritania", at the country's request. This mission was linked to the RRA process, after a first consultation meeting between MPEM, UNDP and IRENA in June 2013.

Preparations were carried out by a national consultant, an international consultant and MPEM. These, in collaboration with IRENA and UNDP, formed the "expert team" working group of the RRA. The development of the RRA methodology entailed an intensive literature review of the various assessment methodologies in the renewable energy sector and interaction with key experts in the field. The "expert team" invited a representative panel of stakeholders to present the findings of the preliminary report and to start a discussion on the key needs, in order to promote the increased use of renewable energy in the country.

The official launch of the RRA process was held on 12-13 November 2013 in Nouakchott. Approximately 70 participants from the public and private sectors discussed the main issues that the sector faces. The lively discussions helped highlight a number of priorities that were identified in sub-workshops, including access to energy services, on-grid production and productive activities.

In parallel, IRENA and MPEM launched a mission to identify capacity-building needs, which offered an opportunity to take stock of existing in-country training and additional needs.

The results of the RRA workshop and the mission identification needs were then included in an interim report. To determine the prospects of the renewable strategy and the initial findings of the report, a meeting was held in early April 2014 with the RRA-selected committee. The committee provided comments and suggestions to finalise the report and the recommendations.

The final report validation workshop was organised on 28 May 2014 in Nouakchott. Participants, as numerous as those for the launch workshop, were very active and satisfied with the report. Comments on the report were summarised and included in the final report.

The process adopted for the country-level RRA has several distinct stages, as shown in figure 6.

Figure 6: Renewables Readiness Assessment process

1. SCOPING

Step 1a: Preparatory Work

- Setting up of a RRA team initiated and lead by National Government
- Contextualisation of the RRA
- Identification of key stakeholders, renewable energy projects and programmes
- Roadmap and timeline for assessment

Step 1b: Planning the Process

- Identification of appropriate service–resource pairs
- Preparation of list of interviewees, appointments and tentative questionnaire for bilateral meetings

2. ASSESSING

Step 2a: Initial Plenary Session

- Introductory session led by high-level government official
- Discussion on status, potential and barriers to scale up renewable energy
- Description of how to conduct the RRA
- Refining and selection of key renewables applications

Step 2b: The Assessment

Filling out of RRA templates with regards to:

- Policy & strategy
- Business models
- Institutional, regulatory & market structure
- Resources, technologies & infrastructure
- Finance, building, operations & maintenance

Step 2c: Validation Workshop

- National workshop to present and validate preliminary findings

3. FINALISING

Step 3a: Final Report

- Final report-writing drawn on preparatory materials, completed RRA templates and list of actions
- RRA Director comments and approves work on behalf of the country

Step 3b: Follow-Up Actions

- Working with IRENA
- RRA Director and Government Focal Point identify areas for subsequent collaboration and action

CONDUCTING RRA IN MAURITANIA

The RRA implementation in Mauritania was initiated with an extensive literature review of studies and reports relevant to the national context of the energy sector and the current renewable energy status. A preliminary background report was prepared in accordance with IRENA guidelines.

The stakeholder mapping exercise identified key entities in public sector bodies, financial institutions, research bodies and the private sector. A series of visits to Mauritania was conducted between June 2013 and May 2014, comprising the following activities:

- An introductory meeting with the Ministry of Energy and UNDP, focused on RRA initiation and information sharing with key stakeholders.
- An inception workshop with stakeholders aimed at presenting the RRA template information, eliciting further feedback on the findings, and developing the action agenda, which is the key RRA outcome document.
- A consultation process involving the key governmental bodies to identify the main elements and priorities of the action plan and to give guidance on the direction that the future renewable energy strategy should take.
- A validation workshop with key stakeholders aimed at discussing and validating the RRA recommendations.

Aims and Objectives

The key objectives of this report are:

- To assess the energy issues that Mauritania currently faces and to review the status of the country's energy policy, specifically regarding renewable energy.
- To critically review employed and planned approaches for developing institutional structures for deploying renewables.
- To review the framework for providing access to renewable energy, as well as the current status of technology and infrastructure to deliver it.
- To critically assess the opportunities and barriers for developing viable business models for renewable energy projects.
- To suggest a set of actions to address the identified barriers.

OBJECTIVES

ASSESS & REVIEW

STATUS AND ISSUES
of energy & renewable energy in Mauritania

APPROACHES
for developing institutional structures for renewable energy

FRAMEWORK
for providing access to renewable energy

TECHNOLOGY & INFRASTRUCTURE
for delivering energy & renewable energy

OPPORTUNITIES & BARRIERS
for viable business models for renewable energy

RECOMMEND
A SET OF ACTIONS TO ADDRESS IDENTIFIED ISSUES

Wind power generation in Mauritania
Photo: Tractebel Engineering

The country already has hydropower resources provided by the Senegal River through the OMVS. In addition, it boasts extensive wind and solar resources, while meeting a majority of its primary energy needs through the use of traditional biomass.

II. Enabling Framework For Renewable Energy

RENEWABLE ENERGY RESOURCES AND USE

Mauritania is at a critical stage in its energy development. Numerous steps have been taken to guarantee electricity supply at a low price through exploitation of the Banda gas field. Nevertheless, the country is endowed with substantial renewable resources that can contribute significantly, both economically and competitively, to energy supply and development. The country already has hydropower resources provided by the Senegal River through the OMVS. In addition, it boasts extensive wind and solar resources, while meeting a majority of its primary energy needs through the use of traditional biomass.

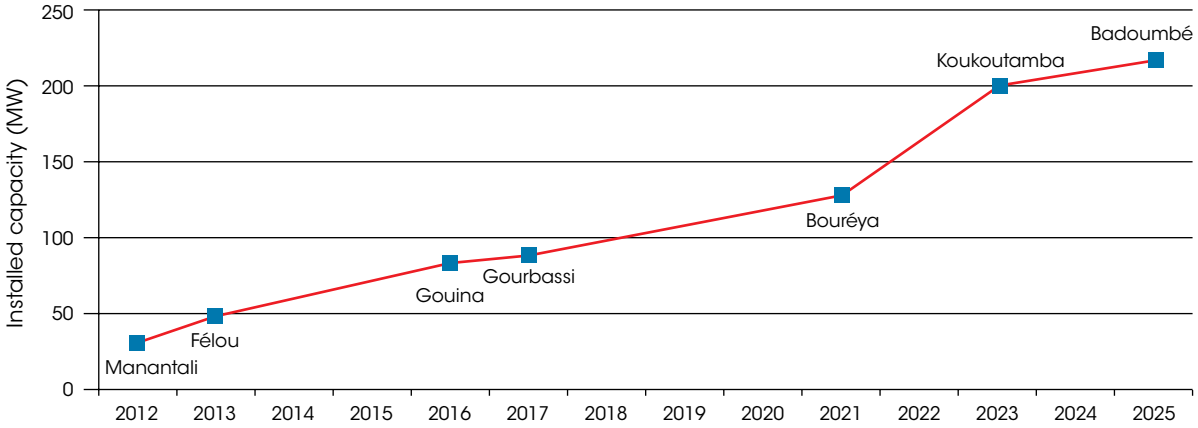
HYDROPOWER

Mauritania has significant hydropower resources, the majority of which are linked to the Senegal River. As a member of the OMVS, Mauritania participates in projects that are conducted and planned within this framework.

The two main projects currently in operation are the Manantali dam, for which Mauritania has 30 MW of the 200 MW of available capacity, and the Félou dam, for which it has 18 MW of available capacity (see figure 7). Mauritania has received close to 217 MW of the just under 690 MW of capacity planned for all OMVS projects. Additional OMVS dams in Gouina and Gourbassi, slated for completion by 2020, are coupled with interconnection projects to distribute the electricity produced to participating countries.

Apart from these planned large-scale projects, Mauritania has limited small hydropower potential in the south that could be exploited to serve small communities. The extent of these resources is not well assessed, but they could lead to a joint irrigation and power generation operation. It is recommended that the country better measure and promote the use of its hydropower resources through studies and measurements of the technical and economic potential of building reservoirs and/or dams.

Figure 7: Installed hydroelectric capacity (OMVS) available to Mauritania, 2012-2025 (in MW)



Source: APAUS, 2013

SOLAR

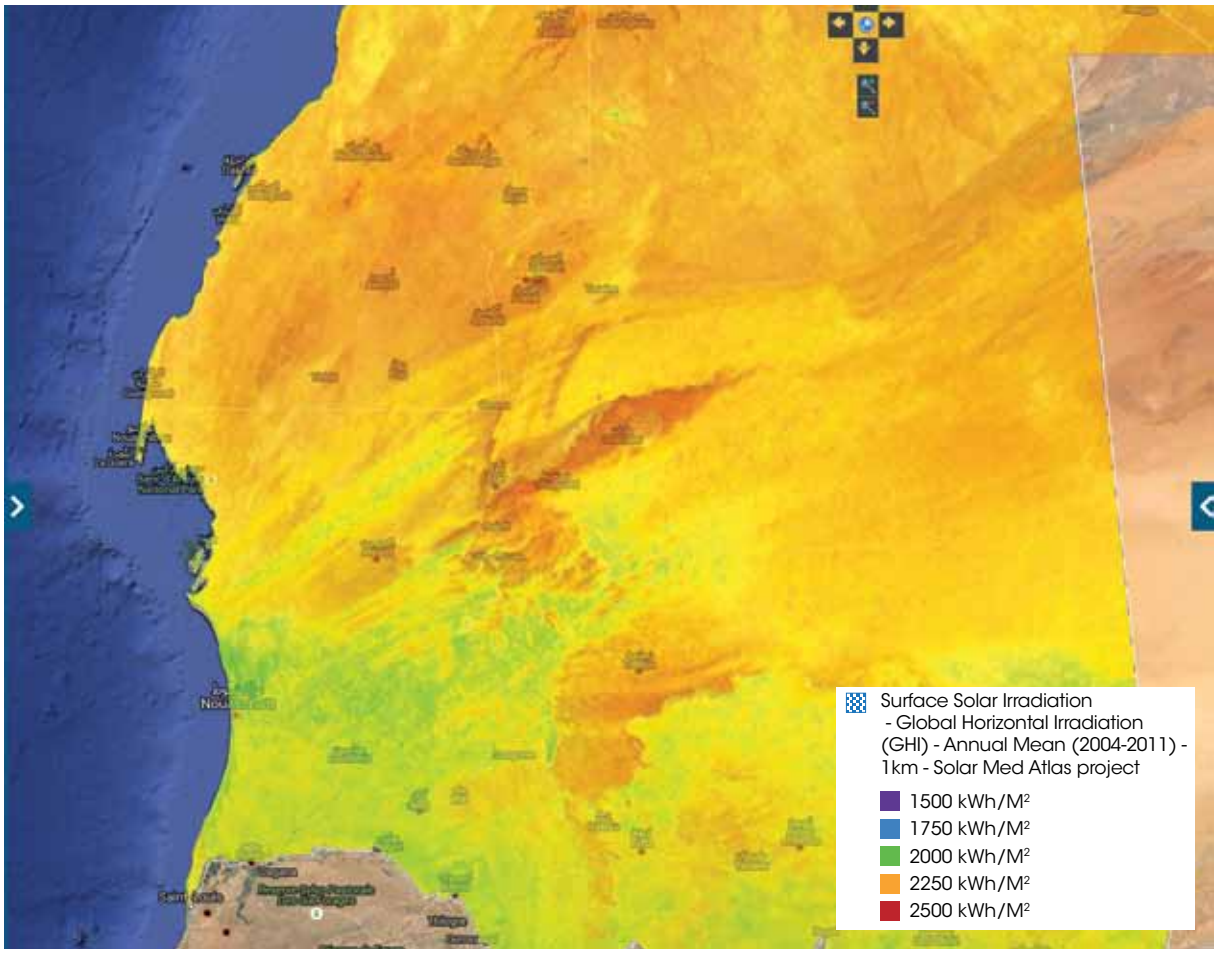
Mauritania receives a large amount of sunshine. The average radiation on a horizontal surface is 4.9-6.5 kWh/m²/day (1 800-2 400 kWh/m²/year), within three general climatic regions: the north, exposed to a hot and dry desert climate; the south, exposed to a more humid climate with lower solar resources; and coastal areas, exposed to lower temperatures but more humidity.

As illustrated in figure 8, radiation varies between a minimum of 1900-2 000 kWh/m²/year and a maximum of 2 300-2 400 kWh/m²/year. There are several potential "hot spots" (with higher radiation) in coastal areas (GTZ, 2009; INTEC, 2012).

Table 6 provides an overview of estimated solar PV production at five potential project sites. These measurements, which offer an order of magnitude for the expected scale of production, are estimated on an annual basis from direct and indirect radiation. The projected production at these sites is substantial compared to other regions where solar energy is strongly developed, such as Europe.

Variations in production among regions are related to differences in overall irradiation as well as estimated heat losses (which can be limited through the use of appropriate technologies) and barriers such as cloud cover, wind, sand and mist. Table 6 also shows that the optimum tilt of solar panels varies between 15° for the localities situated in the south of the country (Rosso and Nouakchott) and 21° for the localities located in the north, such as Atar and Nouadibou.

Figure 8: Solar potential in Mauritania



Source: IRENA Solar Atlas, 2015
The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

Table 6: Potential annual electricity generation from conventional fixed PV systems

Location	kWh generated per kWp	Optimum tilt installation
Nouadhibou	1 780	21°
Atar	1 590	20°
Kiffa	1 460	16°
Rosso	1 420	15°
Nouakchott	1 330	16°

Source: EC JRC, 2008

Mauritania has high levels of direct and indirect radiation. Current data, obtained primarily from satellite measurements, allow for good estimates of the available potential but need to be verified at the ground level. Several pilot projects and measures launched in the 1990s could be used to refine the data, but this information often is not available or usable.

Although solar energy has been explored for a long time in Mauritania, existing facilities are based almost exclusively on PV. Other technical options, such as concentrated solar power (CSP) and solar hot water, are possible (given the nature of the radiation), but they remain largely overlooked. Many PV systems are available locally, but these are mostly for small-scale (individual or collective) applications. Nouakchott is home to a PV module framing assembly unit with a limited production capacity.

Off-grid solar applications

Until recently, solar was used in Mauritania primarily for decentralised, off-grid applications. One of the first large-scale solar programmes implemented in the country was the Regional Solar Programme (PRS), which focused initially on the use of PV systems to supply drinking water (CILSS undated-a,b) and was expanded to include the distribution of community solar systems (*e.g.* lighting and refrigeration kits). Approximately 210 water and community systems were installed during the two phases of PRS 1 (1990-1998) and PRS 2 (2001-2007). Notably, as many as 30% of the systems installed during PRS 1 had to be rehabilitated during PRS 2, highlighting the need to properly design and maintain the units on site.

ADER, a Mauritanian non-governmental association that acts on behalf of the state, has installed just over 12 000 solar kits throughout the country, with a total installed capacity of 309 kWp. ADER has since included the development of mini-grids in its programme. APAUS, the main public stakeholder for rural areas in hydropower and energy, is also active in identifying solar-based solutions. These include solar lighting and refrigeration kits and water pumping, as well as the hybridisation of diesel plants used to power some mini-grids and multifunctional solar platforms (MFSP) (see box 1).

Box 1. Solar platforms for rural electrification

The solar platforms project, implemented by the French NGO GRET in conjunction with APAUS, cost USD 4.8 million and was funded with USD 3.4 million from the ACP-EU Energy Facility and USD 1.37 million from the Mauritanian government. It aims to install 100 multifunctional solar platforms in Brakna, Gorgol, Assaba and Hodh El Gharbi, with the goals of contributing to economic development and employment, improving socio-economic conditions and integrating the rural population into the national community.

Based on lessons learned from past projects, several different models of platforms will be installed, ranging from 1.5 kWp to 5 kWp. Past initiatives include 24 platforms within the PERUB project (funded by Energy Facility/APAUS, at USD 2.2 million), 24 platforms from UNDP/USAID/APAUS and 6 platforms from APAUS.

The new models will be adapted according to village size and identified needs. The feasibility study has identified the following types:

- A comprehensive platform consolidating the services of phone and battery charging, television, welding, crafts, cooling and a mill.
- A simplified platform consolidating the services of phone and battery charging, television, a mill or cooling (or other services, as defined with local input).
- A single-service platform providing cooling OR a mill OR crafts and welding.
- A charging station, consolidating the services of phone and battery charging (two-way or four-way charging load) (or other services, as defined with local input).
- Individual lighting kits, using a 12V socket, one to three low-energy bulbs, and a regulator that controls the discharge level of the battery and maximises the lifetime.

Large-scale solar projects (on- and off-grid)

Among the country's objectives are multiple large-scale solar PV projects. The Sheikh Zayed plant, with a peak capacity of 15 MW, was launched in March 2013 in Nouakchott, funded primarily by a donation from Abu Dhabi in the United Arab Emirates (see box 2). Many other projects are also under consideration or in progress.

Among the planned initiatives are several hybrid solar-diesel generation projects coupled with 33 kV distribution networks for areas not yet electrified. The first is expected to be the Kiffa project, which includes 1.3 MWp of solar power and 4 MW of thermal power. Other similar projects are expected in the coming years and will be implemented depending on the availability of financing. The proposed 2.6 MW Aftout Echargui project, involving 200 km of 33 kV line, already has raised up to USD 30.4 million in funding from the Islamic Development Bank (IDB) and the OPEC Fund for International Development (OFID).

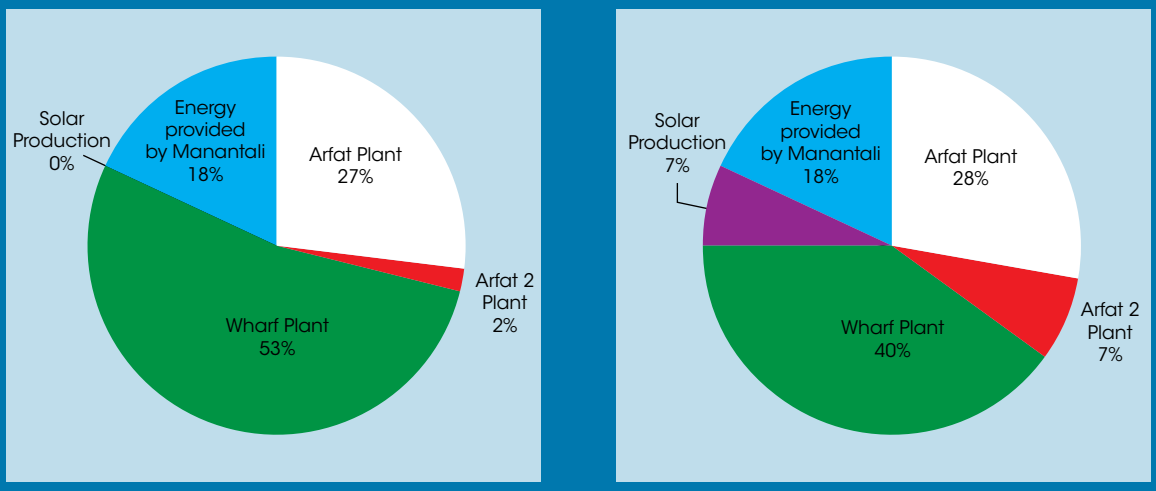
Projects to reduce the fuel use of off-grid industries are being considered as well. The first, the 3 MWp Zouerate project, is being carried out by SNIM and should begin operations shortly.

Box 2. The Sheikh Zayed solar PV plant in Nouakchott

Photo: L. Dittrick

The Sheikh Zayed solar PV power plant in Nouakchott, commissioned in March 2013, has a capacity of 15 MWp and covers an area of 30 hectares. The PV modules, provided by MASDAR Company, are made from amorphous silicon with two power ratings (410 W and 420 W) and from micromorph silicon with power ratings ranging from 470 W to 560 W. The plant is equipped with 17 SMA inverters and transformers of 9 1.6 MVA each. The electricity that is produced is sent to the station north of Nouakchott, providing 7% of the city's supply (see figure 9).

Figure 9: Energy supplied to Nouakchott, by source, January and April 2013



Source: SOMELEC, 2014

SOMELEC has calculated that the solar PV plant enables annual savings of approximately 5 million litres of HFO, 46 000 litres of diesel and 72 800 litres of oil, resulting in cost savings of more than USD 4 million/year. In addition, the plant has reduced greenhouse gas emissions by an estimated 20 000 tonnes of CO_2-equivalent. The plant construction cost a total of USD 32 million, funded by the Emirate of Abu Dhabi.

Solar manufacturing and supply chain

The recent development of Mauritania's solar market, previously limited to off-grid applications, has not yet fostered the emergence of significant industry and expertise in this area. Nouakchott is home to one assembly unit for mounting solar panels (assembling the frame and junction box) – ATERSA Mauritania – but its activity is irregular. The market is currently too small to justify the existence of a complete solar manufacturing supply chain.

From an economic perspective, Mauritania's significant solar resources can be considered competitive with the fossil fuel resources currently being used (*i.e.* diesel HFO). However, comparing the actual costs of providing power on site from various energy sources remains difficult, as this would require accounting for all development funding obtained for each infrastructure element.

Rural solar electrification projects are numerous in Mauritania and include village electrification via hybrid solar-diesel mini-grids, the installation of solar platforms (MFSP) and the distribution of solar lighting and refrigeration kits. Recurring issues with these projects include:

- Sustainability of the systems: Once the projects are implemented, their economic viability depends on their financing capacity and ability to increase their revenues. However, currently applicable tariffs help fund only the operation and a small part of renewal, which remains primarily the responsibility of the state and whose terms have not yet been defined.

- Maintenance of the installed systems, during and after the programmes. Management of fees and funds collected from customers, as well as differences in pricing among areas connected and not connected to the grid; communities managed by SOMELEC; and communities served by the ASPs and by solar platforms.

- The necessary transition between off-grid communities and those that potentially could be connected but are not covered by SOMELEC. Communities previously connected to an independent mini-grid that potentially now could be connected to the main grid do not have access to it due to a lack of SOMELEC resources.

- The need for harmonisation of tariffs between the communities served by SOMELEC and those served by ASPs.

The context is particularly favourable for implementing extensive solar projects to reduce the fuel consumption of off-grid industries, particularly the mining sector. The first SNIM test projects will help to better evaluate possible savings. Similarly, hybridisation projects for mini-grids will reduce energy costs.

Despite all this, the following challenges remain:

- It is difficult to prove that savings have been achieved or are feasible because of the existing tariff system and the lack of information regarding the true costs of generating electricity savings. However, off-grid, this measurement is easier.

- There remains a need for better control of hybridisation and/or coupling of solar with other technologies to balance electricity production and consumption either on- or off-grid.

- A project to monitor and evaluate the impact of existing solar plants would provide a better understanding of the conditions of implementation, productivity and the need to extend these applications throughout the country.

WIND

Mauritania's wind resources are estimated mainly from global satellite measurements and need to be confirmed through measurements

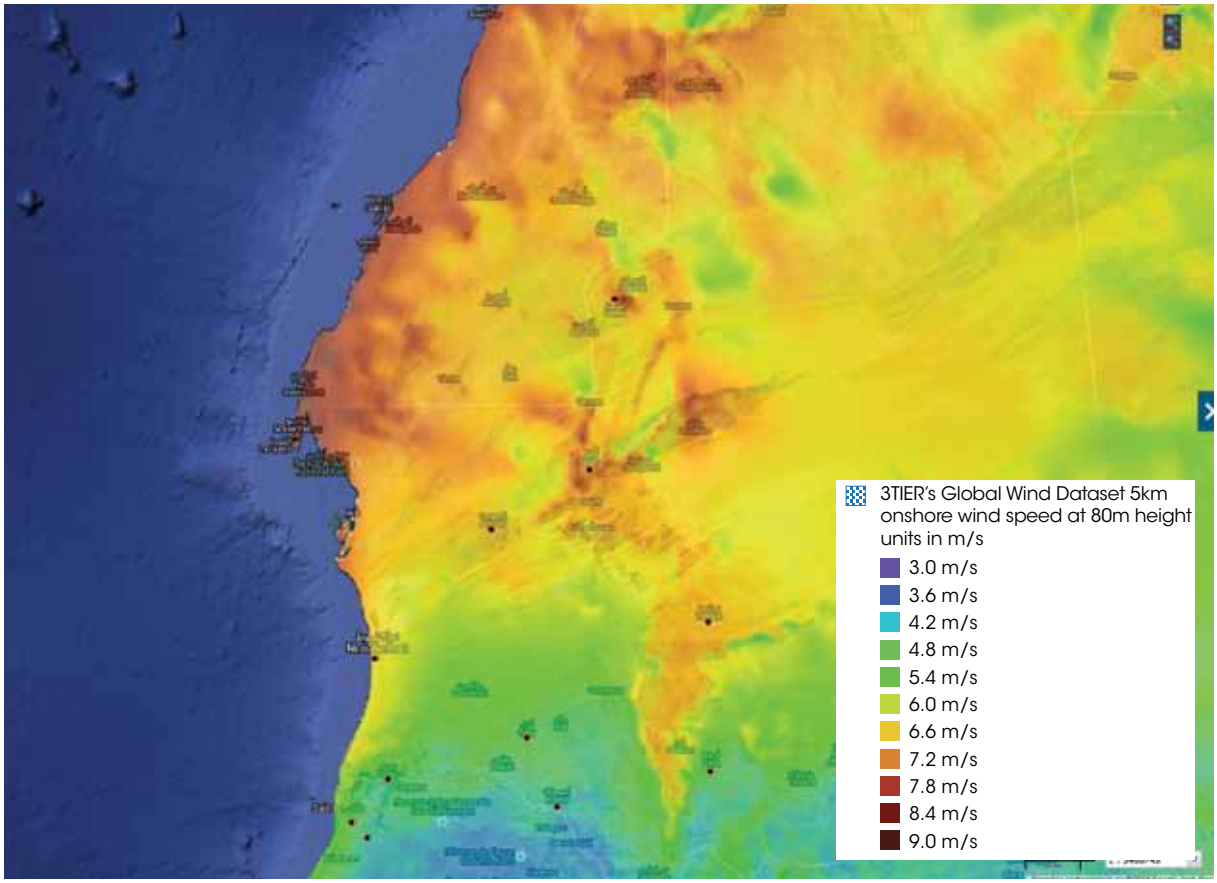
and assessments on the ground (see box 3). As illustrated in figure 10, the northern coastal areas show wind speeds of between 8.3 m/s and 8.7 m/s, although speeds can exceed 9 m/s in Nouadhibou. Moving south, values drop gradually but remain above 7 m/s along the coast, a level that is still high in absolute terms. It is more difficult to establish wind patterns inland, as they are affected by topography and specific conditions related to the sites.

Box 3. Solar platforms for rural electrification

IRENA's Global Atlas for Renewable Energy initiative, which Mauritania joined in January 2014, was launched with the support of an international global consortium. The Global Atlas provides an Internet platform that includes homogeneous global solar and wind data and allows users to add layers of information on, for example, protected areas, roads or infrastructure, in order to identify areas of opportunity to develop projects. The Atlas also helps with the formulation of energy policies, in planning and with the stimulation of investments in pre-feasibility studies for wind and solar projects.

IRENA's Global Atlas platform provides basic information, while enabling businesses and service providers to focus on personalised and high-added-value services based on specialised commercial databases for specific sites and projects. Through the initiative, Mauritania will receive support from IRENA to tackle gaps in data collection and availability in the country.

Figure 10: Wind energy resources in Mauritania



Source: IRENA Wind Atlas, 2015
The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

Wind power projects

Wind power has been explored in Mauritania since the late 1980s, focusing primarily on the use of mechanical wind energy for water pumping and electricity generation (both on- and off-grid). Between the late 1990s and early 2000s, a major demonstration and testing programme in collaboration with the Canary Islands Institute of Technology (ITC) included the development of a wind atlas for the country, a demonstration platform for renewable energy and maintenance at the University of Nouakchott, and the commissioning of four water desalination units (20-40 m^3/day) in Banc d'Arguin National Park (Izquierdo, 2005).

A research project involving Mauritania and Morocco, funded by NATO under the Science for Peace and Security programme, is exploring ways to convert wind energy into hydrogen gas (through electrolysis) and to store it to use when necessary. Currently, some wind measurement instruments have been installed on communication towers in the two countries (NATO, 2012).

Since 2012, a 4.4 MW wind farm has been in operation in Nouadhibou, serving SNIM needs for the mining industry. It comprises 16 Vergnet turbines mounted on retractable pylons. In addition, a new 30 MW plant is being finalised in Nouakchott and will be connected to the SOMELEC network. The result of the call for tenders for wind power in Nouakchott surprised many national stakeholders because of the low price per kWh stipulated, despite slower wind speeds in this area than in the country's north.[3]

Wind supply chain and technical barriers

The size of the Mauritanian market does not justify developing local wind turbine manufacturing, although some elements, such as towers and civil works, can be produced locally. However, an assessment of the potential of local manufacturing of wind components should be performed.

The major technical barriers to the integration of wind power in Mauritania include:

- The lack of companies with experience in the field.
- The difficulty of connecting to the network. Today, the only wind plant in operation, in Nouadhibou, feeds a small percentage of potential output into the SNIM network. The plant is used only for marginal production when most fuel units are in use.
- The lack of lift capacity. There is no crane in Mauritania capable of installing modern masts and turbines, which can reach over 100 metres high and weigh tens of tonnes.
- No overall wind measurement campaign has been conducted in the country.[4] However, some measurements have been made from specific masts, either with a view to carrying out pre feasibility studies for projects or as part of past scientific research.[5] The most accurate data obtained for feasibility studies have been collected over short periods of a month. These, provided by scientific facilities, are difficult to process today, although they are still available, and require further study.

In addition to these barriers, it would also be useful to process the long-term data from installed measuring stations, as well as to retrieve the data related to the Wind Atlas prepared in 2000.

[3] MPEM calculated the price of wind power at USD 0.052/kWh. Since this price is highly dependent on the structure and cost of financing, it should not be used as a standard or benchmark (any comparison should be made as an equivalent cost of funding); however, it helps to show how some of these solutions become competitive with the existing system.

[4] The only modern measurement campaigns were performed at Nouadhibou and Boulanoir, mainly by EED and Hélimax.

[5] Sites already equipped thanks to the NATO Science for Peace and Security programme (Sahara Wind implementation) include: Tweila, 40 kilometres northeast of Nouakchott; the ACS building roof, with a measurement of solar radiation; Wad Naga, 50 kilometres southeast of Nouakchott; and Nouadhibou road, 33 kilometres north of NKT. Sites to equip quickly include: Nouadhibou; Boulanoir, 129 kilometres south of Nouadhibou and its water source Inal, 40 kilometres east of Boulanoir on a proposal from the APAUS, and another site to be identified reserved for APAUS.

Wind project in Mamghar carried out by APAUS and opened in July 2013.
Photo: APAUS

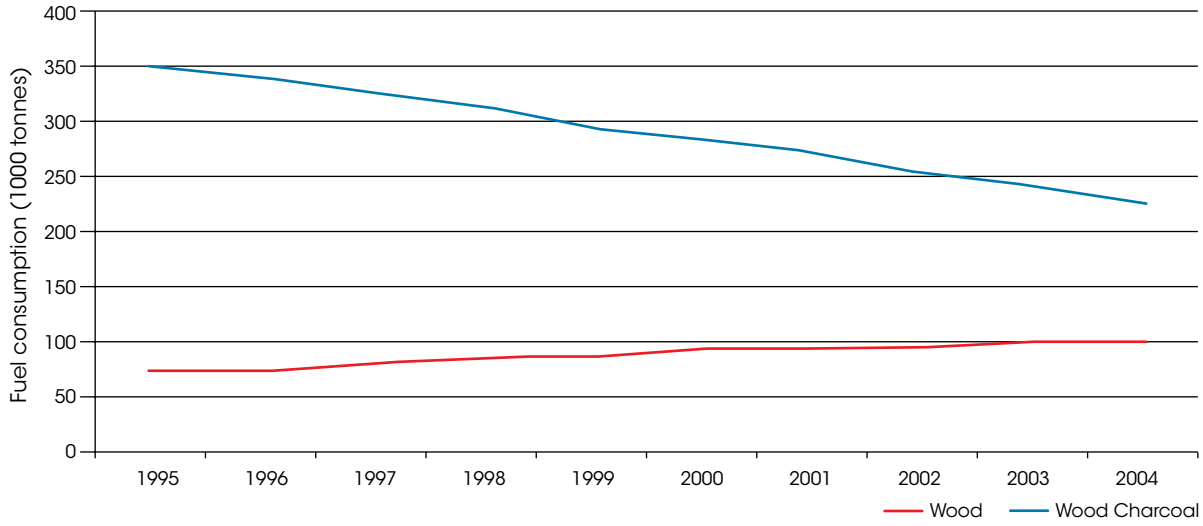
BIOMASS

Despite Mauritania's largely desert climate, an estimated 67% of the country's primary energy needs are met through the use of traditional biomass (wood and charcoal). Between 1995 and 2004, the use of wood decreased, while the use of charcoal increased (see figure 11). Although these resources are a preferred energy source for cooking food, the use of traditional biomass combined with the effects of drought and fire have severely reduced the vegetation cover. The country is engaged in substantial replanting programmes, the results of which have yet to be evaluated.

Agricultural waste in the country previously totalled just over 500 000 tonnes/year, with a corresponding energy potential of some 3.7 gigawatt-hours (GWh). However, the period between 1991 and 2001 saw a decline in agricultural production. Although agricultural activities have since resumed, the resource potential should be re-evaluated.

Two additional potential biomass resources are jatropha and typha. Jatropha (nettlespurge), a perennial plant that consumes little water, has been praised for its potential to combat desertification and boost biofuel production. It could be used as part of the Mauritanian replanting programme. Typha (bulrush, cattail) could replace charcoal in cooking. Its use as a fuel would also help combat the typha invasion in rivers and streams, which has contributed to habitat destruction and biodiversity loss.

Figure 11: Consumption of wood fuel and charcoal, 1995-2004 (in thousand tonnes)



Source: Environment Directorate, 2008

Potential biomass projects

Typha charcoal could reduce pressure on forest resources. A typha carbonisation programme is being tested in Rosso to produce a replacement for wood charcoal. The first production units have been established, and efforts should gradually be extended in the area. The project is an initiative of APAUS, implemented by the French NGO GRET in collaboration with the High Institute of Technological Education (Institut Supérieur d'Enseignement Technologique - ISET) and UNDP, and co-funded by the European Union within the framework of the African Caribbean and Pacific/ European Union Energy Facility.

Preliminary results show the value of the programme in restoring biodiversity – for example, the re-emergence of water lilies and fishing in typha-prevalent areas.

Other biomass projects include a feasibility study that is under way for a gasification / waste incineration plant in Nouakchott, which is intended to be an independent power producer (IPP) and could allow for 15-20 MW of generation capacity. Additionally, a sugar production project being evaluated in Foum Gleita could enable up to 18 MW of electrical output from the combustion of sugarcane bagasse and produce 38 million litres of ethanol per year.

Producing Typha charcoal in Rosso
Photo: APAUS

Biomass supply chain

The main biomass energy technologies produced in the country relate to improved cookstoves. About 56% of the population (roughly 30% of the urban population and 82% of the rural population) uses solid fuels (wood and charcoal) for cooking. According to the interviews organised during the inception phase of the RRA, only an estimated 0.4% of the population uses improved cookstoves, leaving significant room for growth.

The two main available improved stoves are the Ouaga Metallic Vita wood-burning stove, which has efficiencies greater than 45% and costs about USD 4.11-8.22/unit (Reikat, 2012), and the Multi 4-7-30 or "maslaha" wood-burning stove, which was introduced in the 1990s and has efficiencies of 30-35% (PREDAS, 2005).

The first outreach and training programmes for improved cookstoves, supported by the World Bank's Energy Sector Management Assistance Program (ESMAP), targeted the neighbourhoods of Nouakchott in 1990. The programmes included significant training for potential producers of the stoves, including 190 blacksmiths and metalworkers. More recently, the ProCEAO programme, funded by GIZ and the European Commission, implemented a project to distribute improved Vita cookstoves to approximately 5 000 households in the Guidimaka region by 2014. However, an evaluation of the success of this project should be carried out to determine whether the initial aims of the project have been achieved and if the project can be duplicated elsewhere.

Biomass energy can be used for both centralised and decentralised generation, and the options are numerous, ranging from the development of waste-to-energy plants, to the distribution and manufacture of improved cookstoves, to the potential use of biodigesters. There remains a need for:

- Updated estimates of the resource potentials for agricultural waste, generation capacity and the use of improved cookstoves;
- Capitalising on past experiences (whether successes or failures); and
- An updated summary of available technologies and assessment of local producers in business.

SUMMARY

Mauritania has significant renewable energy resources, the extents of which are generally unknown and poorly quantified. One priority would be to improve the level of knowledge by collecting and collating existing (often unprocessed) information sources to enable an initial assessment and the identification of priorities for further action. With regard to biomass, where the exploitable resource depends directly on the management of forest and agricultural resources, it would be useful to learn the extent to which certain laws and decrees have been applied, as well as their effects (*e.g.* regarding community participation provided for under the Forest Code).

ENERGY POLICY AND REGULATORY FRAMEWORK

Mauritania's energy policy is defined largely in an ad hoc manner, based around existing opportunities and financed by international institutions and bilateral projects. This approach has served the country by allowing it to become a leader in the sub-region in the installation of renewable energy projects. To capitalise on this success and to ensure ongoing and co-ordinated development of renewables, the country needs to better define its goals and the means of achieving them.

STRATEGIC GUIDELINES

Energy has been identified as a priority for Mauritania's development. The first theme of the country's Poverty Reduction Strategy Paper (PRSP), for example, emphasises:

- Developing infrastructure to support growth through the improvement and diversification of electricity production –

with particular emphasis on the fact that the country pays "specific interest to the development of energy as a factor of production".

- Optimal exploitation of sources of growth through the development of oil drilling and exploitation of the Banda gas field to overcome the energy deficit.

In all, the four priority themes of the PRSP are linked either directly or indirectly to energy. The document also reflects the country's renewable energy objectives, pointing to the role of renewables in not only contributing to national development, but also reducing the influence of external factors on the economy.

Mauritania has clearly identified the lack of access to basic services, including energy, as a stumbling block to national development efforts. The PRSP seeks to expand existing electricity distribution channels as soon as possible and to provide services independently in locations where the grid is not available. Specifically, it mentions the need to develop local or regional energy resources (natural gas and hydropower) and to balance the renewable energy mix.

The PRSP includes targets for the electrification of 108 villages in the 9 poorest wilayas and support for collective and private electrification initiatives in 192 local areas (villages of 500 to 1200 inhabitants). It also includes the objectives of increasing the urban electrification rate from 50% to 80% by 2015, and the rural electrification rate to 40% by 2015 (IRM, 2011).

REFORMS IN THE ENERGY AND ELECTRICITY SECTORS

The economic situation for energy supply development in the country is complex. The electricity sector still faces chronic deficits linked to a combination of factors that are being examined.

Mauritania began a reform programme based on liberalisation of the electricity sector in 1998 (World Bank and Nodalis, 2010). This specifically planned for the abolition of any power supply monopoly, for the participation of private operators in the sector and for setting rates that reflect the cost of service. The reform was intended to result in the privatisation of SOMELEC. However, the privatisation process tender was not conclusive, with only one qualifying bid.

Key laws and regulations relating to the electricity sector are described below.

Act 2001-19: This legislation establishes the electricity code and has among its objectives: liberalisation of the electricity sector; the harmonious development of electricity within the framework of existing laws; the creation of economic conditions that guarantee a return on investment in the electricity sector; growth in electricity use in all segments of the population and industry; and the conditions for just and fair competition, upholding the rights of users and operators.

Although planned privatisation projects have been abandoned, some of the structure that was put in place under the Act to support the industry still exists, including the possibility of IPPs and the establishment of a regulator that is now active in the sector. For the moment, however, the regulator covers only authorised service providers (ASPs), not SOMELEC.

State–SOMELEC Programme Contract: To date, this is the only formalisation of relations between the state and SOMELEC. The contract dates from 2001 and does not cover the role of the regulator. Since then, the state has implemented several specific measures, such as shifting the supply of energy services in the mougathaas from ASPs to SOMELEC.

Master Plan for the Production and Transport of Electricity: In its Master Plan for the Production and Transport of Electricity Between 2011 and 2030, the country studied

energy scenarios and their consequences, covering the major themes of diversifying production and reinforcing and expanding the transport and distribution network.

PRSP: The PRSP specifically mentions renewable energy sources and includes renewable generation targets of 15% by 2015, 20% by 2020 and 35% by 2030 (IRM, 2011). It recognises the contribution of renewable energy in helping to secure the country's energy supply, reduce its dependence on imported oil, stabilise electricity generation costs and improve energy access in off-grid areas. However, the PRSP does not specifically point to renewables as an option for producing lower-cost electricity for large, off-grid applications. The Banda gas project is seen as an end-all solution for developing the mining and industrial sector. However, many centres of energy demand are located so far from the network that grid extension is not feasible. In these cases, renewable energy could be used as a "fuel saver" to complement conventional generation.

In a pragmatic way, Mauritania has deployed renewable energy through a project-based approach, making it a leader in the sub-region in major solar and wind power capacity (in addition to the hydropower projects deployed through the OMVS). The country has made similar strides with efforts to improve access to energy services, with substantial achievements in solar hybrid off-grid production and the construction of wind-diesel hybrid projects for coastal communities, in addition to grid-connected projects.

With these models in place, it would now be useful for Mauritania to provide structure to its renewable energy activities by developing a policy that clearly defines the country's goals and means to achieve them. This would allow it to continue to progress in a more deliberate manner by ensuring the continuity and sustainability of actions, while giving visibility to participants in the renewable energy field. This long-term vision is critical not only to help national actors plan electricity generation needs, but also to help reduce prices. Any instability in energy policies, whether perceived or real, may increase country risks, potentially discouraging participants from investing in projects and increasing the cost of financing available from banks and donors.

INVESTMENT AND FINANCING

As in other countries in the region, much of the financing for energy sector investments in Mauritania comes from international donors. This is the case for most newly built projects as well as for many of the projects currently under evaluation. SOMELEC's shaky financial position precludes additional debt, and the company is unable at present to provide energy services in rural areas (whether based on renewables or conventional fuels). The current average generation cost for ASPs is MRO 261 (USD 0.93) /kWh (APAUS, 2014a), which far exceeds the selling price of MRO 51-90 (USD 0.18-0.32) /kWh.

Many international donors are active in Mauritania's energy sector. A leading donor is the Arab Fund for Economic and Social Development (FADES), which in 2013 contributed USD 10.4 million to finance power generation facilities in rural areas, USD 5.2 million to finance the 30 MW wind power plant in Nouakchott and USD 105 million to modernise the national electricity generation and transport system (AF, 2011). All of this funding, in the form of concessional loans, is granted with interest rates ranging from 2.5% to 3% over a period of 20-25 years.

The French development agency AFD has been active in the electricity sector, providing budgetary support in the form of two sovereign concessional loans, totalling USD 89 million, to accompany reform of the sector. It also granted a sovereign loan of USD 26 million, plus a European grant of USD 6.6 million, for the construction of a hybrid solar-thermal power station in the Kiffa region. In addition, it participated in the financing of the Nouakchott-Tobène high-voltage line.

The World Bank is heavily involved in the institutional arena and in guaranteeing development of the Banda gas field, which involves processing the gas, converting it into electricity and transmitting this power throughout the country and beyond. Other donors – such as the European Commission through the European Development Fund (EDF) and the ACP-EU Energy Facility – are involved in energy service provision projects. Additional donors include the Islamic Development Bank (IDB), one of the country's major donors today; the OPEC Fund (OFID); and the Saudi Fund, which allocated the additional USD 70 million needed for construction of the Nouakchott - Nouadhibou high-voltage line. In addition, the Crown Prince of Abu Dhabi funded the 15 MW Sheikh Zayed solar PV plant in Nouakchott, through a grant of USD 32 million.

This financing structure allows the country to limit capital costs for national projects. But it also reflects a difficulty in raising commercial funds, given the national economic situation. Mobilising low-cost funding from donors can be an advantage for renewable energy projects, which typically are capital intensive and have low variable costs. The 30 MW wind plant in Nouakchott, for example, was funded with USD 52 million from FADES and USD 6.85 million from the Mauritanian government, bringing the cost to USD 0.066/kWh (MPEM, 2014). But renewable energy sources are not necessarily best suited to donor funding mechanisms, as these mechanisms are not always able to take into account renewable energy project specificities (*e.g.* smaller projects require the same administrative processing costs as larger ones).

Moreover, national funding mechanisms do exist in Mauritania. The country's Fund for Universal Access to Services (FAUS), for example, is funded through several sources. These include: fees collected within specific laws, among them the law relating to the Multisectoral Regulatory Authority (ARM) and sectoral laws relating to water, electricity (only ASPs contribute fees, not SOMELEC) and telecommunications (a key resource); allocations from the state budget; partner contributions for developments; and allocations for poverty reduction resources.

A critical issue for renewable energy in particular is the availability and cost of financing. Because most renewable technologies have low variable costs, the bulk of the funding must be raised during the project's "bank closing" to cover fixed costs. This is perhaps an area where the government of Mauritania can have the most influence. Without spending more, it can significantly reduce the cost of financing renewable energy projects by implementing stable legislation that would reduce country-related risks. Technological risks could be managed by developing a strong national capacity for installing, managing and maintaining renewable technologies. Many measures could be taken to use planned and commissioned projects (both on- and off-grid) to train future installers and project managers. The country also may consider creating a specific national fund dedicated to the promotion of renewable energy, thereby reducing financial risks and helping to lower the cost of projects.

The government's biggest impact on the development of renewable energy sources could be through the creation of a stable, sustainable and transparent environment. In this context, it may be useful to consider creating long-term rate guarantee mechanisms for power producers, whether they are on the SOMELEC network or directly producing electricity for off-grid industrial needs. The legal framework of the National Electrical Code provides for the existence of IPPs, but it could include specific provisions for renewable energy, as well as provide a standard power purchase agreement (PPA) that could be adapted as needed.

R&D AND CAPACITY BUILDING

Research and development (R&D) is an important component for harnessing new technologies, developing know-how and improving energy performance. In Mauritania, a variety of R&D institutions and training centres for renewable energy have been established to provide up-

to-date information for policy makers and developers (see table 7). But close co-ordination among industry, academia, research institutions and governments is needed to better take advantage of renewable energy resources.

Additionally, there is a great need in the country for training in renewable energy at the technical and engineering levels (CNA, 2013). Companies lack qualified personnel for maintenance and installation jobs, and the courses offered today are not suitable or are too theoretical to meet the need. Training institutions also lack the resources to conduct quality training.

To overcome these shortcomings, the following steps are encouraged:

- Regional and international co-operation to allow the exchange of experiences, expertise and know-how. ECREEE (of which Mauritania recently became a member) provides various capacity development, internship and knowledge - exchange activities. Other regional training institutes, including at the secondary level, could share technical platforms, teaching and methods.

- Collaboration with companies in the country and region, to take advantage of their feedback and to ensure that trainees are tailored to their needs.

- Renovation of existing R&D and training facilities and the identification of sustainable resources to maintain them, as well as installation of additional equipment adapted to new R&D needs.

Table 7: Key R&D institutions and training centres in Mauritania*

Institution/Centre	Description
Centre for Applied Research in Renewable Energy in Mauritania (CRAER)	Created in the context of the proposed Renewable Energy Park funded by the Canary Islands (Spain) to promote renewable energy applications, desalination of water, and cooling with national and international partners. CRAER uses applied research to solve new problems posed by different applications in the field and the need for academic training; however, the lack of resources and the cyclical nature of projects make data collection and capitalisation difficult.
Nouakchott University – Faculty of Science and Technology	Offers theory-based bachelor-, master- and doctorate-level courses, focused mainly on energy calculation and the design of renewable energy systems. However, it suffers from a deficit in teaching staff and a need for training. It also lacks the necessary resources to meet all requests received for the Renewable Energy Masters.
École des Mines in Mauritania (EMIM)	A newly created institution (the first graduates have not yet completed their engineering education) that offers a specialisation in electro-mechanics. EMIM plans to create a renewable energy option, but details on this are not yet available.
Higher Institute of Technological Education : Institut Supérieur d'Enseignement Technologique (ISET)	Primarily an institute of higher education, at the technician level. It provides training that touches on energy but does not specialise in this field. In collaboration with GRET, it also conducts applied research on system maintenance and processing of Typha for the manufacture of a charcoal replacement. ISET offers many agricultural activities that may be of use in the field of bioenergy (use of agricultural residues, etc.).
Centre for Advanced Technical Training (CSET)	Provides short vocational training in tertiary areas (secretary, office assistant, managing SME) and technical occupations (mechanical, electrical, cooling and air conditioning, maintenance, etc.).
SNIM Technical Training Centre of Zouerate	Offers vocational and technical training through alternated learning, including courses in mechanics, industrial electricity and welding. Graduates of the Training Centre are given priority when applying for SNIM.

* Other centres include the SOMELEC Centre of Professionals, the Centre/Laboratory of ADER, the agriculture sector of the School of Education and Agricultural Extension (ENFVA), and the National Research Centre for Agronomy and Agricultural Development (CNRADA).

One of the greatest limitations to renewable energy development is the difficulty of comparing investment costs. Renewables are often deemed "more expensive" than conventional fossil resources, in part because most cost comparisons do not account for the environmental or social benefits of renewables or for the large subsidies that fossil fuels still receive.

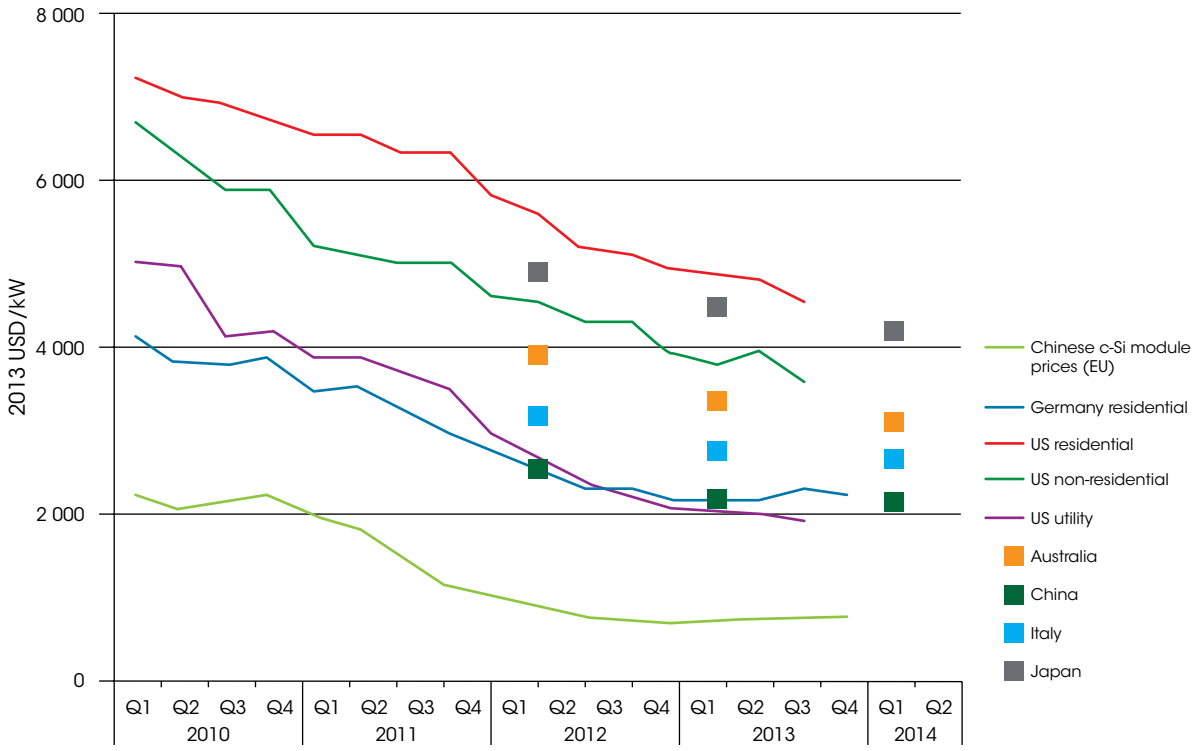
III. Challenges In The Deployment Of Renewable Energy

COSTS AND ELECTRICITY TARIFFS

Mauritania boasts substantial renewable energy resources in many areas. However, the electricity network and the level of interconnection are still limited. Many population pockets and economic activities are not connected to the grid and could benefit from a renewable energy supply. Existing renewable energy projects have demonstrated their potential to provide generation to the grid as well as their competitiveness with conventional solutions. However, many of the benefits of renewables – in terms of securing energy supply, price stability, job creation, climate change mitigation and others – are currently not included in calculations of the cost of generating electricity.

One of the greatest limitations to renewable energy development is the difficulty of comparing investment costs. Renewables are often deemed "more expensive" than conventional fossil resources, in part because most cost comparisons do not account for the environmental or social benefits of renewables or for the large subsidies that fossil fuels still receive. Because of their inherently different characteristics, including their variable nature, renewable energy sources cannot be planned, managed or analysed in the same manner as conventional solutions. Nevertheless, price trends in the global renewable energy sector – especially for wind and solar (see figure 12) – confirms that these resources already are competitive with conventional sources in some regions.

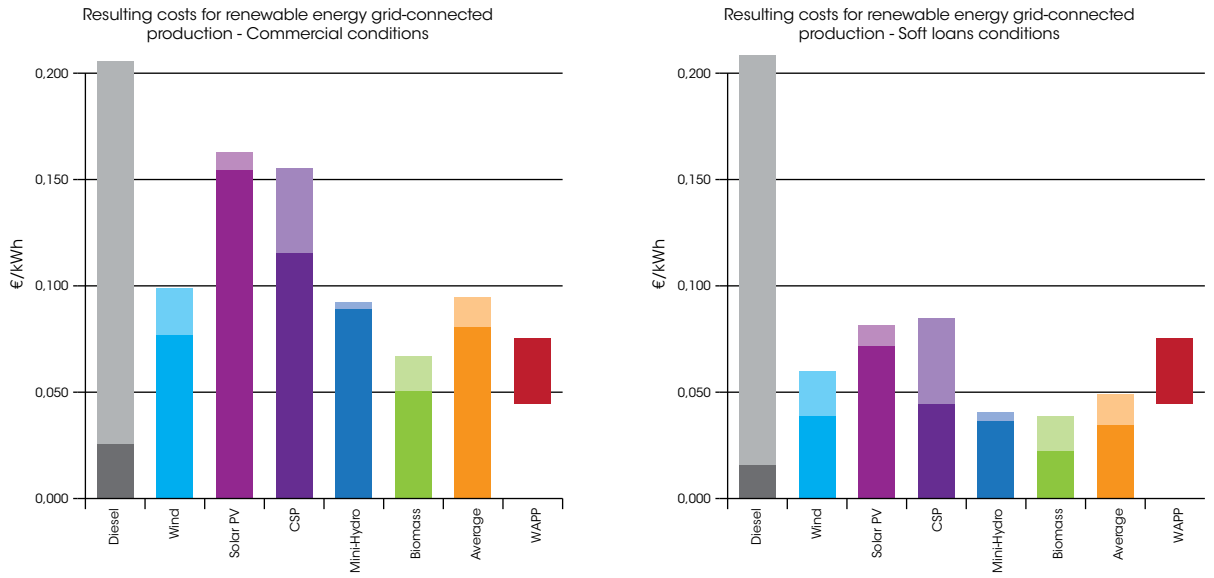
Figure 12: Price of solar PV in selected countries, 2010-2014



Source: IRENA

Price comparisons should also be made under similar conditions. Most global comparisons of conventional versus renewable generation costs are made under commercial bank financing conditions, which are not always available in Africa. Projects in Mauritania typically are funded by development banks, combining grants and traditional debt to reduce interest rates (see earlier discussion of financing). Comparing costs for grid-connected generation funded by development financing (soft loans), as opposed to commercial conditions, paints a very different picture, with diesel costs much higher than those for renewable energy (see figure 13).

Figure 13: Electricity generation costs, by source, on the ECREEE network: commercial versus soft loan conditions



Source: ECOWAS, 2012

The comparison also shows that the "average production price"[6] of the West African Power Pool (WAPP) is quite low, at USD 0.068-0.096/ kWh. This is because most of the infrastructure built – including the transmission network and the generation capacity – has been subsidised, and because cost calculations are based on infrastructure that has already been widely written off, limiting costs to the variable costs of this infrastructure.

To be consistent, cost comparisons should be made between new infrastructure to be installed, in order to provide a better idea of the opportunity cost of each option. Furthermore, renewable energy provides the important benefit of price stabilisation: the low share of variable costs helps to stabilise the generation cost over the long term. In addition, renewables can, among other benefits, significantly contribute to climate change mitigation and, in an increasingly resource-constrained environment, meeting growing demands for water and food (IRENA, 2015).

For Mauritania, comparing the calculated generation costs for electricity from the Banda gas field (table 8) and centralised wind power (table 9) shows that the costs not only are comparable, but even give wind energy the edge. A similar comparison for centralised solar PV generation has not been possible, because the analysis (Tractebel, 2010) used a methodology based on off-grid use. Nevertheless, centralised solar PV could reach similar levels of competitiveness.

[6] It is important to distinguish between "price" and "cost". Price involves measuring a unit of value expressed in the market that does not necessarily take into account all costs incurred by the state and the population. To make two options comparable, it is necessary to talk in terms of overall costs, which at times requires information that can prove difficult to collect.

Table 8: Unit cost of generation from the Banda gas project (SPEG)

Components of the unit cost	IRR = 10%	IRR = 13%	IRR = 15%
	USD/MWh	USD/MWh	USD/MWh
Spec cost. recov. capital	34.22	43.51	34.22
Fixed cost O&M	7.41	7.41	7.41
Variable cost O&M	9.2	9.2	9.2
Cost of fuel	167	167	167
TOTAL	117.82	127.10	133.86

Source: Tractebel, 2012
Note: IRR = Internal Rate of Return; O&M = Operation and Maintenance

Table 9: Updated generation costs of wind power plants

Wind speed (m/s)	Production (MWh/MW)	Updated production costs (USD/kWh)
9.0	4 004	0.768
8.5	3 627	0.850
8.0	3 224	0.954
7.5	2 803	1.098
7.0	2 375	1.296

Source: Tractebel, 2010

OFF-GRID PRICE COMPARISON

As might be expected, renewable resources have much higher investment (capital) costs than diesel in Mauritania (see table 10). However, the costs per kWh generated paint a different picture. According to one calculation (Tractebel, 2012), the average generation cost for isolated SOMELEC diesel plants was MRO 78.83/kWh (USD 0.28/kWh), and for authorised service providers (ASPs) (who manage smaller plants), it was MRO 141/kWh (USD 0.51/kWh) (excluding fuel) and MRO 261/kWh (USD 0.93/kWh) (including fuel) in 2009. This is higher than the average generation cost for solar energy with storage, calculated at USD 0.27/kWh in the Master Plan for the Production and Transport of Electricity (Tractebel, 2012).

However, the Master Plan does not take these figures into consideration when comparing generation costs. This is not surprising, because the document is mostly technical and does not cover micro- and macro-economic aspects. Nevertheless, the country needs to be aware of the true price and consequences of its energy choices, which is not the case today given the difficulty of measuring the true costs of generation.

Table 10: Unit costs of bids received by APAUS over three years for off-grid RFQs for capacity ranging from 50 kWp to 120 kWp

Resource	Cost (USD/kW)
Solar	5 297.8
Wind	4 281.2
Diesel	471.28

Source: APAUS, 2014a

ON-GRID ELECTRICITY

As seen above, renewable energy can prove competitive for grid-connected generation. It also offers numerous economic and environmental benefits that are difficult to measure through electricity tariffs. However, the competitiveness of a renewable energy solution ultimately depends on the technology, the quality of available resources, the availability of funding, as well as issues specific to the location of the generation.

For example, although the Nouadhibou region has strong wind resources – and thus high potential for large wind farms – local electricity demand may not be sufficient to warrant such an investment. Even in the case of significant demand, however, it would be necessary to plan generation based on the capacity of the existing transmission grid, to enable the transport of the electricity to consumption centres. The Banda gas project includes significant transmission capacity, including the creation of a major north-south transport axis, which could be used in part by renewable power plants. The wind conditions in the country's north could enable Mauritania to consume and export any excess power at reasonable prices to ECOWAS countries via the OMVS network.

For solar PV, based on the country's average electricity production price of USD 0.34/kWh (AFD, 2013), generation is already competitive with numerous national production solutions.

One advantage of renewable energy is its inherently decentralised nature. If there are sufficient resources, they can be deployed directly where they are consumed in order to reduce transmission costs. This makes it possible to plan renewables deployment based on network needs and not vice versa, as in the case of conventional technology (with the network designed around the plant). Renewable energy therefore can provide significant value added by being produced on-site. For example:

- End-of-the-line production can strengthen the grid, reduce transmission losses and reduce the consumption of HFO.
- Siting a renewable energy plant at an overloaded substation can help reduce electrical losses and avoid the construction of a new line.
- A renewable power plant can be built faster than a conventional plant; for example, a solar PV plant can be completed in three months to quickly strengthen the grid where needed.

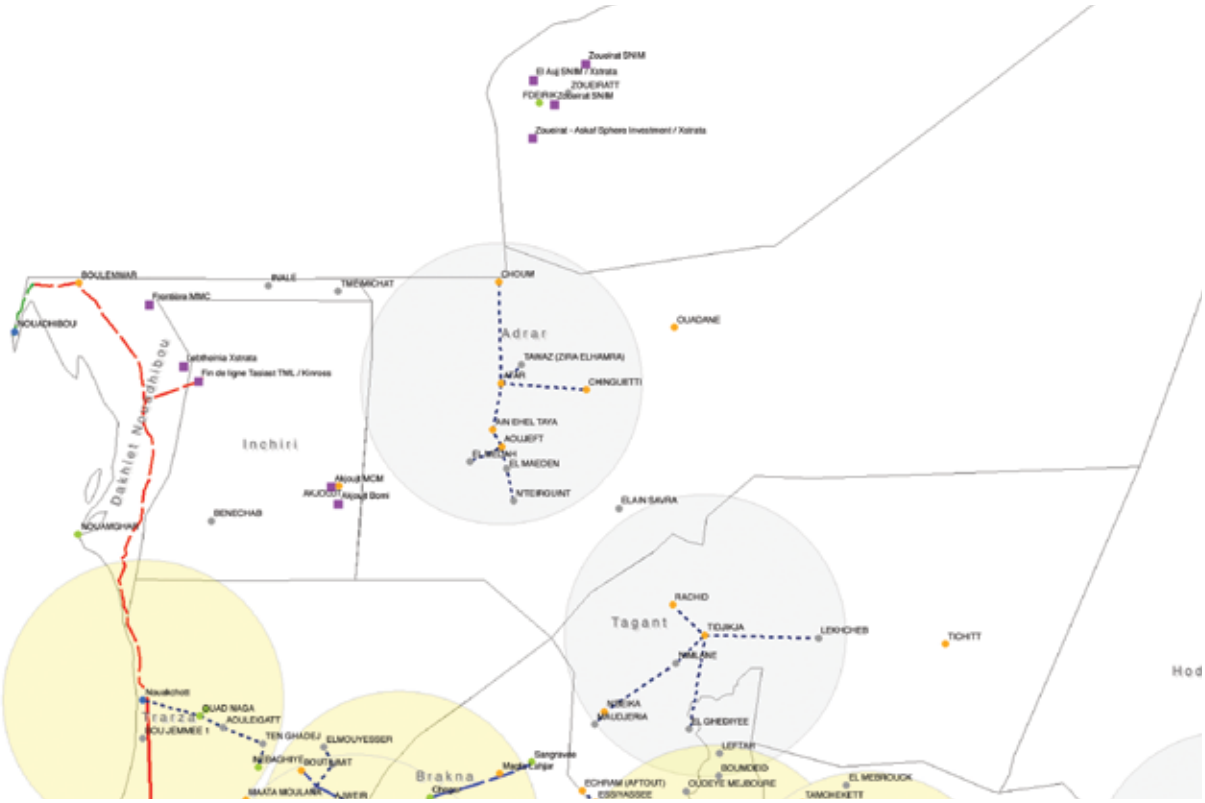
Finally, long-term planning of renewable power plants is necessary for the preparation of feasibility studies, the possible extension and capacity expansion of the transport or distribution system, and to demarcate areas (zoning) with high renewables potential. This systematic planning should lower potential risks related to site selection and therefore reduce the burdens and costs of projects.

OFF-GRID ELECTRICITY

Mauritania is a vast country with a small population that does not require an extensive electricity network, and load centres are spread throughout the country. Therefore, the need for decentralised services is important. Mining operations are often located outside populated areas and away from the grid in the north (see figure 14; mines are depicted with pink squares).

These mining centres are supplied mostly by large diesel/HFO plants (up to 10 MW per unit and 50 MW per mining centre). But in these conditions and locations, solar and wind energy (depending on wind conditions) can be competitive with existing solutions and used to reduce fuel consumption. There is a rising awareness of renewable energy's potential to lower production costs within these areas; however, applicable solutions are still not fully understood or are unsuited to the needs of industry (there is a need for IPP offers). Little information is available on planned projects in the short term, but the potential for renewables use is significant.

Figure 14: Mauritania's electricity grids and mining areas



Source: INTEC, 2012
The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

The Banda gas project is seen as the solution for meeting industrial power needs at a reasonable cost. Although the project will help to supply existing needs, many industrial centres (such as those in the northeast) will remain unconnected to the network. The country should encourage the use of renewable energy in these remote centres to reduce the overall cost of generating electricity and to reduce the effect of imported petroleum products on the balance of trade. Moreover, greater private sector investment in renewables would allow Mauritania to reduce numerous costs related to renewable energy deployment (maintenance, installation or merely investment costs), as the market would be much larger.

GENERATION IN OFF-GRID CONSUMPTION CENTRES

The Master Plan for the Production and Transport of Electricity offers an interesting scenario for connecting consumption centres outside of the main grid system. Because these local networks are unable to benefit from grid-based electricity, they depend on diesel generation. Renewable energy, depending on the location, can be used economically in the energy production mix.

This solution already is being used in several isolated consumption centres to reduce the cost of electricity through the hybridisation of generation. One of the first such projects, being built in Kiffa, includes a 4.8 MW thermal unit and a 1.3 MWp solar field. Other planned projects will be launched as and when they can be financed.

ENERGY SERVICES IN RURAL AREAS

Numerous programmes and electrification projects in Mauritania focus on poor rural areas that are not connected to the grid (see box 4). The government has developed a unique process within Africa to finance a portion of the cost of extending services to rural areas through the Fund for Universal Access to Services (FAUS), which is presently supplied by telecommunications revenues. This fund could

be supplemented by contributions from the country's grid-connected network, including authorised service providers (ASPs) and SPEG in the future, bearing in mind that the current electricity tariff does not generate even enough money to make SOMELEC financially viable.

The country has been able to develop a market for ASPs. It would be interesting to support and extend this system to provide solutions for off-grid populations. Nevertheless, ASP businesses are still struggling, with tariffs and state subsidies barely able to maintain the status quo. The inclusion of renewable energy sources in these production systems would reduce the variable costs of production and, by the same token, the subsidies required by the state. However, it is essential to consider revising electricity rates to introduce some degree of balance among different areas. Prices and services vary greatly among the areas connected to the grid, the moughataa mini-grids managed by SOMELEC, and networks managed by the ASPs.

As part of the Master Plan for the Production and Transport of Electricity, an exercise was carried out to measure potential demand and existing solutions for off-grid villages and to identify potential additional means to provide them with the necessary services. However, the plan largely downplays the potential for renewables and heavily overstates their generation costs. For wind power, it plans for an additional 120 MW by 2030, and for solar, it plans for an additional 105 MW by 2030 to meet state goals for renewables. But the plan only provides these figures as indicative – highlighting that the necessary production margins would not be sufficient – without explaining further.

Box 4. IRENA wind and hybrid projects for rural communities including fishing villages

A wind power mini-grid project and a grid-connected hybrid solar, wind and hydro project were approved for funding by the IRENA-ADFD (Abu Dhabi Fund for Development) project facility in 2014 and 2015 respectively. Valued at USD 22 million, the projects will be 50% funded by ADFD the rest coming from the Mauritanian government. The multi-sectoral projects seek to provide access to clean energy to 169 villages with an average population of about 1 000. The National Agency for Development of Renewable Energy (ANADER) and the Agency for the Promotion of Universal Access and Services (APAUS) are the project coordinators.

Solar plant from IRENA-ADFD backed hybrid project in Mauritania
Photo: APAUS

The wind energy mini-grid project is to use wind not only to meet electricity needs but also water (desalination) and refrigeration needs (ice production) in the conservation of fishery products. It would include 18 wind turbines of 15 kW each, a meteorological measurement system, a 4 kilometre medium-voltage (15 kV) transport network, a 5 kilometre low-voltage (0.4 kV) distribution network, storage with batteries, two desalination units based on reverse osmosis of 100 m^3/day and two ice manufacturing units producing 5 tonnes/day.

[i] The IRENA-ADFD project facility supports renewable energy projects in developing countries The total available concessional loans per year are USD 50 million. The amount available per project is USD 5-10 million, with the loan amount not allowed to exceed 50% of the estimated project cost. Interest rates on concessional loans granted vary between 1% and 2% annually, with a term of 20 years and a grace period of 5 years. See http://adfd.irena.org/.

CHALLENGES

Despite Mauritania's existing efforts to develop renewable energy sources, many challenges remain that continue to impede the scale-up of renewables. Several of these challenges were mentioned at all of the workshops and sub-workshops associated with this report, including:

- The **lack of an identifiable strategy and long-term vision** for the development of renewable energy.

- The **inability of the current legal environment**, whether the regulatory or the institutional framework, to sufficiently reflect these priorities and thus to provide a sufficient level of support.

- The existence of **too much overlap between current programmes** and institutional participants, creating inefficiencies in managing priorities and available budgets. This overlap affects both equipment maintenance and the management of production facilities. It also creates price inequality, mostly for off-grid applications, as the SOMELEC-supplied moughataas co-exist alongside the ASPs that supply the smaller villages, as well as alongside solar platforms and individual solar kits – each with a specific per kWh price.

- The lack of a **stable regulatory and tariff structure**, and the need to overhaul existing electricity tariffs.

- The need to **expand the role of the regulator** to cover the electricity company, SOMELEC, and to have broader authority in setting tariffs and market rules.

Challenges also were identified in the capacity-building arena, starting with a lack of qualified personnel. This highlighted the need to adapt existing vocational training in line with business needs. Finally, expertise and necessary data, which are sometimes collected but not saved, are often missing.

RRA Validation workshop in Mauritania
Photo: IRENA

The key drivers for integrating more renewables into the country's energy mix are clear, and there is political support from all of the stakeholders. There is a consensus to diversify the energy mix, particularly through increased use of renewable energy, increased energy efficiency and greater integration of the private sector.

IV. Strategy and action plan for deployment of renewables

The recommendations for the RRA process outlined in this report all were made during presentations and validation workshops, or were confirmed later within the RRA process.

All of the stakeholders unanimously adopted the three service-resource pairs identified during the framework of the process. These were defined, based on Mauritania's economic development objectives, as follows:

- Access to energy services: solar, small hydro, biomass and, to a lesser extent, wind.
- Productive activities (mining, fishing, agriculture): solar and/or wind (depending on the location) for, *e.g.* cooling and freezing fisheries resources after processing.
- Centralised production network: wind and solar, plus storage and network management.

The main discussions and exchanges were structured around these service-resource pairs. Several common themes emerged from exchanges on the RRA process.

The main objective of the RRA process and this report is to prepare the ground for the formulation of a renewable energy strategy and action plan in Mauritania. The RRA seeks not only to identify barriers and challenges to renewable energy deployment, but also to develop a targeted programme of actions through a comprehensive participatory approach and consultation process.

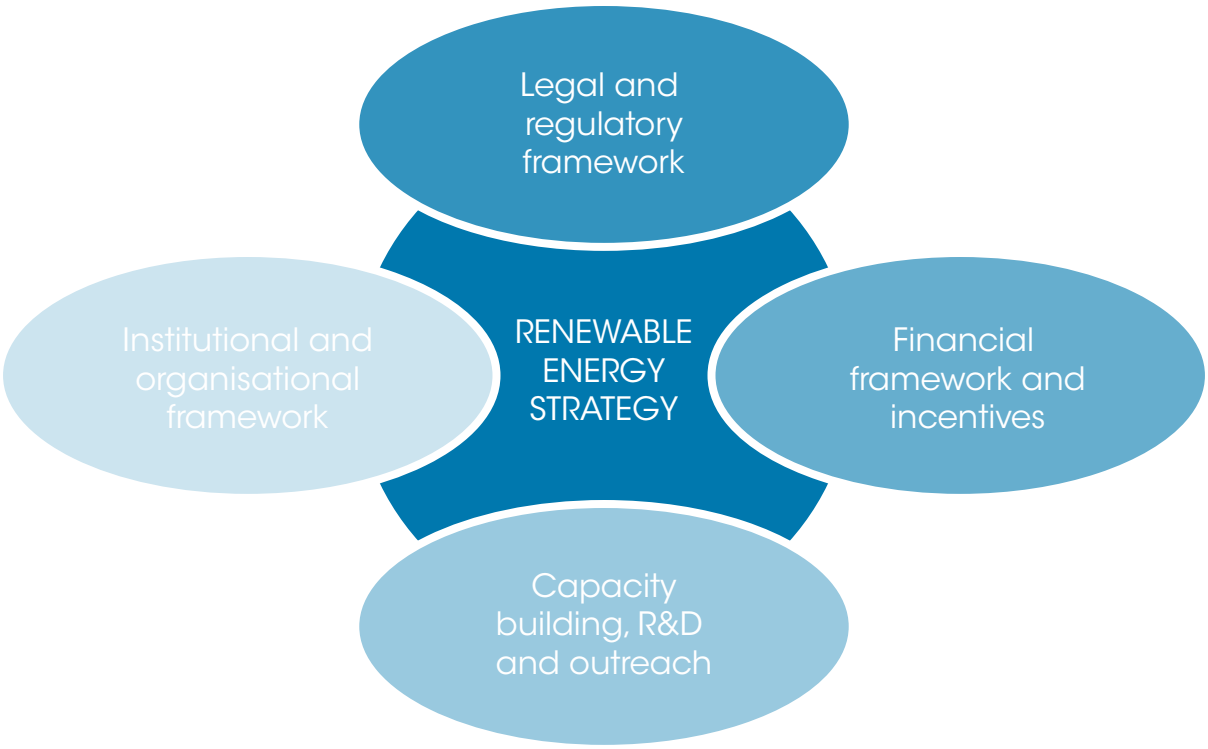
ELEMENTS OF A RENEWABLE ENERGY STRATEGY

The key drivers for integrating more renewables into the country's energy mix are clear, and there is political support from all of the stakeholders. There is a consensus to diversify the energy mix, particularly through increased use of renewable energy, increased energy efficiency and greater integration of the private sector. However, key obstacles holding back developments in the renewable energy sector include: 1) the absence of a clear strategy and policy for renewable energy, 2) the lack of a clear institutional framework to facilitate implementation of the policy and 3) the lack of a clear financial mechanism to support the deployment of renewables projects (both on- and off-grid). A national strategy and policy for renewable energy therefore should be launched in Mauritania with involvement of the key stakeholders.

The renewable energy strategy can be segmented into four main pillars (see figure 15):

- Legal and regulatory framework
- Institutional and organisational framework
- Capacity building, R&D and outreach
- Financial framework and incentives.

Figure 15: Renewable energy deployment strategy in Mauritania



LEGAL AND REGULATORY FRAMEWORK

Although long-term objectives for renewable energy exist in Mauritania, they are included only in the Poverty Reduction Strategy Paper (PRSP) and may not be sufficiently visible. It therefore is necessary to reiterate the country's goals in a general policy document. Participants in the RRA process and ministry officials have suggested including the specific elements of the renewable energy strategy in the country's more ambitious "Energy policy declaration note", in order to increase the visibility and political significance of the strategy. It is expected that this note will be updated to better reflect the situation.

This policy declaration note should include the following ambitious targets already set in the PRSP:

- The share of renewable energy in electricity generation is to increase to 15% by 2015, 20% by 2020 and 35% by 2030. To make these goals more ambitious, it would be possible to exclude hydropower generated from the OMVS from the renewables share.
- Electrification rates are to increase from 50% to 80% in urban areas, and from 5% to 40% in rural areas, by 2015. The energy policy note could maintain these goals while adopting a longer time frame, for example 2030, to reflect the government's commitment within the UN SE4ALL initiative, which aims to double the current share of renewable energy by 2030.

Moreover, the note should indicate the specific legislative, institutional and capacity-building framework actions detailed below. The note should also cover private sector involvement in the successful implementation of this policy.

A recurring comment made during discussions with RRA participants was the need to enforce and harmonise existing policies and regulations. Although the laws and statutes of the various entities cover the main needs of the country, they are not necessarily enforced. As a result, there was less interest in adopting a renewable "stand-alone" law and greater support for including a declaration note within a more ambitious energy policy that

would contain the necessary elements for renewables.

Initially, the general policy note, which is expected to be produced shortly, will integrate the country's vision and objectives for renewable energy. The corresponding decrees must be adapted to account for the changing needs of the country and to set the conditions for renewable energy use and operation – for example, by giving renewables priority access to the grid, establishing the conditions for export, opening up the market to IPPs within a PPA framework, and establishing the roles of various participants.

A specific law for renewable energy could then be developed in a second phase and would further strengthen the role of renewables and provide a legal and statutory basis, while attracting investments and building a climate of mutual trust between public and private sector participants. This law could reflect the initial results in applying the general policy note, making it possible to draft the law to better meet the country's renewable energy objectives.

An initial set of amendments to the laws and decrees in force is summarised below. These changes could later be reflected directly in the new renewable energy law, or modified in response to lessons learned.

Electricity Code: The current electricity code, which dates from 2001, should be amended to:

- Change regulation thresholds (currently at 30 kVA) to require all producers, via mandatory declaration, to notify the regulator, in order to ensure better monitoring of the country's facilities.

- Include the possibility for derogation regimes (for self-generation), in order to:

    - Feed excess electricity into the grid where this is in the national interest, at a rate to be determined.

    - Build and manage distribution networks, limited to the people surrounding the self-generation site, where the public grid is not available.

    - Allow multiple non-grid-connected entities to form a consortium to generate electricity for their production needs (extended self-generation).

    - Encourage or even require self-generators to "hybridise" a portion of their production with renewable energy in order to further reduce the national oil bill.

- Recognise the importance of the private sector in off-grid generation (self-generation) and encourage their participation in discussions about the country's energy choices and decisions.

- Reflect the possibility of increased regional co-operation, especially with regard to production and export.

State-SOMELEC contract: The 2001 contract between the state and SOMELEC should be updated to better reflect the changing needs of the country and the energy sector. The contract should place SOMELEC within the scope of the regulator, which is presently not the case, despite the fact that ARM statutes provide for this.

Electricity tariff framework: The tariff framework (whether on- or off-grid) should be revised to better reflect the situation of the country and to ensure operators' economic viability (a principle already stated in the Electricity Code), while also reflecting the purchasing power of the population. The tariff changes being evaluated should:

- Ensure the economic viability of operators, such as SOMELEC and the ASPs.

- Balance the situation in rural areas, where SOMELEC network rates co-exist (for

unconnected moughataas) with ASP tariffs, leading to a confused price signal.

- Consider tariff equalisation mechanisms to ensure that subscribers in urban areas can contribute, even if only partially, to subsidising rates in rural areas.

ASP statutes and concession contracts: Statutes and contracts related to ASPs should be revised to better reflect changes in markets, delegations and population needs. Proposed changes include:

- Revising tariffs to ensure the economic viability of operators, while adjusting to the purchasing power of the population.

- Restructuring balancing subsidies to allow operators to install renewable systems (*i.e.* making it possible to front-load subsidies at the start of projects to allow for investment in renewable energy).

- Revising the concession contract length to provide better long-term visibility to local operators.

- Revising the equipment leasing concept (affermage) to allow operators who wish to do so to invest in renewable energy facilities.

- Providing necessary maintenance of light and heavy equipment to ensure its longevity.

- Seeking additional funds (such as those collected under the Fund for Universal Access to Services, FAUS) to stabilise available revenues for financing access to services and to allow authorities to extend access to energy services.

INSTITUTIONAL AND ORGANISATIONAL FRAMEWORK

As with the country's legal framework, institutional needs relate mainly to optimising and co-ordinating existing institutions. As an illustration, competition between institutions led to the decision to dissolve the National Agency for Renewable Energy Development (ANADER) in January 2013, after being in existence for just over two years, and to share ANADER's powers among existing agencies and institutions rather than maintaining a specific entity. This highlights the need to co-ordinate the actions of key actors before considering the creation of new entities.

An initial set of recommendations for key institutions is summarised below.

MPEM: MPEM should be the exclusive institutional anchor for all structures and interventions in the energy sector, in order to provide a clear framework for interventions in this area. This role can be shared with other departments, such as APAUS, which is also controlled by the Ministry of Economic Affairs and Development. However, MPEM should maintain its role in policy co-ordination and intervention. A specific service for renewable energy could be created within MPEM to co-ordinate policies and actions in this area.

Multi-sector committee: As is the case for ECOWAS countries, Mauritania should consider establishing a multi-sector committee that brings together all "operational" departments, headed by MPEM, to co-ordinate line ministry investment needs in energy services. This would optimise the funds invested in these resources and ensure that they are put to best use and maintained.

ARM: The scope of the Multi-sector Regulatory Authority should be extended to cover all participants in the energy sector, including SOMELEC, to ensure greater consistency among market stakeholders, fair and reasonable pricing, market transparency and the possibility of arbitration in case of dispute or conflict.

Monitoring centre: The creation of a monitoring centre for renewable energy would help to overcome the lack of information about

existing projects, specifically those run by NGOs, the private sector and individuals. This monitoring centre could be created within a public-private-NGO partnership framework and should be responsible for collecting all renewable energy project information in the country. The centre also could be responsible for centralising all renewable energy data collected in the country, including data related to rural electrification. A geographic information system (GIS) database could be created to include all existing and planned installations, to ensure better co-ordination of the location and maintenance of installed systems.

ASP equipment maintenance: Currently, several entities are responsible for heavy maintenance of ASP equipment, including APAUS and ADER. However, it seems that heavy maintenance is currently problematic. This may be related in part to the day-to-day maintenance that must be performed by the ASPs, but also to the difficulty of organising such maintenance, given that several participants are tasked with ensuring the maintenance without necessarily having the ability or opportunity to influence the use of the equipment to guarantee its longevity. It would be useful to give this responsibility to a single entity or to completely revise the concession contracts so that the responsibility for heavy maintenance falls to the ASPs.

CAPACITY BUILDING, R&D AND OUTREACH

An initial set of recommendations in the area of capacity building, R&D and outreach is summarised below.

Training and education: These are perhaps the most important issues for the country's future development. Existing training and education programmes should be supported and expanded to better meet the needs of the private sector and to enhance co-operation with this sector and within the various regional organisations. In addition to education, vocational training should be developed to meet the immediate needs of the country. This requires regular financial resources to fund institutions, training centres and laboratories.

Technical platform certification, testing, research and training: There is a need to maintain a technical platform for testing, certification and training. Currently, there is no certification process for imported materials, leading to wide-ranging quality in imported equipment. Although numerous training and demonstration materials were installed historically in Mauritania, inconsistent budgets did not allow for their maintenance. It would be appropriate for the country to consolidate a number of technical activities into a single common entity to facilitate the maintenance of a capacity to test, certify, train and demonstrate.

This technology platform could be shared by different institutes for training, research and demonstration to give the country the ability to track the evolution of technology and to adapt training and national standards. Equipment already exists and could be regrouped under a common entity to ensure better operation and maintenance. This platform would need regular funding, which could come from certification and testing activities (which can be funded), from training institutes (based on their use of the facilities) and from international donors. When combined, these resources could be used to create a common platform, facilitating the provision of additional and sustained support for local capacity building. There is also a need to certify the personnel who would be ensuring the installation and maintenance of, for example, off-grid PV systems.

Resource assessments: Numerous resource assessments have been carried out in the country at different times, but the measurements and results often have been lost due to lack of regular resources. It is necessary to collect these existing results in a common database and to conduct additional assessments, particularly for wind, solar, biomass and small hydropower. The technical platform team could conduct these resource assessments in collaboration with

researchers already involved in the renewables field in the country.

To be as complete as possible, the assessments should include local measurements from already established projects (each plant solar and wind is equipped with measuring devices to enable estimation of performance). These measurements should be incorporated into a GIS system that includes existing and future infrastructure in order to better assess the technical potential and development opportunities by location. The "monitoring centre" should store the collected data so that it is made available to all participants.

Technical studies: Mauritania is among the leaders in the region in installed renewable generation capacity. To capitalise on this experience and go further, the country should initiate several pilot projects to manage the integration of existing renewable resources and to develop additional expertise in co-ordinating the renewable generation with existing conventional production.

Installation, operation and maintenance: Mauritania already has a relatively large number of installed renewable energy projects. To ensure their sustainability, the country needs to develop its own capacity for maintenance and installation through a shared technical platform and the development and adaptation of technical training on these topics. This should be done through the support of existing maintenance structures in the country. In addition, private companies with experience in providing energy services could be trained to potentially provide services and maintenance to existing solar power plant facilities.

Regional co-operation: Mauritania intersects several regional power groupings (COMELEC in the north and OMVS/WAPP in the south). It could benefit greatly from more extensive co-operation with these regions in order to draw useful experiences for its own development and its potential to become a regional production "hub" based on renewable energy. Several national projects are already under way to meet the needs of neighbouring countries; this model could be expanded and developed to provide an additional source of national economic development.

Outreach and communication: Finally, the country should consider launching an outreach and communication programme with the public and policy makers to raise awareness about renewable energy and its applications and to help ensure the sustainability of implemented programmes.

FINANCIAL FRAMEWORK AND INCENTIVES

Mauritania's renewable energy market must be developed in a concerted and sustainable manner. The actions outlined above will provide the framework for developing renewable energy resources while reducing the technical risk perceived by the private sector and banks. However, the stability of the legal and regulatory framework will be decisive in developing this market by reducing the country risk. Technical and country risk factors most affect the cost of financing. Because renewable energy entails primarily capital costs and not variable costs (fuel, maintenance, etc.), controlling these two risk factors (which influence the cost of capital) will likely have the greatest effect on the country's development of renewables. Even if most project funds come from international donors, the donors themselves use banking methods for calculating risk when establishing their funding conditions.

An initial set of recommendations regarding financing and incentives is summarised below.

Financial and customs incentives: The government should consider possible financial and customs incentives that would encourage the deployment of renewable energy without endangering the national budget. To bolster its efforts to reduce exposure to risk and to volatile commodity prices, the country may consider earmarking a portion of resources tied to the export of raw materials

to promote renewables. This would not only limit the import of petroleum products, but also potentially redistribute mining profits in sectors that have not necessarily benefited from them until now.

Revolving access fund: Apart from grid investments, which are rising at a constant rate, a leading challenge in the country is access to energy services. The country already has implemented a universal fund (FAUS) to help increase this access. The energy-specific elements of this fund should be strengthened by identifying additional resources to maintain a consistent pace of progress in access to services. Including SOMELEC in regulation would raise additional resources related to licensing, but other resources should be identified as well. Some of these resources could come from an increase in electricity tariffs from grid-connected populations (as a sign of solidarity towards rural and poor populations), while additional funds would need to come from donors and, for example, from a slight increase in mining activity taxes (similar to the tax on mobile telecommunications that helps to support FAUS).

Centralised purchasing platform (centrale d'achat): To reduce the overall costs of access to energy, Mauritania could consider creating a centralised platform for purchasing PV modules and materials to supply off-grid projects. By purchasing and trading in bulk, the country could greatly reduce its supply costs.

Standard power purchase agreement (PPA): A fairly specific legislative measure would simplify negotiations for PPAs that are now established on a case-by-case basis. Developing a standardised PPA that outlines the main terms, conditions and state guarantees needed (while allowing enough flexibility to adapt to the specifics of each project) would offer the advantage of clarifying the main clauses for producers wishing to invest in the country, while providing the authorities in charge of negotiations with a stable basis for their work that is accepted by all parties.

Dedicated renewable energy fund: Finally, to facilitate financing of renewable energy projects, a dedicated renewable energy fund could be developed to support renewables deployment in Mauritania. This fund could be supported by local, regional and international donor funds.

CONCLUSION

Mauritania is blessed with substantial renewable energy resources in the areas of wind, solar, biomass and even small hydropower (with large hydropower being developed as part of the OMVS). The country is highly dependent on the availability of energy and electricity for its development and is also highly sensitive to changes in commodity prices, both for its export revenues and its import costs. Within this context, the large Banda gas field project was presented as a means to provide additional power generation capacity (260 MW by 2022 and 350 MW by 2030).

Developing renewable resources to meet the country's energy needs can help stabilise the economy by reducing its dependence on energy imports and its exposure to price fluctuations. Already, Mauritania is one of the first countries in sub-Saharan Africa to install large renewable energy projects, including the 15 MW solar PV plant in operation, the 4.4 MW wind project installed by SNIM and the 30 MW wind plant under construction. Renewable energy has also been used historically (since the early 1990s) to meet off-grid generation needs.

Today, the opportunities far outweigh the constraints. The country can use its pro-active policy for grid-connected projects to become an energy exporter to both West Africa and North Africa. Substantial work will be needed to strengthen management of both the network and generation, but it may allow the country to develop a new expertise that could generate further export revenues. To promote development of the national market, the country should facilitate and encourage the

adoption of renewable energy solutions by off-grid industries. This would enable the country to develop expertise in low-cost renewable energy deployment for off-grid applications, which remains a top national priority.

Mauritania now has an opportunity to move towards achieving the targets outlined in the UN Millennium Development Goals as well as in the SE4ALL initiative,[7] which Mauritania joined in 2014. To do so, the country should clearly define and announce its goals and plan the implementation and action needed to achieve them. This activity should be reflected in national laws and decrees to ensure the stability of the institutional framework and the monitoring of all sector participants.

Beyond this, the institutional and regulatory structure should ensure the monitoring of these objectives. A significant programme of capacity building is needed to assist the country in this area by providing essential skills on-site, ensuring the necessary training and supporting applied research needs. A financial framework and incentives should also be implemented to achieve these objectives without putting a strain on public finances.

This effort would contribute not only to the security of supply and to the availability of energy for all at reasonable prices, but also to widespread access to energy by 2030, while ensuring streamlined energy consumption and protection of the environment. The effects on the country's development would be significant and long-term, ensuring diversification of economic activity and employment sources.

Participants in the RRA process also recognised the crucial role that co-operation with IRENA has in assisting the country in its efforts to integrate more renewable energy into the energy mix. In particular, international and regional co-operation can be effective in capacity building, education, technology transfer, information sharing, R&D and the mobilisation of resources.

The concluding section provides an outline of actions identified and recommended during the RRA process.

[7] The SE4ALL initiative aims to provide universal access to electricity, double the energy efficiency rate and double the share of renewable energy in the energy mix by 2030.

Wind power generation in Mauritania
Photo: Tractebel Engineering

RECOMMENDATIONS

The RRA process for Mauritania has identified and recommended five main actions and related steps, as outlined below. These actions apply to all three of the identified service-resource pairs and have been developed in light of the SE4ALL guidelines. The actions are not listed in any order of importance, nor are they exhaustive, given the rapid nature of the assessment process.

Action	Steps
Develop a national policy on renewable energy	• Redefine the country's objectives through a "general policy note" for renewable energy. • Set breakthrough objectives for renewable energy. • Equalise pricing principles and sectorial priorities. • Set up clear institutional and regulatory objectives.
Include the objectives for renewables and operating principles in a new electricity code and related implementing decrees	• Develop a new electricity code that includes the objectives and operating principles relating to the promotion of renewables in all sectors, as well as the operating principles of potential regional co-operation and export. • Update the State-SOMELEC contract to include SOMELEC in the scope of regulator. • Review and update the bylaws and contracts related to ASPs to allow for the economic equalisation of operators, review of concession periods (better visibility) and revision of the concept of leasing to make it easier for ASPs to invest in renewables. • Work towards levelling the costs associated with electricity generation and the price differences between SOMELEC and ASPs in rural areas.
Create the institutional and regulatory framework to facilitate the deployment of renewable energy	• Address jurisdiction overlaps between the agencies, NGOs and SOMELEC to optimise the use of resources. • Give MPEM exclusive institutional anchoring structures and operations in the field. • Create a unit of renewable energy and energy efficiency within the DEME. • Revise the legal framework to place the Multi-sector Regulatory Authority (ARM) at the heart of the system. • Consider creating a multi-sectorial committee dedicated to access to energy services and assemble a national energy access programme with a renewable energy component, involving all participants (especially local authorities and the private and public sectors). • Set realistic and achievable goals for 2030 and take into account the guidelines of the SE4ALL initiative. • Create a "monitoring centre" for renewable energy in a collaborative framework between the government, the private sector and NGOs to focus information on past experiences, data and reports within a single unit. • Clarify responsibility for the maintenance of ASP heavy equipment so that one entity is responsible.

Action	Steps
Promote capacity-building and research programmes, dedicated training and education	• Create a common technical platform for certification, testing, research and training. Consolidate existing equipment within a single entity that is able to operate and maintain this equipment as well as facilitate applied research in the country. • Evaluate the country's renewable resource potential by using existing data and launching additional measures. Allow for the development of a solar and wind atlas to be integrated into a GIS system that includes the resources, existing production facilities and infrastructure. • Initiate technical impact assessments and projects to manage the further integration of renewables into the Mauritanian grid. • Develop the technical capacity for operation, maintenance and installation of renewable systems in the country. • Enhance local skills in finance analysis to help with assessment of renewable energy projects. • Reinforce vocational training and education related to renewable energy to ensure its applicability. • Launch an outreach and communication programme with the population and renewable energy decision makers.
Financial framework and incentives	• Stabilise the legal and institutional framework to reduce country risk, and ensure technical capacity for installation and maintenance to reduce technology risk. • Identify and implement possible financial and customs incentives that may encourage renewable energy development. • Create a national fund dedicated to the promotion of renewable energy (*e.g.* state guarantees) and decentralised rural electrification projects. • Consider creating a purchasing centre using the orders related to large-scale power plants to reduce the provision costs for off-grid renewables projects. • Develop an IPP model contract containing the main terms, conditions and state guarantees to facilitate the negotiation and finalisation of contracts in the country. • Reform the system of subsidies for fossil fuels to improve the cost comparison with renewable energy and to remove barriers to the introduction of renewables. • Encourage industrial self-generators to hybridise via the production of renewable resources. • Facilitate access to guarantee funds and loans for private companies.
Actors	• MPEM, Ministry of Finance, APAUS, SOMELEC, Regulatory Agency
Timing	• Preparation during 2015-2016 and implementation from 2017.
Keys for success	• Nomination of one key Mauritanian actor to drive the process, setting and respecting a time frame for stakeholder consultations and inputs.

REFERENCES

AF (Arab Fund for Economic & Social Development) (2011), *www.arabfund.org.*

AFD (French Development Agency) (2013), "*Public Operation Communication note, Financing a hybrid photovoltaic/thermal plant in Kiffa and electricity networks in the region of Kiffa"*, April.

APAUS (Agency for the Promotion of Universal Access to Basic Services) (2014a), internal note.

APAUS (2014b), *"Annual Report"*.

CNA (2013), *"Mission Report, Capacity Needs Assessment under the RRA Mauritania"*, IRENA, Touria Daffrallah, November.

CILSS (Permanent Interstate Committee for Drought Control in the Sahel) (undated-a), *"Objectives and results, Regional Solar Programme 2",* www.cilss.bf/prs/article.php3?id_article=5.

CILSS (undated-b), *"Areas of intervention, organisation and implementation of the PRS 2"*, www.cilss.bf/prs/article.php3?id_article=5.

EC JRC (European Commission Joint Research Centre) (2008), Ecole des Mines de Paris/Armines/CNRS, *"PVGIS (Photovoltaic Geographical Information System)"*, Institute for Energy and Transport, http://re.jrc.ec.europa.eu/pvgis/.

ECOWAS (Economic Community of West African States) (2012), *"ECOWAS Renewable Energy Policy (EREP), Final Version"*, September 2012.

EIA (U.S. Energy Information Administration) (2013), *"Mauritania country profile"*, www.eia.gov/countries/country-data.cfm?fips=MR#pet.

GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) (2009), *"Renewable Energies in West Africa"*, Regional Reports on Potentials and Markets – 17 Country Analysis, Energy Policy Framework papers, Bonn.

IMF (International Monetary Fund) (2012), *"Islamic Republic of Mauritania: Letter of intent, memorandum of economic and financial policies, and technical memorandum of understanding"*, Washington, DC, November 5, www.imf.org/external/np/loi/2012/mrt/110512.pdf.

IMF (2013), *"Sixth Review under the Three-year Extended Credit Facility Arrangement and Request for Waiver of Nonobservance of Performance Criterion"*, Washington, DC, 31 May, www.imf.org/external/pubs/ft/scr/2013/cr13188.pdf.

INTEC (2012), *"Master Plan for the Production and Transport of Electricity in Mauritania Between 2011 and 2030"*, November.

IRENA (International Renewable Energy Agency) (2013a), *"Renewables Readiness Assessment. Design to Action"*, Abu Dhabi, www.irena.org/DocumentDownloads/Publications/RRA_Design_to_Action.pdf.

IRENA (2013b), *"The Gambia Renewable Readiness Assessment 2013"*, Abu Dhabi. www.irena.org/DocumentDownloads/Publications/RRA_Gambia.pdf.

IRENA (2014), *"The Socio-economic Benefits of Solar and Wind Energy"*, Abu Dhabi, www.irena.org/DocumentDownloads/Publications/Socioeconomic_benefits_solar_wind.pdf.

IRENA (2015), *"Renewable Energy in the Water, Energy & Food Nexus"*, Abu Dhabi, www.irena.org/documentdownloads/publications/irena_water_energy_food_nexus_2015.pdf.

IRENA (undated), *"Global Atlas for Renewable Energy"*, www.irena.org/globalatlas/.

IRM (Islamic Republic of Mauritania) (2000), *"Poverty Reduction Strategy Paper"*.

IRM (2001a), *"Law No. 2001-18 on the Multisectoral Regulation Authority"*.

IRM (2001b), *"Order No. 2001-06, Establishing the Agency for the Promotion of Universal Access to Services"*.

IRM (2006), *"Poverty Reduction Strategy Paper Action Plan 2006-2010"*, October.

IRM (2011), *"Poverty Reduction Strategy Paper. Volume 2: Action Plan 2011-2015"*.

Izquierdo, Gonzalo Piernavieja (2005), *"The Canary Islands Institute of Technology ITC"*, Presentation, www.exportinitiative.de/fileadmin/publikationen_veranstaltungsdoku/dokumente/Expo_ES_05/6b_Do_n_Wrage_proexca.pdf.

MHE-MCI (2008), *"Joint Order 2418, MHE MCI fixing the maximum retail prices of electricity in locations subject to delegation by the public electricity service"*, 23 June.

MPEM (Ministry of Petroleum, Energy and Mines) (2014), *"Annual Report"*.

NATO (North Atlantic Treaty Organization) (2012), *"NATO-sponsored project helps harvest wind energy in the Sahara"*, 29 October, www.nato.int/cps/en/natolive/news_91105.htm?selectedLocale=en.

Nodalis (2012), *"Study on the Delegation of Public Service of Electricity in Mauritania"*, Paris.

OECD (Organisation for Economic Co-operation and Development) (2009), *"Regional Atlas on West Africa"*, Paris, http://browse.oecdbookshop.org/oecd/pdfs/product/4409011e.pdf.

PREDAS (Regional Programme for the Promotion of Household and Alternative Energies in the Sahel) (2005), *"Surveys on Domestic Energy Consumption in Mauritania"*, CECO COUNCIL, CILSS PREDAS, February.

Reikat, Andrea (2012), *"Programme pour l'Energie de Cuisson Economique en Afrique de l'Ouest : Présentation globale"*, presentation at the ECOWAS Regional Bioenergy Forum, Bamako, Mali, 20 March, www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/2012_events/WGCB_Activity_1_Bamako_19-22_March_2012/IV.3_Presentation_on_GIZ-ProCEAO_Cookstoves_project.pdf.

SNC-Lavalin (2013), *"Rate Study of SOMELEC"*, Montreal, March.

SOMELEC (2013), Annual Report.

SOMELEC (2014), Annual Report.

SWERA (Solar and Wind Energy Resource Assessment) (undated), *"Mauritania"*, http://en.openei.org/apps/SWERA/?active=Mauritania.

Tractebel (2010), *"Study on the Master Plan for the Generation and Transport of Electric Power in Mauritania (2011-2030)"*.

Tractebel (Tractebel Engineering SA) (2012), *"Report of Stage III (APD) of the Feasibility Study for the Production and Transport of Electricity Based on Gas (SPEG)"*, September.

United Nations (2014), *"World Urbanization Prospects, The 2014 Revision"*, New York.

World Bank and Nodalis (2010), *"Restructuring of SOMELEC and the Electricity Sector in Mauritania"*, February.

Zawya (2013), *"New oil finds to prop up Mauritanian economy"*, 15 April, www.iii.co.uk/investment/detail?code=cotn:CHAR.L&display=discussion&id=10538102&action=detail.

ANNEX: DETAILED DESCRIPTION OF RECOMMENDED ACTIONS

The RRA process has identified and recommended the five actions below. They are not given in any order of priority and should not be considered exhaustive. These actions could improve the ability of Mauritania to develop and deploy renewable energy more rapidly and more sustainably.

ACTION 1 Develop a national renewable energy policy and an action plan	
Action	Centralised production, access to energy services, productive activities, all renewable energy sources
Service-Resource Pair(s)	Centralised production, access to energy services, productive activities, all renewable energy sources
Description	There is broad consensus among government and non-governmental participants in Mauritania on the importance of the potential role of renewable energy. The Ministry of Petroleum, Energy and Mines (MPEM) is responsible for developing renewable energy policy and the action plan that sets guidelines for the widespread use of renewable resources. Apart from the centralised hydropower plant (developed under the auspices of the OMVS), wind and solar energy can greatly help reduce the country's dependence on oil. MPEM will set achievable goals for existing renewable resources based on the results of the RRA process, additional resource assessments and network capacity. Initially, MPEM shall formalise existing targets and the means of achieving them within the energy policy note expected in early 2016. Depending on the results, a second specific law for renewable energy could take into account experiences related to the implementation of the note on energy policy.
Key participants	MPEM, ARM, APAUS
Timing	2016-2017
Key to success	The success of the policy depends on how realistic the objectives are (based on the results of resource assessments and network penetration studies) and its adoption by industry stakeholders. The objectives of the note on energy policy may be integrated into a specific renewable energy law if it turns out that the note is not sufficiently encouraging or binding.
ACTION 2 Include the objectives and operating principles for renewables in a new electricity code and related implementing decrees	
Action	Inclusion of renewables objectives and operating principles in the electricity code and related decrees
Service-Resource Pair(s)	Centralised production, access to energy services, productive activities, all renewable energy sources

Description	The existing consensus on the use of renewable energy in the country should be expressed specifically in the laws and decrees relating to the energy sector that do not currently take renewables into account. MPEM shall be responsible for developing legislative proposals and implementing regulations to put this policy into practice. The texts to be modified include: • The electricity code, which must include the objectives and operating principles for the promotion of renewable energy and potential regional export; • The State-SOMELEC contract, which should include SOMELEC in the scope of the regulator; and • ASP statutes and contracts with the ARM, which should reflect a better economic balance of the operators, revised duration of concessions and updated leasing that allows direct investment in renewable ASP solutions. Moreover, the costs of electricity generation should be levelled to balance the price differences between SOMELEC and ASPs in rural areas.
Key participants	National Assembly, MPEM, ARM, SOMELEC, APAUS, ADER, NGOs, private sector
Timing	2016-2017
Key to success	One of the main keys to success will be the inclusion of industry representatives in discussions and debates related to the structuring of new laws, decrees and acts to be implemented. Furthermore, the inclusion of SOMELEC in the scope of the regulator will require real co-ordination work between SOMELEC and the state to ensure that objectives are understood and shared by all participants.

ACTION 3 Create the institutional and regulatory framework to facilitate the deployment of renewable energy	
Action	Create the institutional and regulatory framework to facilitate the deployment of renewable energy
Service-Resource Pair(s)	Centralised production, access to energy services, productive activities, all renewable energy sources
Description	MPEM, shall, with its institutional, private and community partners, define and implement an institutional and regulatory framework for optimising actions within the sector. As part of planned development work, this should be presented and developed in collaboration with participants so that everyone can take part and ensure its adoption. The framework should permit MPEM to ensure the institutional anchoring of the sector. But MPEM needs to provide the regulator with comprehensive coverage in the industry to ensure the consistency of measures put in place. MPEM should also create a "monitoring centre" for renewable energy in a collaborative framework between the government, the private sector and NGOs to focus information on past experiences, as well as the relative data and reports within a single entity. Moreover, MPEM should encourage the emergence of a dedicated multi-sectoral committee for access to energy services in rural areas. This will, among other things, co-ordinate the actions of public participants in the provision of energy services in these areas and maintain them more efficiently. This committee should set realistic and achievable goals for 2030, in accordance with the guidelines of the SE4ALL initiative.

Key participants	MPEM, ARM, APAUS
Timing	2016-2017
Key to success	One of the keys to successful implementation will be the participation of stakeholders and their adoption of shared goals.
ACTION 4 Promote capacity-building and research programmes, dedicated training and education	
Action	Promote capacity-building and research programmes, dedicated training and education on renewable energy
Service-Resource Pair(s)	Centralised production, access to energy services, productive activities, all renewable energy sources
Description	Mauritania already has significant experience with renewable energy, dating from the 1990s. However, part of this experience has been diluted due to lack of resources or capacity. Capacity building – including in the areas of R&D, education and awareness – is essential for the success of this policy. By creating a common technical platform for users (whether in the area of research, training or standards), the country would develop a centre of excellence, based on its own needs, that would significantly reduce the technical risk of the projects implemented. In technical terms, there is a need for additional means to test and certify equipment used, as well as a need to use existing equipment to produce detailed solar and wind atlases that are integrated into a GIS system. In addition, studies and pilot projects should be launched in the short term to better measure the impact of renewables on the current network and to manage the network and the existing means of production according to renewable energy sources. Renewable energy training within the country should be strengthened and made more relevant to ensure better "employability" for students and to ensure the highest possible practical vocational training. Finally, a public awareness programme would help to better integrate renewable energy within the country.
Key participants	MPEM, Ministry of Education, universities, schools, NGOs, private sector
Timing	2016-2017
Key to success	Capacity building should be implemented in a fair and transparent manner in order to maximise its effects. It should also take into account the needs for fiscal stability of the agencies involved, regarding both research and training units and testing of equipment to ensure sustainability.

ACTION 5 Developing Capacity Building for renewable energy	
Action	Develop a financial framework and incentive schemes for the development of renewable energy
Service-Resource Pair(s)	Centralised production, access to energy services, productive activities, all renewable energy sources
Description	Before considering any further action, it is important to recognise how legislative, institutional and regulatory stability is critical to reducing project costs. MPEM, in partnership with industry players, may suggest the use of customs and tax incentives for renewable energy sources in the country. These actions can be justified by the potential savings that they offer in terms of balance of trade and energy dependence. A fund dedicated to the promotion of renewable energy could be considered. This would cover a portion of energy access needs by complementing the actions of the Fund for Universal Access to Services (FAUS) to encourage the use of renewable resources. Actions in the field of centralised projects and self-generation/independent production should be measured accurately. Because budgets are limited, it is more difficult to guarantee a significant impact.
Description	However, the country could create a specific"guarantee fund" for Renewable Energies-IPP contracts that would not need to be refinanced but would have the advantage of further reducing the cost of financing, including for international financial institutions. Other concrete and high-leverage actions to be implemented could include: • Defining an IPP model contract for renewable energy resources. • Creating a purchasing centre that takes advantage of larger volumes to reduce the cost of equipment. • Encouraging industrial self-generators to hybridise with renewable-based generation. Finally, the system of subsidies for fossil fuels should be reformed to ensure greater market balance and to reduce barriers hindering the development of renewable energy.
Key participants	MPEM, ARM, APAUS, Ministry of Finance, industries
Timing	2016-2017
Key to success	The sustainability of financial resources used and their optimisation are the biggest keys to the success of this policy.

P.O. Box 236
Abu Dhabi, United Arab Emirates
Tel: +971 2 4179000
www.irena.org