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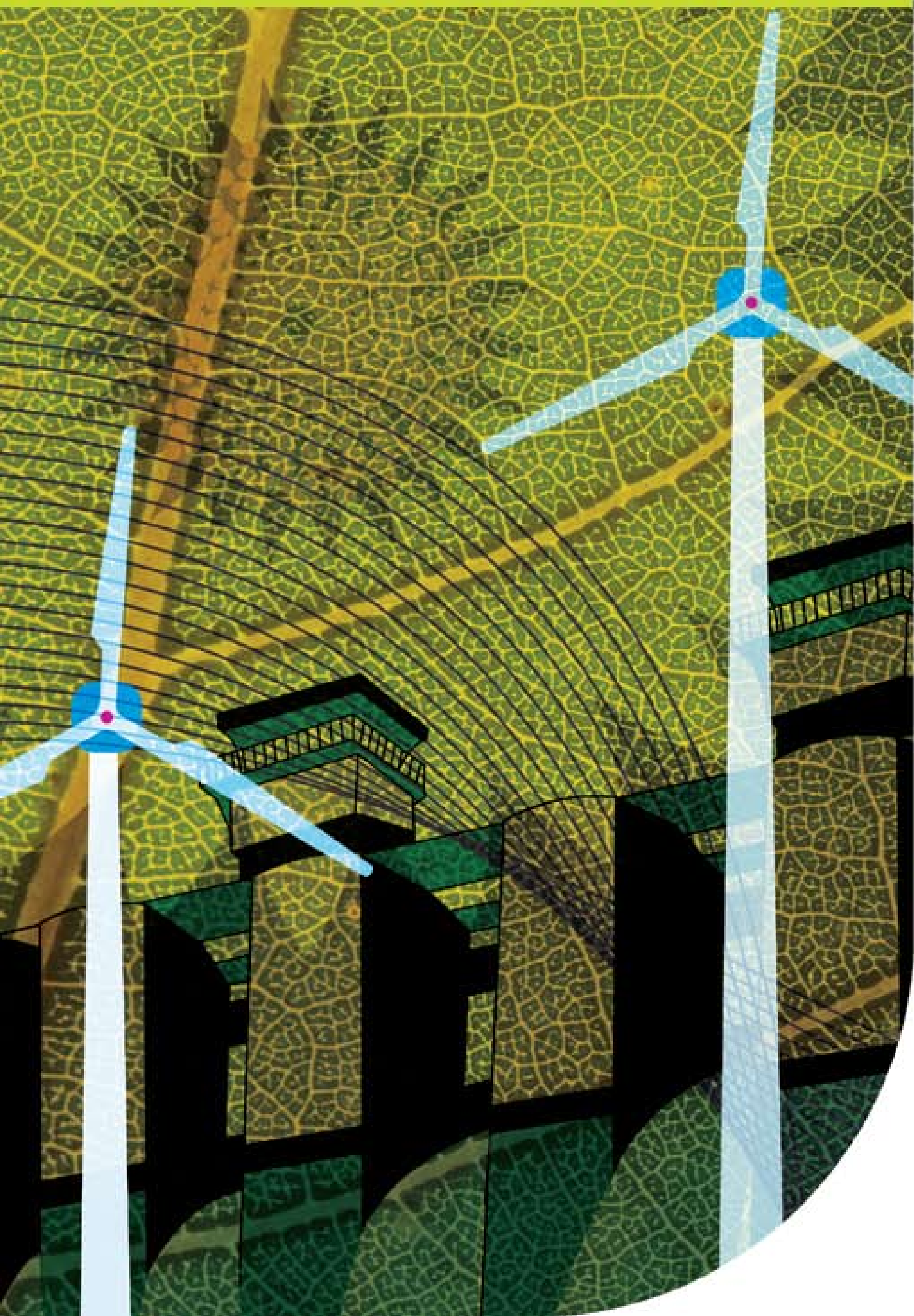
NIGER
RENEWABLES READINESS ASSESSMENT 2013



About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. 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.

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About RRA

A Renewables Readiness Assessment (RRA) is a holistic evaluation of a country's conditions and identifies the actions needed 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, meanwhile, has allowed IRENA to continue refining the basic RRA methodology. In June 2013, IRENA published a guide for countries seeking to conduct the process in order to accelerate their renewable energy deployment.

For more information visit www.irena.org/rra

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NIGER

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FOREWORD

It is a great honour and pleasure for me to introduce our Renewables Readiness Assessment (RRA), which allowed us to identify specific, high-impact actions for the optimal deployment of renewable energy, taking into account the elements of economic, social and environmental sustainability. Although Niger developed its Strategy and Action Plan on Renewable Energy as far back as 2004, these have suffered from a lack of clear objectives and have hardly been translated into results the ground. Lately, however, we have started implementing our National Reference Programme for Access to Energy Services (PRASE) with the assistance of our technical and financial partners. This ground-breaking programme for improving access to energy services was launched in 2010, in line with the regional energy policy outlined in the White Paper of the Economic Community of West African States (ECOWAS). Furthermore, our Plan for Economic and Social Development, adopted in November 2012, calls for a substantial role for renewable energy.

Findings from RRA consultations, therefore, will definitely aid the Government of Niger in its efforts to alleviate poverty by increasing the population's access to energy. Already, some of the recommended actions are being implemented: renewable energy sources are increasingly being factored into the on-going Master Plan for Power Generation and Transmission; a renewable energy law has been initiated; and the government's commitment has been underlined with budget allocations for the renewable-based electrification of 100 villages yearly.

I can further assure you, measures will very soon be taken to address the institutional and regulatory gaps highlighted by this study. Overcoming such gaps will be fundamental for the sustainable uptake of renewable energy in Niger. Furthermore, the outcomes of the RRA process, as outlined in this report, will provide a basis for the development of future cooperation programs with our international partners, as well as for our discussions with investors in the renewable energy sector.

I would like to take this opportunity, therefore, to express our gratitude to the International Renewable Energy Agency (IRENA) for assisting Niger in the drafting of this important decision-making tool, as well as to the consultants involved for their endeavours and teamwork during the process in the country.

Foumakoye Gado
Minister of Energy
and Petroleum, Niger

FOREWORD

The Africa High-Level Consultative Forum held by the International Renewable Energy Agency (IRENA) in July 2011 highlighted the need for technical support for African countries and regions to identify their renewable-energy readiness. The Renewables Readiness Assessment (RRA) process stemming from this involves a holistic evaluation of a country's conditions and identifies the actions needed 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.

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 good practices and supports international cooperation to enable the accelerated deployment of renewable technologies. Niger, in keeping with its strong and consistent support of IRENA's mission, is one of those pioneering countries.

The new Rural Electrification Agency, established shortly after Niger's RRA, will help to manage electrification more holistically and create the conditions to enable private-sector investment in rural areas. As the RRA confirms, decentralised systems could ensure universal electricity access, despite Niger's dispersed population and largely rural economy, as long as the country continues to address identified institutional and financial gaps.

IRENA wishes to thank Minister Gado and his team for their tireless contributions and warm hospitality in hosting this study. We are grateful for their positive engagement and valuable input, which has given us additional insights for undertaking further RRAs in the 2014-2015 period. Additionally, this report will feed into other IRENA regional work, including modelling and analysis on planning and prospects for renewable energy in West Africa.

We sincerely hope that the outcomes of these RRA consultations will assist Niger in fulfilling its aim to scale up renewable energy. IRENA stands ready to provide continuing support to Niger in implementing the actions identified.

Adnan Z. Amin
Director-General, IRENA

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ACRONYMS

AfDB	African Development Bank
CNES	Centre National d'Energie Solaire/National Centre for Solar Energy
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EREP	ECOWAS Renewable Energy Policy
GDP	Gross domestic product
INRAN	Institut National de Recherche Agronomique du Niger/ National Institute for Agronomy Research
IPP	Independent power producer
IRENA	International Renewable Energy Agency
kV	Kilovolt
kWh	Kilowatt hour
LPG	Liquefied petroleum gas
MDGs	Millennium Development Goals
MoEP	Ministère de l'Energie et du Pétrole/Ministry of Energy and Petroleum
MP/AT-DC	Ministère du Plan, de L'Aménagement du Territoire, et du Développement Communautaire / Ministry of Planning, Territorial Zoning and Community Development
MW	Megawatt
NIGELEC	Société Nigérienne d'Electricité/Niger Electricity Company
PDES	Plan de Développement Economique et Social/ Plan for Economic and Social Development
PPP	Public Private Partnership
PRASE	Programme National de Référence d'Accès aux Services Energétiques/ National Reference Programme on Access to Energy Services
RRA	Renewables Readiness Assessment
SONICHAR	Société Nigerienne du Charbon d'Anou Araren/ Nigerien Anou Araren Coal Company
TPES	Total Primary Energy Supply
TOE	Tonnes of Oil Equivalent
UNDP	United Nations Development Programme
WAPP	West African Power Pool
Wp	Watt Peak

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EXECUTIVE SUMMARY

Niger is a landlocked country in West Africa and a member of the Economic Community of West African States (ECOWAS). It has a surface area of 1,267,000 square kilometres (km^2), and population of 16 million with an annual growth rate of 3.3%. Over the past ten years, the Nigerien economy grew at an average rate of 5%, but only grew 2.3% in 2011, because of a poor harvest and a severe food grain shortage. However, it bounced back in 2012, growing by 13%, according to the African Development Bank. The economy is dominated by agriculture, forestry and livestock, which contribute 43% of gross domestic product (GDP) and employ about 80% of the country's workforce. The energy balance in dominated by biomass, which represents 79% of total energy consumption and meets 83% of household energy needs, followed by petroleum products (18%) and mineral coal for electricity generation (3%). Renewables other than biomass remain negligible at less than 1%.

The energy sector in Niger is at a critical crossroads. The country has recently discovered oil and gas. This will contribute to widening energy access and allow the country to solve the enormous problem of household energy access through a liquefied petroleum gas (LPG) programme. Niger also aims to move towards greater electricity security by investing in domestic power production, thereby reducing its dependence on imports from Nigeria. However, Niger's energy demand is growing rapidly, and significant pent-up demand continues to be felt from businesses and socio-economic development sectors, which continue to experience shortages and blackouts. To address this, Niger needs to explore a variety of technological options to diversify its energy supply base and build stability in the energy sector. This would include harnessing the country's significant renewable energy resources and accelerating their exploitation to power the growing economy. The government recognises the important role renewable energy will play in Niger's future energy infrastructure, providing input to both centralised and decentralised systems. Policies are currently being developed and relevant laws drafted to create the governance structure required for a credible energy access and security programme.

View over the Niger River
Photo: IRENA/H. Lucas

Like in most countries in the region, the energy sector in Niger is characterised by parallel energy systems, the traditional and the modernised. Both face intrinsic challenges, which cross all sectors and affect the whole population. Current biomass use in Niger has major health implications, especially for women. It also has significant environmental implications in terms of land degradation and deforestation. With the population increasing at over 3% per annum (p.a.), the pressure on humans and ecosystems will continue to increase.

Electricity – in terms of both quality and access – is a key challenge for Niger. The existing power infrastructure is underdeveloped, and the country continues to rely heavily on imported electricity from neighbouring Nigeria. Niger has been importing electricity at a very low price, which has historically served as a disincentive to boosting its own generation capacity. There are occasional power-supply interruptions from Nigeria due to technical problems, and these highlight Niger's vulnerability in the arrangement between the two countries. Load shedding and blackouts are as commonplace in Niger as in Nigeria, prompting most businesses and urban households to invest in portable diesel generators, or "gen-sets", as a standby power source. The impact of voltage fluctuations, spikes, blackouts, brownouts and other disruptions has been considerable for the wider economy. Energy insecurity has, therefore, become a barrier to development.

The West African Power Pool (WAPP) represents an opportunity for Niger. As part of its contribution to WAPP, Niger will invest in two fossil-fuel (coal and gas) power generation systems. However, major proportion of the power expected to be generated through WAPP will be hydropower. Given the scale of power produced through the power pool, as well as power production and transmission challenges in Niger, the country is likely to benefit noticeably in terms of cheaper and more reliable electricity.

Broadening energy access is a central national development objective in Niger. At present, less than 25% of the population enjoys access to electricity, and the picture in rural areas is bleaker, at less than 5% electricity access. Generation of electricity through renewables has long been viewed as an important way to close this gap. However, the focus on the contribution that renewables could make to the national grid has only emerged because new technologies are beginning to compete with conventional power generation. To this end, an energy policy is needed, embracing renewables as part of a longer-term energy vision. This must include a systematic roadmap for delivery, supported by research and financial support.

Off-grid renewable power can meet the demand in currently unserved rural areas. Niger, still in the early stages of building its energy infrastructure, has the opportunity to develop and invest in its energy system in a planned and systematic manner. At the moment, the rural electrification programme relies largely on international donors. However, Niger has begun to allocate funding to meet the cost of implementing decentralised renewable technologies for a range of social development needs. This effort could be extended to productive sectors in rural areas, since renewable energy systems, with their flexibility and scalability, are especially well-suited to meeting rural energy demand.

Niger possesses significant renewable energy resources to meet its present and future energy needs. The country is endowed with abundant solar energy resources, good biomass resources in its southern parts, and a modest wind regime, especially towards the north. These resources can be harnessed to bring higher-quality energy services to populations across the country.

Niger was one of the first countries across the world to consider renewable energy technologies as a solution to its energy needs. This dates back to the 1960s, when Niger set up the Solar Energy Office (Office de l'Energie Solaire – ONERSOL), later renamed the National Solar Energy Centre (Centre National d'Énergie Solaire – CNES). ONERSOL was founded to undertake applied renewable energy research, provide diagnostic studies on renewable energy technology use, and run training programmes on renewable energy systems. Yet this ambitious and promising programme did not achieve its intended goal of creating a strong renewable energy technical capability for the West African region. This was because financial resources for sustaining the programme dried up and priorities shifted.

The Government of Niger views providing reliable electricity and other basic energy services to all populations and parts of the country as a critical aspect of its inclusive economic transformation plans. It also recognises decentralised renewable energy options as a cost-effective alternative to grid expansion in many rural areas.

The government electrification strategy has embraced both grid-based and off-grid options, although the main policy focus still remains on the former.

KEY RECOMMENDATIONS

Niger needs to develop an energy policy that embraces renewables as part of a longer-term energy vision. The current strategy has set the objective of 10% renewables (excluding biomass) in the national energy mix by 2020. However, there are no specific guidelines or road-map for reaching the target. This needs to be rectified, in order to provide sufficient substance to for the successive shorter-term targets needed to realise this goal. Additionally, work is about to begin in Niger to develop a master plan for the production and transmission of electricity, part of determining the country's medium- to long-term investment priorities for developing the power sector (up to 2035). This offers a real opportunity to integrate renewable energy into future plans and also strengthen Niger's case for support from development partners. To better inform the development of the master plan, the country's solar and wind economic potential needs to be adequately quantified.

Although Niger's power generation sector has been opened to IPPs, renewable power projects have not come forward. The development and expansion of the country's renewable energy market partly depends on the creation of a favourable legal and regulatory framework. This would, among other things, reduce technical, legal and administrative barriers while increasing private-sector confidence. An overarching renewable energy law would create the right conditions. Such a law should provide guaranteed access to the grid and priority dispatch of renewable electricity generation. These are currently lacking in the grid code. Furthermore, the development of a standardised, bankable PPA would greatly support the evolution of renewable energy auctioning. Transaction costs, which currently reflect lengthy permitting and administrative procedures, could be greatly reduced by setting up a one-stop shop for the private sector dealing with renewable energy projects.

Niger's Public-Private Partnership (PPP) office, which has expressed the desire to promote solar power investments, could be mandated by the renewable energy law to become the permitting and licensing authority for all renewable energy projects. The law could also enshrine a bankable PPA model that would reduce the length and complexity of negotiations required with private sector for every investment. A model of this kind could open the door to self-producers and IPPs wishing to feed their electricity into the grid. It could also let in producers who wish to collaborate with utilities to hybridise existing fossil-fuel generators. PPP office capacities would need to be upgraded and streamlined, with clear, transparent administrative procedures being created for the private sector.

Niger has been using auctions to select IPPs to provide power to the grid at competitive prices. Although these have for the most part been for conventional (fossil-fuel) generators, the country can capitalise on this experience to design renewable energy auctions and support large-scale renewables deployment. Renewable energy auctions have already become a commonly used policy instrument in some countries. Such auctions have helped achieve large-scale deployment in a cost-efficient and regulated manner, while allowing price discovery for renewable-energy based electricity through their inherent price competition, which also tends to boost the scale of competition.

Niger needs a comprehensive energy policy that puts the needs and demands of rural communities at centre stage and provides clear guidance on how to achieve progress on rural energy services. The policy should confirm explicitly that rural communities need a bottom-up approach, due to their low energy demand and scattered nature. The comprehensive policy would bring together local development plans and information on resources, finance and skills, facilitating the design of coordinated plans of action, sensitive to location. An organisation must be established to manage, develop and implement Niger's rural renewable electrification strategy and programme. The proposed organisation must also create enabling conditions for the private sector, ensure effective implementation, and maintain quality assurance. This organisation needs to be a legal entity. It could fill several important gaps.

The proposed organisation must aim to optimise the use of resources for rural electrification and maintain mechanisms already in place, while upholding important principles. These include equity, technology neutrality, high technical standards, poverty eradication and the protection of investor interests. Furthermore, provisions should be made within the renewable energy law to amend the country's current tax policies on renewable energy technologies. Amendments would include reducing current import duties and VAT that affect the competitiveness of renewable energy.

The rural electrification challenge is enormous and will require both external and domestic finance. Niger's Renewables Readiness Assessment (RRA) drew attention to the importance of raising domestic finance, as well to calibrate internal investment with wider development goals. As the consultation process underscored, rural electrification should feature prominently within any such framework.

Niger could consider raising funds to promote rural electrification from taxes on mineral and petroleum exploitation. Decentralised renewables, despite their comparative advantage in rural electrification in particular, are unsuitable for conventional financing because of their high transaction costs.

In Niger, rural communities with little disposable income hardly feature as natural clients for conventional financial institutions. Soft loans can be attractive, requiring only a small sum as a down payment on the total price, with the rest being payable over a number of years. Therefore, grants from multilateral agencies or donors could be ring-fenced to mobilise soft loan schemes for household or community electrification. While this cannot be considered a long-term solution to the challenge of raising funding, it could provide energy for social development needs. It may also serve to stimulate the renewables market in rural areas.

The cost of each type of technology, including hybrid technologies, needs to be assessed and documented in the different regions of the country. This would provide a dynamic data system, assembling data on the range of technologies and their performance under different conditions. The diesel based mini-grid operated by NIGELEC offers a compelling case for hybridisation with renewable energy sources. Solar irradiation is abundant throughout the country. Detailed feasibility studies on hybridising the diesel mini-grids with solar PV would, therefore, help demonstrate the economics of these systems to potential investors.

Niger will rely on technologies sourced from abroad for the foreseeable future. Technology imports must continue in tandem with efforts to upgrade innovation systems that will support domestic technology adoption and development. However, cheap solar panels and components are entering the Nigerien market from neighbouring countries, with no institutionalised quality assurance and standard schemes. This does not help the reputation of these technologies, still in their early stages, when systems break down.

As part of the industry's revitalisation, CNES could play an important role in supporting the development of renewable energy technology standards and certification schemes for installers. A programme of this kind would have the additional benefit of creating new skilled jobs throughout the value chain, from small distributors to installers, maintainers and end-users.

In various parts of the world, the biogas sector has delivered excellent results and supported rural development. Niger has significant potential for biogas, and feasibility studies in the biogas sector have been conclusive. The development of a biogas business model would be worth exploring for Niger, with a view to bringing microfinance institutions to the negotiating table to set up a commercially viable biogas industry, including innovative and effective financial structures. This would contribute to the well-being of the country's population while reducing pressure on natural resources.

I. INTRODUCTION

COUNTRY BACKGROUND

Niger is a landlocked country in West Africa and a member of the Economic Community of West African States (ECOWAS). It has a surface are of 1,267,000 square kilometres (km^2), bordering Mali, Burkina Faso and Benin to the West, Nigeria to the South, Chad to the East and Algeria and Libya to the North. Niger is divided into eight regions, 36 provinces and 265 districts. It is crossed by the Niger, the country's only perennial river, which has a length of 550 km. Niger has a population of 16 million with an annual growth rate of 3.3%. The population density is of 12 people per km^2. It is young (52% under 15 years of age), and predominantly rural (84%). However, it is undergoing a high urbanisation growth rate of about 6.2% p.a. (International Fund for Agricultural Development (IFAD), 2012); Institut National de la Statistique (INS), 2012).

Over the past ten years, the Nigerien economy grew at an average rate of 5%, but only 2.3% in 2011 due to a poor harvest and a severe food grain shortage. However, it bounced back in 2012, growing by 13%, according to the African Economic Outlook (2013). This was helped by heavy rains that generated a surplus of over 5 million metric tons (t) of cereals (World Bank, 2013a). This clearly demonstrates the Nigerien economy's direct dependence on rainfall and water availability. It also illustrates the country's vulnerability to climate shocks and the importance of managing water resources to sustain development. Niger's growth is attributed to an exceptionally dynamic secondary sector, which grew by almost 38% in 2012 driven by the extractive industries. Niger commenced oil production in late 2011 in a joint venture with the Chinese National Petroleum Corporation (CNPC). As part of this plan, a new refinery has been built with a capacity of 20,000 barrels per day. The emergence of oil on the Nigerien economic landscape has triggered new optimism concerning the country's future development and balance of trade management.

The economy is dominated by agriculture, forestry and livestock, which contribute 43% of Gross Domestic Product (GDP) and employ about 80% of the country's workforce (IMF, 2013). Given the country's location in the Sahel region, these sectors are highly vulnerable to climate variability, leading to frequent droughts and affecting productivity. Service and

A village school in Niger
Source: Wikimedia

commercial sectors are also major contributors to the economy, accounting for 41% of GDP.

Although it is a fast growing sector with significant potential, heavy industry accounts for only 16% of GDP. Uranium, gold, coal and limestone are the principal products mined, contributing 6.3% of GDP in 2011. With the emergence of oil production as a major activity, exports from the extractive industries are expected to double by 2016 compared to 2011. Manufacturing has also increased its share to about 6% in 2011, largely in the domain of food processing (AEO, 2013).

AfDB states that flows of Foreign Direct Investment (FDI) exceeded USD 1 billion (bn) in 2011 and remained high in 2012 at about USD 830m. Much of the investment was in the mining and oil sectors.

Over the past two decades, Niger's social indicators have improved noticeably. The gross primary school enrolment rate has increased from about 29% in the early 1990s to 76% in 2011. The ratio of girls to boys in primary schools also increased from 25% to 40% during the same period, and further improvements are expected. The mortality rate for children under five has fallen from 320 to 130 per thousand in 1990-2010 (World Bank, 2013b). However, major challenges remain, as all development indicators point to very low human and economic development according to the United Nations Development Programme (United Nations Development Programme UNDP, 2013). Niger is currently ranked 186th on the Human Development Index (HDI). Nearly 76% of the population lives on less than two dollars a day and is experiencing extreme poverty. Improving living conditions in Niger will therefore remain at the forefront of the country's growth agenda.

The government of Niger's new poverty reduction strategy — its Plan for Economic and Social Development (PDES) — is the country's overarching development framework according to the Ministry of Planning, Lands and Community Development (MP/AT-DC, 2011). The principal focus of the PDES is to achieve economic growth of about 8% in 2012-2015. It identifies 86 programmes needed to reach 11 strategic objectives. The programmes are clustered into five areas:

(i) strengthening the credibility and effectiveness of public institutions

(ii) creating the conditions for sustainable, balanced and inclusive development

(iii) providing food security and sustainable agricultural development

(iv) promoting a competitive and diverse economy for accelerated and inclusive growth

(v) fostering social development.

The PDES acknowledges the central role energy services will play in reaching social development goals and raising income generation. This is required for individual development and community transformation. It therefore channels energy access into short and long-term development objectives. It also suggests specific plans for modernising the electricity supply infrastructure, improving coverage levels, reforming the existing regulatory framework and increasing the contribution of renewable energy to energy security.

ROLE OF ENERGY IN DEVELOPMENT IN NIGER

Fulfilling the vision outlined in the PDES depends on the ability of Niger to scale up and improve the quality of energy services. This means putting in place good policies, creating the enabling environment for energy investment and building strong institutions that can deliver good outcomes. The per capita electricity consumption was less than 50 kWh in 2012 against an African average of over 575 kWh and a global average of over 2770 kWh. This makes the average Nigerien citizen among the lowest consumers of electricity in the world. Moreover, about 76% of the population does not have access to electricity, much of which is restricted to urban areas. This indicates significant pent-up demand in the power sector and a need to close the gap between demand and availability.

Niger's energy profile is typical of a low-income economy in that the household sector remains the main energy user. This signifies a limited use of energy in the productive sector. Households across Niger rely heavily on traditional biomass to meet their basic energy needs. However, during the last couple of years LPG consumption has experienced major growth.

Niger is endowed with significant renewable energy resources and has the potential to develop a diversified portfolio of renewable energy technologies. With improvements in technologies and costs, potential renewable energy is well suited to both urban and rural applications. Although Niger's recent discovery of oil and gas will provide much-needed relief from the country's energy security problems and endless difficulties maintaining a healthy balance of trade in the short term, renewables are also likely to feature as an important long-term platform for closing the electricity access gap, especially in rural settlements. Several strategies such as Programme National de Reference d'Acces aux Services Energétiques –PRASE - National Reference Programme on Access to Energy Services, have outlined the important role of renewable energy in delivering energy services. Over the past five years this programme has increased the installed capacity of decentralised solar systems for a wide range of end uses by about 1 MW.

Niger's future development will largely be determined by whether it exploits the range of energy resources it has to good effect. The country still has some way to go in addressing a number of social development problems in education, health and water services. Energy services will continue to play a major role in resolving them. The government of Niger has long recognised that lack of energy access seriously handicaps development, and efforts to remedy this problem need to be scaled up. Indeed, in many of these successful cases elsewhere, energy intervention in the social and economic sectors namely health, water, agriculture and education was made as part of a comprehensive development strategy. These two aims are not mutually exclusive but intertwined. For Niger, increasing electricity access and making a transition from inefficient biomass use is not only about having the resources available. It will require sound policies, an effective regulatory framework, robust and dynamic institutions and sustained capacity development programmes.

THE RENEWABLES READINESS ASSESSMENT (RRA) PROCESS IN NIGER

A senior officer at the Ministry of Petroleum and Energy (MoEP) with a thorough knowledge and experience in renewables was the RRA focal point in Niger.

Following preparations by the national consultant and MoEP, a representative from the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) wrote to identified key institutions selected to be part of the technical/expert team. They were invited to the formal launch of the RRA at a kick-off meeting on in July 2012 where they were divided into three thematic subgroups. The subgroups met in August 2012 respectively, having had time to go through the background note prepared by the national consultant (ETIC-Sarl) in advance of their scheduled meetings.

The subgroups reviewed the tentative list resource-service pairs suggested by MoEP after discussions with the national consultant to be further analysed and discussed. A national workshop held in September 2012 prioritised five manageable short- to medium-term priority resource-service pairs. The workshop also identified and recommended a set of seven concrete action points to resolve limited systemic, institutional and individual capacity constraints. Resolving these will create good synergies and have a positive cumulative effect on the country's readiness to scale up RE deployment.

This report is structured in five substantive sections. Section 1 presents the introduction covering country background and a brief on the RRA process in Niger. Section 2 presents the renewable and general energy context in the region. It includes an overview of the energy sector in Niger, its challenges and an overview of RE potential and use. It also provides a detailed discussion of the electricity sector. Section 3 explores Niger's energy institutions and the policy and regulatory framework as well as the conditions of financing and investment in the country. Section 4 presents the emerging concerns relating to solar/wind electricity (on-grid), a range of decentralised (off-grid) applications as well as the biomass sector. Opportunities and constraints that affect deployment scale-up are discussed along with the RRA findings. Section 5 presents the recommended action necessary for scaling up RE in Niger. Annex I presents a detailed account of the recommended action identified by the RRA.

II. ENERGY CONTEXT

REGIONAL CONTEXT

The total population of the ECOWAS region in 2011 was about 309 million and growing at an annual rate of about 2.6% according to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2012). Per capita GDP remains low by world levels at USD 983, but the range within countries in the region is at USD 245-3171. Real GDP growth has for the most part remained strong over the past decade. It reached 6.9% in 2012 due to good rainfall and positive developments in the mining and petroleum sectors (ECOWAS, 2013).

The energy system in West Africa is faced with a number of interrelated challenges: low energy access, insecure energy supply and growing environmental degradation. Total Primary Energy Consumption (TPES) in the region is about 155 million tonnes of oil equivalent (MTOE) p.a. (ECREEE, 2012). Fuelwood and charcoal account for the largest sources of energy, representing 77% of primary energy consumption. Petroleum products in 2012 accounted for 22 M TOE of consumption, and as a whole the region consumes about 43 terawatt-hours (TWh) of electricity (*ibid*). Sustained economic growth seen in the past few years has been accompanied by growing demand for a modernised energy infrastructure. This is creating pressure on governments to improve energy production to meet growing consumption.

Access to electricity in the ECOWAS region is low at 42%. Over 75% of those with access live in urban areas, leaving some 77% with no access to electricity (ECREEE, 2012). There are variations between countries. Some are doing better than others at providing electricity for their populations. These include Ghana, Côte d'Ivoire, Cape Verde, Senegal and Nigeria. Unmet electricity demand amounted to around 7-10 TWh in 2006-2010 (ECREEE, 2012).

The electricity systems in West Africa also face challenges arising from existing supply capacities unable to satisfy growing demand. Furthermore, the region faces the difficulty of raising sufficient funds internally or attracting outside investors willing to incur the high perceived risk of the electricity sector in the region (IRENA, 2013a). Overall, unreliable power holds back the region's enterprises and has a negative impact on productive activities. Transmission and distribution losses are around 40%, increasing electricity tariffs significantly. A number of countries in the region have some of the highest tariffs in the world with a regional average exceeding USD 0.20/kWh. The cost of providing backup power (typically USD 0.30-0.40/kWh) handicaps productive industries. Eberhard, et al. (2011) estimate that blackouts reduce annual economic growth in Africa by about 2%.

Concerns regarding energy access and security are not new in the region. Following the adoption of the first ECOWAS energy policy in 1982, the region has been engaged in developing an integrated approach for the energy sector. The aim is to provide better access to modernised energy services. Several initiatives have been made with that in mind and some of these are discussed below.

The West African Power Pool (WAPP) was established in 1999. Its objective was to curtail the power deficit in the region by integrating the operations of national power systems into a unified regional electricity market (cross-border trade flows). This is intended to facilitate stable, reliable and cost-competitive electricity to all ECOWAS citizens in the medium to long term. In 2006, the WAPP secretariat was created and mandated to ensure the promotion and development of power generation and transmission facilities (www.ecowapp.org).

The Energy Protocol was adopted in 2003 by ECOWAS member countries. This is a legal framework aimed at promoting long-term cooperation in the energy field. It is based on complementary relationships and mutual benefit to increase investment in the energy sector and develop energy trade in the region.

ECOWAS/West African Economic and Monetary Union (UEMOA) White Paper for a Regional Policy on Access to Energy Services to Rural and Semi-Urban Areas was adopted in 2006. Three targets were set for 2015:

i) 100% of the total population, or 325 million people, to have access to improved cooking fuels and stoves, including 9.2% to LPG cooking devices

ii) at least 60% of people in rural areas to have access to productive energy services in villages, especially motive power, to boost productivity

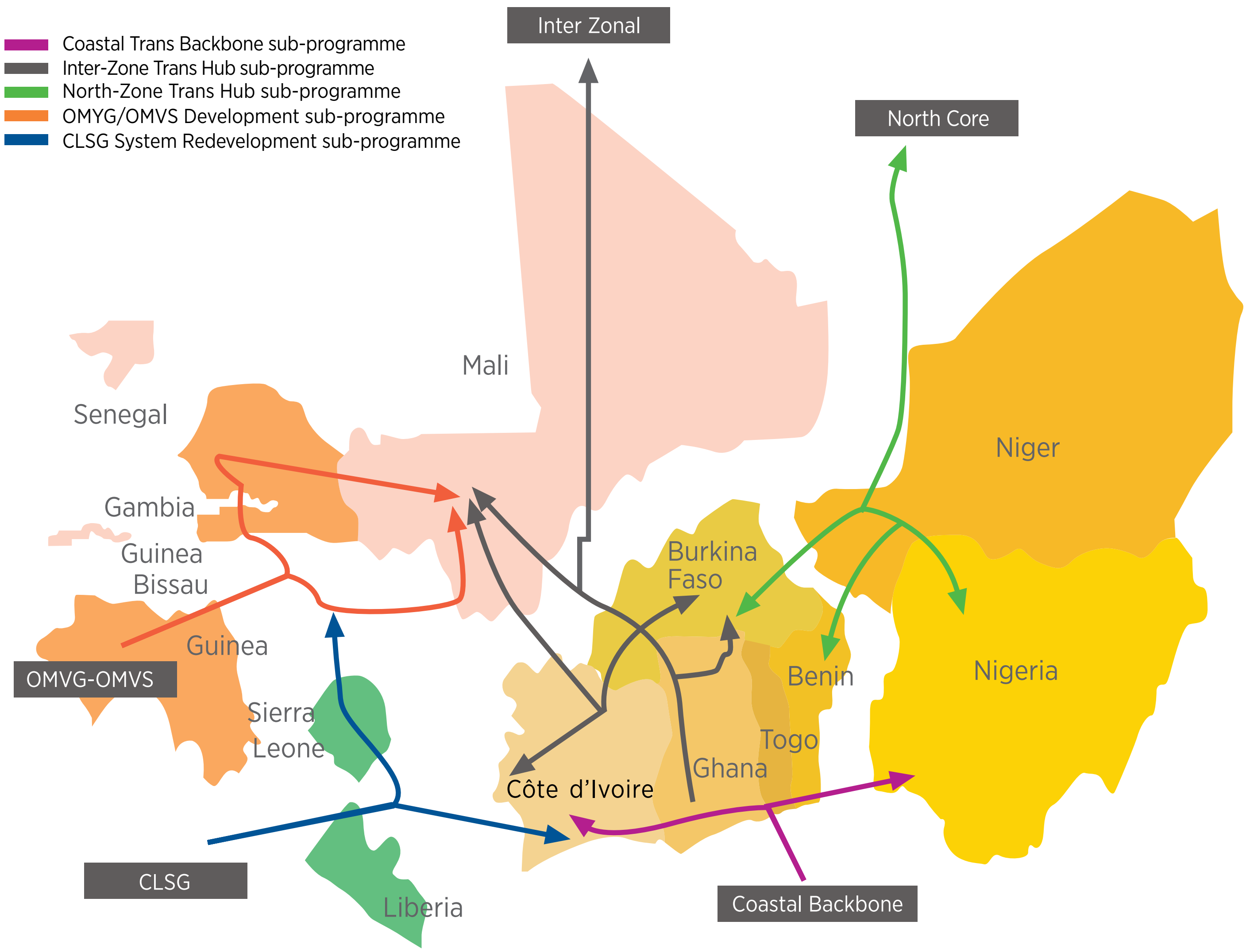
iii) 66% of the population, or 214 million people, to have access to individual electricity supply (ECOWAS, 2006).

The Regulatory Authority for Regional Electricity Sector of ECOWAS (ERERA) was created in 2008. Its aim was to ensure the regulation of cross-border exchanges in electricity and provide substantial support for national electricity regulators of member states (www.erera.arrec.org).

The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) was established by the Council of ECOWAS in 2009. Its mandate was to promote measures to improve access to modern energy services, increase energy security and reduce adverse impacts on the environment. The creation of favourable framework conditions and an enabling environment for renewable energy and energy efficiency are viewed as tools to achieve these goals.

Much effort will be required to address the energy issues in the region and capitalise on the opportunities that clearly lie ahead. ECREEE developed and adopted the ECOWAS Renewable Energy Policy (EREP) in November 2012. EREP is designed

Figure 1
WAPP regional sub-programmes.



Source: MOE, 2012b

to make renewable energy a vector for universal access to electricity by 2030. It is also intended to ensure a more secure and sustainable supply of domestic energy for cooking. This will meet the objectives of the ECOWAS White Paper for access to modernised energy services by 2020.

WEST AFRICAN POWER POOL

WAPP is looking at developing a regional electricity market through successive phases:

Phase 1 will last from 2012 to around 2015, when most regional transmission infrastructure is expected to be commissioned. This phase includes formalising trading arrangements, agreeing transmission pricing and strengthening the role of the regional regulator.

Phase 2 - based on the preparations carried out during Phase 1, should include bilateral agreements on transit through third countries, short-term exchanges through day-ahead markets, regional transmission pricing and regional system operator/market operator functions.

Phase 3 - a long-term vision, which includes regional optimisation of operations. WAPP has approved a regional master plan for infrastructure development with timings for the different projects. This master plan is organised around 30 generation and 26 transmission priority projects with the objective of developing 10% renewable energy (excluding large hydro).

The implementation of the master plan will add an additional capacity of 10,000 MW and 16,000 km of transmission lines in the region. This would consist of an electricity mix of 21 hydropower plants, five thermal power plants and four wind and solar plants (Figure 1).

From a purely economic standpoint, a number of countries would benefit from the opportunity to reduce costs they incur at present by importing more than half their power. Savings for countries such as Guinea Bissau, Liberia and Niger could amount to USD 0.050-08/kWh (Eberhard, *et al.*, 2011). The largest beneficiaries of regional trade would be smaller nations that lack domestic hydropower resources. For these countries, it is estimated that the cost savings generated by regional trade could repay the required investment in cross-border transmission in less than a year. This depends on neighbouring countries developing sufficient surplus power to export.

In cooperation with ECREEE and the International Atomic Energy Agency (IAEA), IRENA has created an energy system modelling tool for West African countries called energy system that meets various system requirements including reliability. At the same time, it takes into account the optimal economic configurations (including both investment and operation costs) of the system to meet daily and/or seasonally fluctuating demand. Using EREP, IRENA developed a transition scenario for the renewable power sector in ECOWAS countries. This shows that the share of renewable technologies in the region could increase from 22% of electricity generation at present to as much as 52% in 2030 (IRENA, 2013a).

More specifically, IRENA assessed the investment needed in addition to funds already committed to the present power supply infrastructure. This investment would mean integrating renewable technology generation into the grid, including off-grid power systems when technologically and economically feasible. Niger has long benefited from cross-border electricity exchange with Nigeria, obtaining electricity at low cost. On occasions, the negative aspects of its overdependence on Nigeria becomes clear when power interruptions occur due to technical problems. This draws attention to the vulnerability of Niger's power sector. Niger would participate in both the generation and transmission priority projects in the region. Two power generation projects are planned that will feed into WAPP. These include a 400 MW coal-fired power plant due to come on stream by 2019 and a 500 MW gas-fired plant that will use the country's newly discovered natural gas. The power generated from these plants will be channelled through the WAPP 330 kilovolt (kV) Nigeria-Niger interconnector. This also connects Burkina Faso via its left branch and Benin and Togo via its right.

ENERGY SUPPLY AND DEMAND IN NIGER

Like all ECOWAS countries, Niger has a dual energy system containing co-existing traditional and modernised energy systems and practices. On the one hand, traditional biomass fuels and inefficient technologies dominate household energy needs. On the other, electricity and more refined fuels are also used in Niger as well as up-to-date appliances. However, these are mainly used in urban areas, where the energy picture is complex. The simultaneous use of biomass fuels, kerosene or LPG is common in urban areas, even in relatively high-income households. The fragmented nature of the energy system creates enormous difficulties for policy makers to overcome the energy challenge in an integrated manner

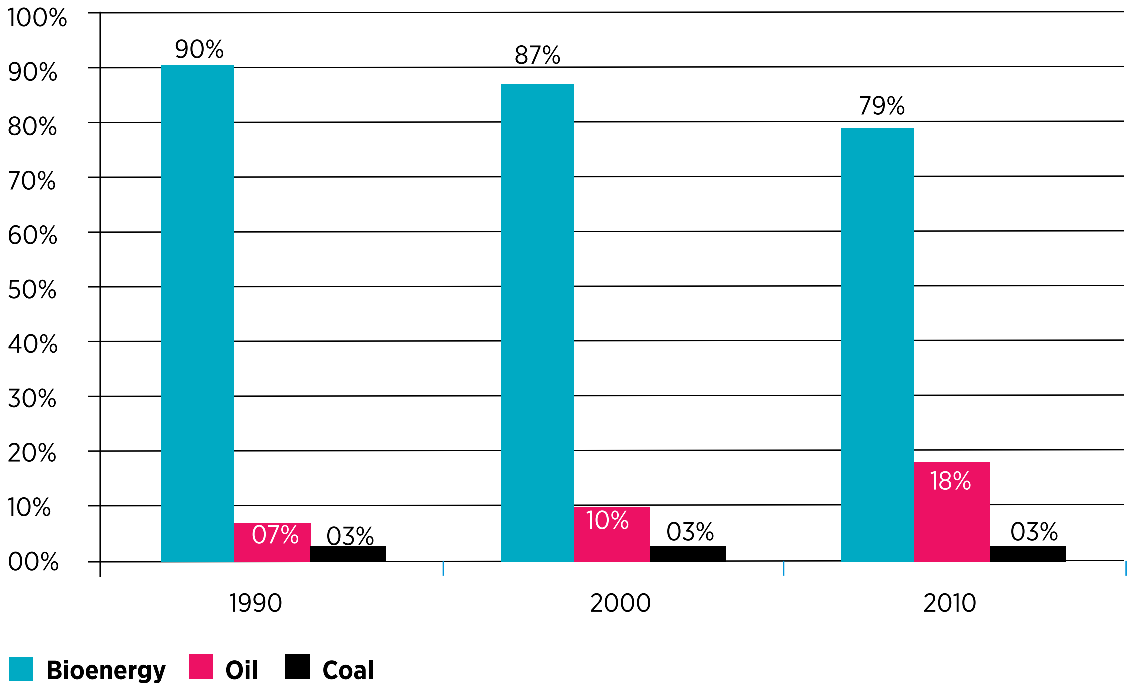
TPES in Niger was about 91 petajoules [PJ] (2173 thousand tonnes of oil equivalent) in 2010. As shown in figure 2, the most striking feature of Niger's energy system is the dominance of biomass. This represents 79% of total consumption and meets 83% of household energy needs. Biomass in the form of fuelwood, charcoal and agricultural residues is used in inefficient cooking appliances. This practice has contributed to the ongoing deforestation problems in Niger. Mainly used for electricity generation and transport, petroleum products account for 18% of Niger's energy mix. Their share of the total has increased in recent years. Mineral coal for electricity generation accounts for the remaining balance at 3% of total energy supplies in Niger. The share of renewables as a proportion of TPES remains negligible at less than 1%, assuming that all biomass is non-renewable - which is not the case.

The household sector is the main end-user of energy in Niger at 90%, followed by transport and industry at 8% and 2% respectively (see figure 3). This energy consumption profile is typical of least developed country economic structures. These countries have limited industrialisation. Furthermore, energy needs for the residential sector are met by traditional biomass, although more recently LPG has come to assume greater importance in the household energy supply mix. Energy consumption in the agricultural and commercial sectors remains small – less than 0.5%.

Until recently, Niger imported oil and gas needed for domestic consumption, creating balance of trade difficulties for the country's policy makers. However, since 2011 Niger has become an oil producer, improving the prospect for social and economic development. The Agadem perimeter, entrusted to NCPC, has proven oil reserves estimated at nearly one billion barrels while its natural gas reserves are estimated at 30 bn cubic metres (m^3). At present, Niger has the capacity to produce 100,000 barrels per day but currently produces 20,000 barrels per day. This is earmarked to meet domestic demand for petroleum products. In 2011, a refinery with

Figure 2

Total Primary Energy Supply in Niger

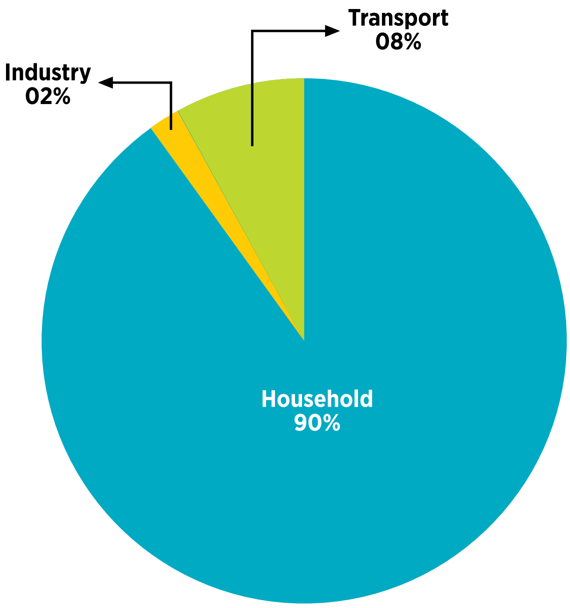


a capacity of 20,000 barrels per day was built in Zinder to supply Niger's current and future needs. Given that Niger's present demand stands at 8,000 barrels per day, some of the surplus petroleum products from Zinder are already finding markets in neighbouring countries, including northern Nigeria.

Moreover, the associated gas is tapped as part of the government's ambitious campaign to promote LPG as an alternative to wood and charcoal consumption in Niamey and other urban centres. The campaign has delivered positive results, with consumption increasing from 3,000 metric tons (t) in 2011 to 10,000 t in 2012 (Practical Action Consulting, 2013). LPG production has reached 47,000 t p.a and is expected to amount to 70,000 t p.a. once the refinery reaches its maximum capacity. This will provide further opportunities for mainstreaming LPG use across the country, including in rural households and businesses. Conditions in Niger for this increased use of LPG are favourable as LPG costs are the lowest in the region. They amount to USD 0.6 per kilogramme (kg), which is a significant reduction in cost compared to USD 1/kg before the refinery was built.

Other options have received attention. Niger is endowed with proven coal reserves amounting to more than 68m t in Salkadamna (Tahoua) with a calorific value of 6,000 kcal/kg and over 20 t in Anou-Araren and Solomi (Agadez). At present, only the Anou-Araren deposit is mined. It feeds a power generation plant for mines in the region, as well as the cities of Agadez, Akokan, Arlit and Tchirozerine. Proven uranium reserves in Niger are estimated at over 280,000 t. The mines are operated by Société Miniere d'Air – Air Mining Company (SOMAIR) and

Figure 3
Energy consumption by sector



Compagnie Minière d'Akouta – Akouta Mining Company (COMINAK). Their annual production increased from approximately 2,900 t at the end of the 1990s to an annual average of 4,000 t in 2005. All uranium produced in Niger is exported, although there are ambitions to use it to generate electricity for the ECOWAS region. The first phase of development of a regional nuclear programme is in progress and has the assistance of the IAEA.

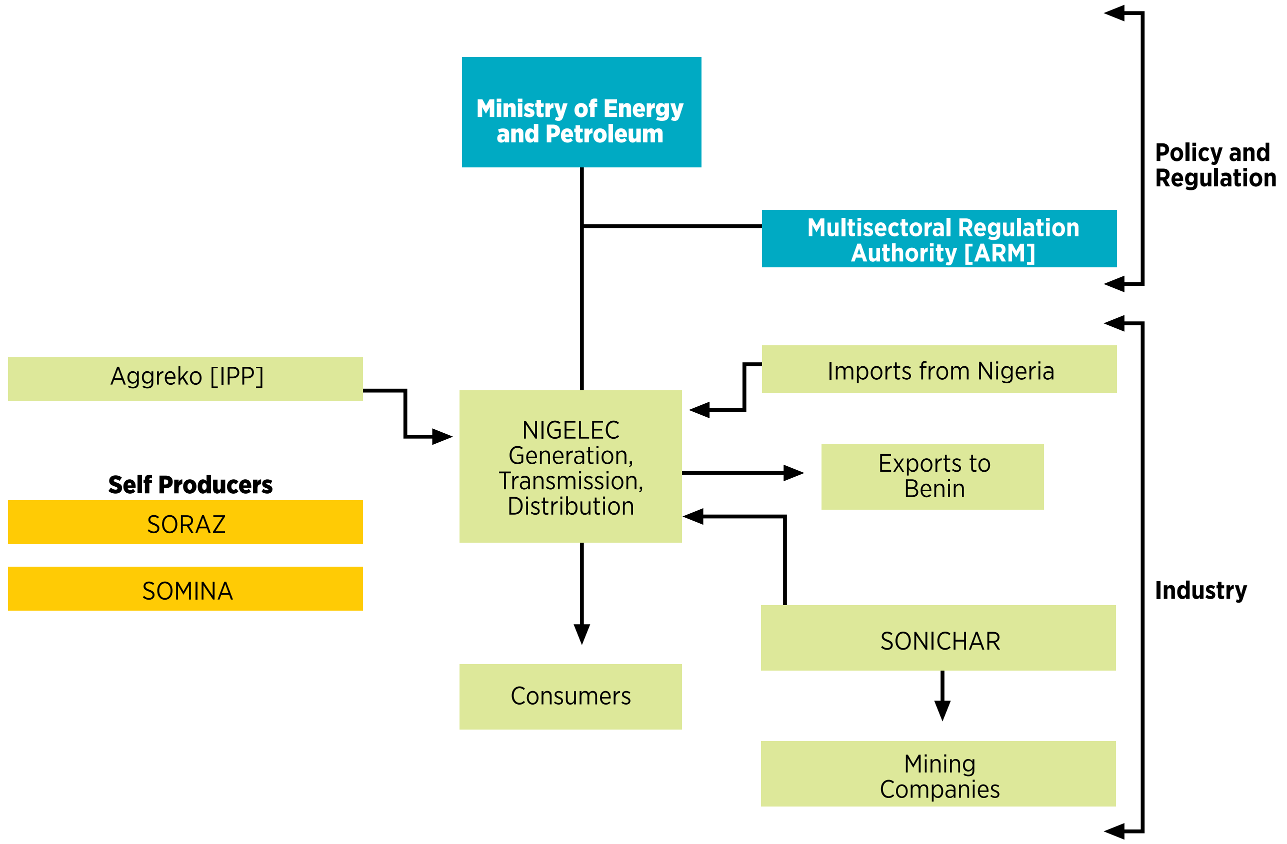
Energy access in Niger remains a critical barrier to the country's development. Modest improvements have been experienced in recent years. However, electricity access in Niger remains low at about 24% and almost all the population relies on the unsustainable use of traditional biomass (MP/AT-DC, 2011). Moreover, there is a major disparity between rural and urban areas in terms of access to modernised energy services (both electricity and heat for cooking). Urban areas enjoy significantly better conditions for access. The following section provides a review of the state of the power sector in Niger, including the tariff structure and planned expansion.

ELECTRICITY SYSTEM

The institutional arrangement of Niger electricity sector is depicted in figure 4. The Ministry of Energy and Petroleum is responsible for policy development and the Multisectoral Regulatory Authority is the independent regulator. The Société Nigérienne d'Electricité - NIGELEC - the Nigerien Electricity Company, is the utility responsible for electric power generation, transmission and distribution in Niger. Established in 1968, NIGELEC is majority owned by the government of Niger. Petroleum products (70%) dominate Niger's energy generation mix, followed by coal (28%) and solar (2%). As shown in table 1, the national installed capacity of less than 175 MW includes the NIGELEC 83 MW thermal power station. It also includes a 36 MW coal-fired power plant run by the Nigerien Anou Araren Coal Company (SONICHAR) and the AGGREKO 15 MW thermal power plant. Furthermore, the two Independent Power Producers (IPPs) SORAZ (a refinery) and SOMINA (a uranium mining company) produce 23 MW and 15 MW respectively to meet their electricity needs (Figure 4). Installed PV capacity amounts to about 4 MW and meets a variety of end uses. Approximately 47% of the electricity produced is consumed by households. Industry uses around 39%, commercial entities and services 13% and agroprocessing 1% (Oumarou, 2012).

Niger does not generate sufficient electricity to meet the growing need for power from its population of 16 million. It has

Figure 4
Niger's Electricity Sector



historically relied on imported power from Nigeria following an agreement in 1977, and this provides 80-90% of its national electricity requirements. Niger's dependence on imported power is illustrated in figure 5. The preferential rate of electricity from Nigeria at USD 0.04/kWh partly explains this continued trend. It amounts to a 50% subsidy for every unit of power imported (Eberhard, *et al.*, 2011), as consumers in Nigeria purchase electricity at USD 0.08/kWh. This agreement is therefore not certain to last and it leaves Niger vulnerable to any tariff adjustments made by Nigerian authorities. The heavy reliance on Nigeria for electricity can potentially undermine the resilience of Niger's energy system, as in 2008 and 2010. Erratic power supplies from Nigeria prompted Niger's government to gradually reduce its reliance on Nigeria by purchasing new diesel-powered generators. However, these interventions appear to be emergency responses driven by necessity to act rather than part of a longer-term strategy of energy self-reliance.

TRANSMISSION AND DISTRIBUTION

The electrical transmission network in Niger is divided into five zones (Figure 6). These consist of:

i) the River Zone fed by the 132 kV interconnection line from BirninKebbi (Nigeria) to Niamey (Niger) with a contractual power of 120 MW

ii) the Niger Centre East (NCE) Zone which brings together the regions of

Table 1
Installed Capacity by Source in Niger

Generation Responsibility	Installed capacity by source (MW)			Total MW
	Oil	Coal	Solar PV	
NIGELEC	83			83
AGGREKO	15			15
SORAZ	23			23
SONICHAR		36		36
SOMINA		15		15
Other*			4	4
TOTAL	**121**	**51**	**4**	**174**

*Other includes households, community installations, telecom towers, etc.

Zinder, Maradi and Tahoua, powered by the 132 kV interconnection line from Katsina (Nigeria) to Gazaoua (Niger) with a power contract of 60 MW with Nigeria

iii) the Northern Zone which includes the towns of Agadez, Arlit and Tchirozerine, as well as mining companies, fed from the SONICHAR coal plant and a central thermal diesel in Agadez with an installed capacity of 37 MW

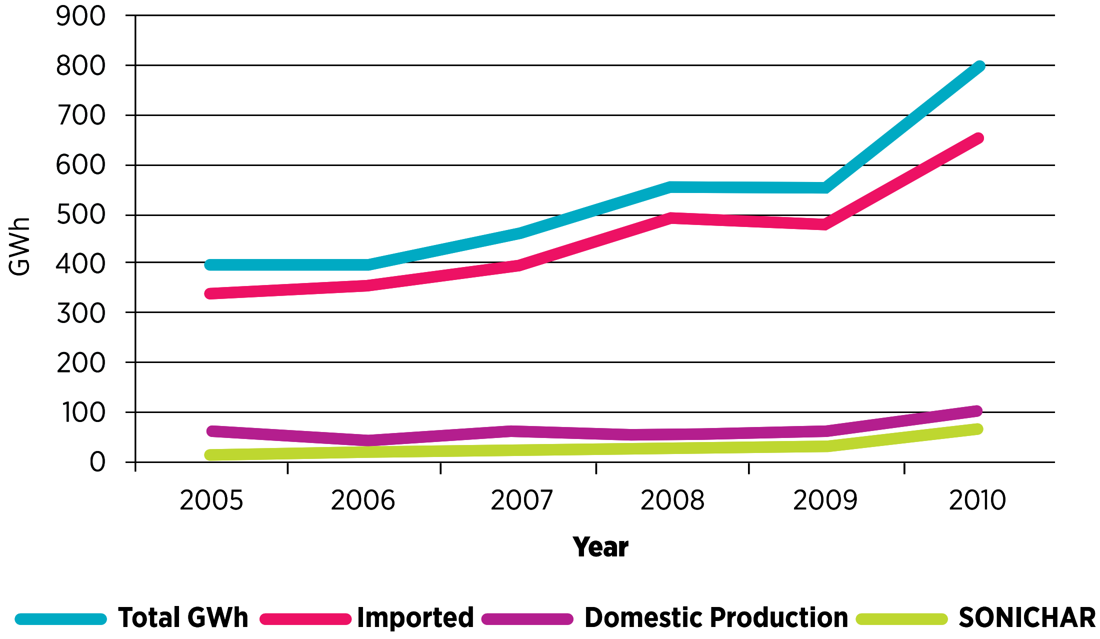
iv) the Diffa Zone connected to the 33 kV Nigerian network from Damasak with a capacity of 5 MW and installed thermal diesel production of 2.3 MW

v) the Gaya/Malanville Zone, which is fed by a 33 kV interconnection from Kamba in Nigeria and has contracted power of 7 MW with Nigeria.

The cost of the transmission infrastructure can be significant, ranging from USD 120,000/km for 132 kV power lines to USD 17,000/km for 20 kV lines. Distribution costs amount to USD 20,000/km. Transmission and distribution losses in Niger are lower than the African average, having been brought down from 27% in 2005 to about 17% now. However, they still remain higher than the European average (6%). Given that a significant proportion of Niger's population lives far from gridlines, electricity from the grid alone will not deliver the promise of universal access. It is important that there is a meaningful dialogue on the genuine prospect of decentralised systems as a complementary solution to energy access in Niger.

Power distribution works through medium voltage 33 kV and 20 kV cables as well as low voltage cables to connect subscribers. Electricity supply in Niger also faces frequent blackouts due to limited power infrastructure. In 2009, for instance, there were some 21 outages a month compared to an average of 11 outages for sub-Saharan Africa (Eberhard *et al.*, 2011). Power outages in Niger were shorter at two hours against six hours for the region. Outages are frequent during the dry season (February-May) when demand is high and power reliability can fall up to 13% as was the case in 2010. Over 40% of Nigerien firms reported that power shortages were a major obstacle to administration and good economic performance. They also reported that 6% of annual turnover was lost due to electricity shortages (World Bank, 2009). This has

Figure 5
Power Generation and Distribution by Source



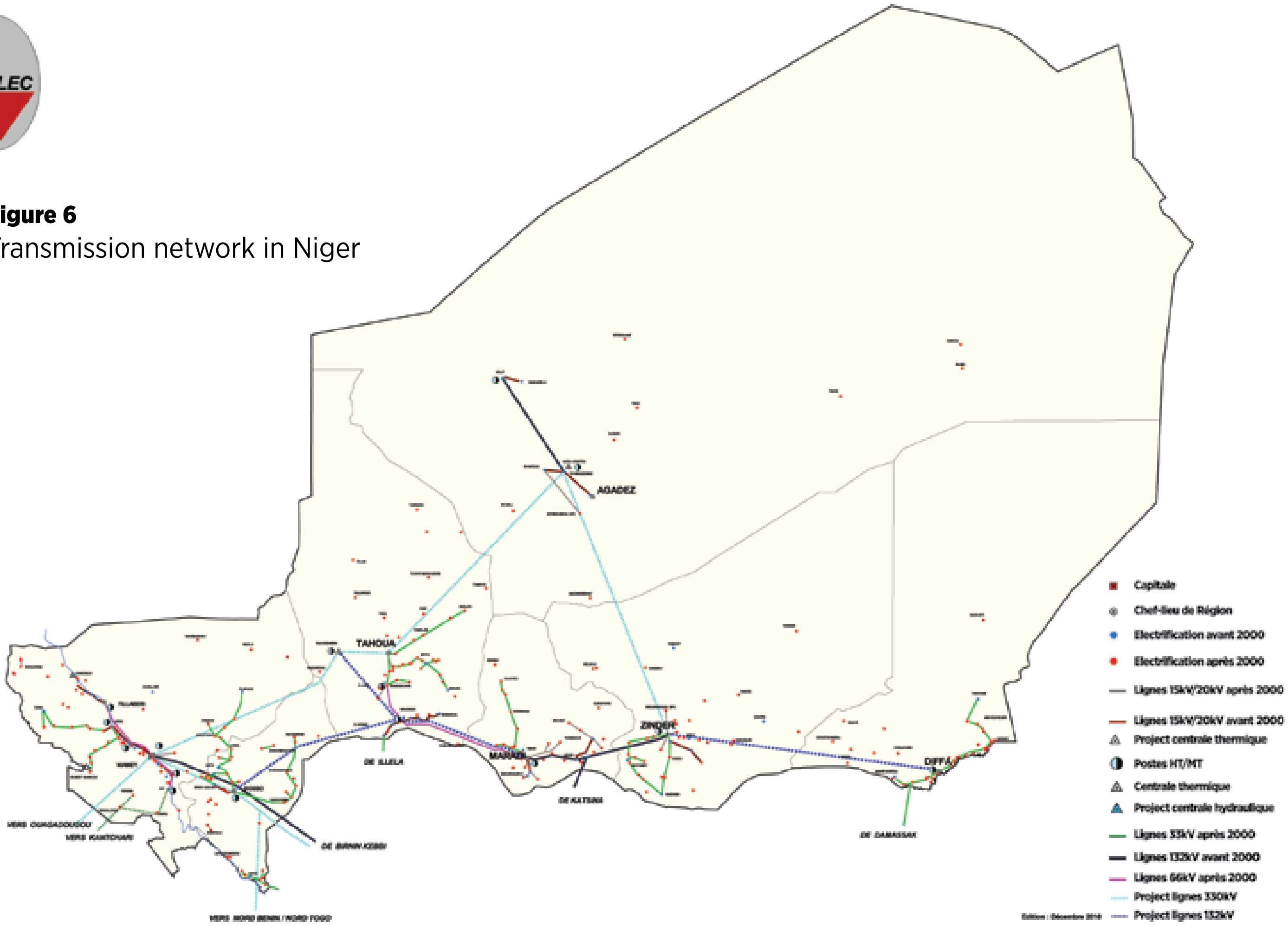
prompted 20% of Nigerien firms to acquire their own generators (World Bank, 2010). A growing number of urban households are also purchasing their own gensets as a backup power source.

As shown in figure 5, power demand in Niger has risen by about 50% in 2005-2010. This trend is expected to increase as the ambitious PDES calls for broadening electricity access to improve livelihoods and deliver the economic growth trajectory of 8% p.a. Projected demand shows that Niger will need to scale up its efforts to boost domestic production as well as rely on imports from Nigeria and WAPP (Figure 7). As part of this endeavour, Niger is actively pursuing wholesale power generation and transmission improvement projects. These will develop its own domestic power sources, particularly hydropower, other renewables and the oil and gas sector (Table 2).

The electricity sector was reformed in 2003. One important change was the adoption of the Electricity Code in 2004. The terms of the code paved the way for IPPs, breaking up the monopoly NIGELEC had enjoyed for electricity generation, transmission and distribution since its establishment. However, IPPs were still required to sell their surpluses through NIGELEC, which remained responsible for transmission and distribution. This new arrangement treats SONICHAR as an IPP. It sells electricity directly to mining companies in northern Niger as well as to NIGELEC for distribution in the cities of Agadez, Arlit, Akokan and Tchirozérine. To date, the number of registered IPPs remains limited, and the few that have emerged use conventional energy sources to generate electricity.

The government of Niger, with the assistance of the World Bank, is currently working on an electricity master plan with a view to providing an integrated strategy for the sector's future development. Intensive stakeholder consultation is taking place with participation from key representatives from government, business and civil society to feed into the strategy.

Figure 6
Transmission network in Niger



Source: NIGELEC

COSTS AND TARIFFS

Electricity tariffs remain in the hands of the government, and are set by decree, as in a number of other West African countries (figure 8). The tariff set depends on a number of factors, such as the electricity production cost (including operation cost), social cost and other political and economic criteria. There are three categories of production costs in Niger. They consist of the NIGELEC domestic power plants (USD 0.22/kWh), coal-fired plants (USD 0.12/kWh) and electricity imports from Nigeria (USD 0.04/kWh). The utility purchases tax-free domestically-produced diesel directly from the refinery at USD 0.70 per litre. The country does not currently export crude oil. However, sale of diesel to the utility at the subsidised price is an opportunity cost if crude oil had been sold at international market prices. It is important to note that Niger will continue to remain dependent on cheap electricity from Nigeria unless there is a price review.

Furthermore, in 2012 the government accepted the creation of a social tariff as part its energy access improvement efforts. This supports low income and low consumption subscribers. This category of households (3 kWh) is charged USD 0.11/kWh for the first 50 kWh consumed. There are also plans to reduce the costs of electrical connections to the poor. These stand at USD 102 for 3kW and USD 144 for 6 kW. Concessionary rates also apply for industries and agricultural facilities for water pumping. These tariffs are fixed at USD 0.11/kWh and USD 0.07/kWh

Table 2
Power Generation and Transmission Project

Power plant projects	Transmission network projects
PV solar electric power: 20 MW in the Niamey area - negotiations are under way.	Power transmission (lines and stations)
Central diesel engine power: 100 MW at Gorou Banda (Niamey right bank) - funding mobilised and installation in progress.	Installation of a compensation series on the BirninKebbi - Niamey 132 kV interconnection line– ongoing contract negotiations
Coal: 200 MW power plant at Salkadamna (Tahoua) extendable to 400 MW - funding sourced for investigation and research	Transport network restructuring in the river zone with project integration between Gorou Banda and Kandadji
Hydroelectric power: 130 MW at Kandadji - work is ongoing	132 kV transmission line projects (Soraz - Zinder and Maradi/Malbaza) - EPC & ongoing partnership negotiations
	WAPP Ridge North 330 kV project - looking for long-term funding
	Lines and posts related to constructing the Kandadji and Salkadamna power plants

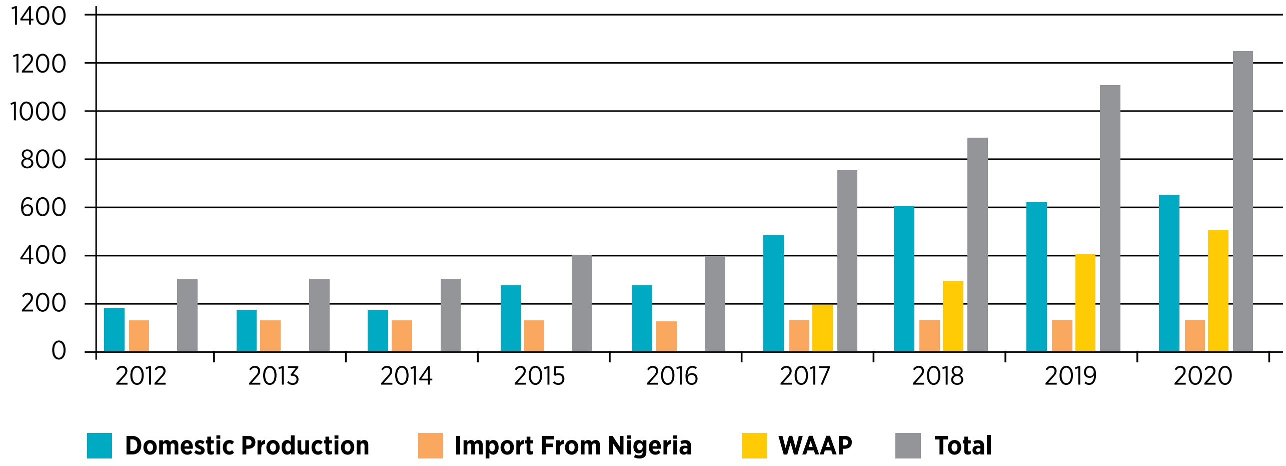
respectively. These lower tariff rates are set in order to reach the government's social and economic goals, which require affordable and reliable energy services.

Power sector reforms in 2004 were supposed to contribute to the recovery of costs and performance improvements in Niger. However, at USD 0.158/kWh, Niger's consumers pay approximately USD 0.07/kWh more than citizens in the average African country that rely heavily on thermal power systems (Eberhard, *et al*., 2011). However, tariffs are lower than in some countries in the subregion such as Burkina Faso, Benin (USD 0.20/kWh) and Senegal (USD 0.24/kWh). These tariffs therefore do not allow the utility to recover costs incurred from the sale of power. Indeed in 2011, for example, revenues from power sales amounted to USD 90.5m (with a recovery rate of 102%) against operating expenses of USD 100m. This clearly demonstrates that present tariff structures do not reflect costs.

The overwhelming majority of those who remain unserved by the grid live in villages very far away from national grid lines. The cost of transmission lines to these communities with low electricity demand could amount to USD 20,000-120,000/km, which in many cases is not financially viable. Furthermore, grid connection fees cost USD 102-145 in Niger. This is far too expensive for low-income households without appropriate financial support. Niger needs substantial investments in system modernisation, but more importantly, in new generation plants, as well as transmission and distribution facilities.

A parallel strategy will be important to meet the needs of remote communities that use little energy. Niger has considerable conventional and renewable energy

Figure 7
Forecasted Electricity Supply until 2020 (MW)



resource potential. It therefore has the opportunity to create a more cost-effective grid and off-grid renewable energy supply system. This can play a major role in reducing dependency on imported power and increasing access to energy services. The practical solutions may appear obvious, but Niger will need to develop the policy framework and incentives to accommodate new business models and new domestic and external energy investment.

RENEWABLE ENERGY RESOURCE POTENTIAL AND USE

The energy sector in Niger faces some formidable challenges and new opportunities. Its resource constraints in the energy sector have undermined economic and social development goals. Rural communities face a particular challenge. Widespread poverty, low incomes, limited scope for moving beyond subsistence activities and the inherent disadvantage of the grid's remoteness create structural obstacles to rural development. Niger's untapped renewable energy potential provides opportunities for transforming urban and rural livelihoods.

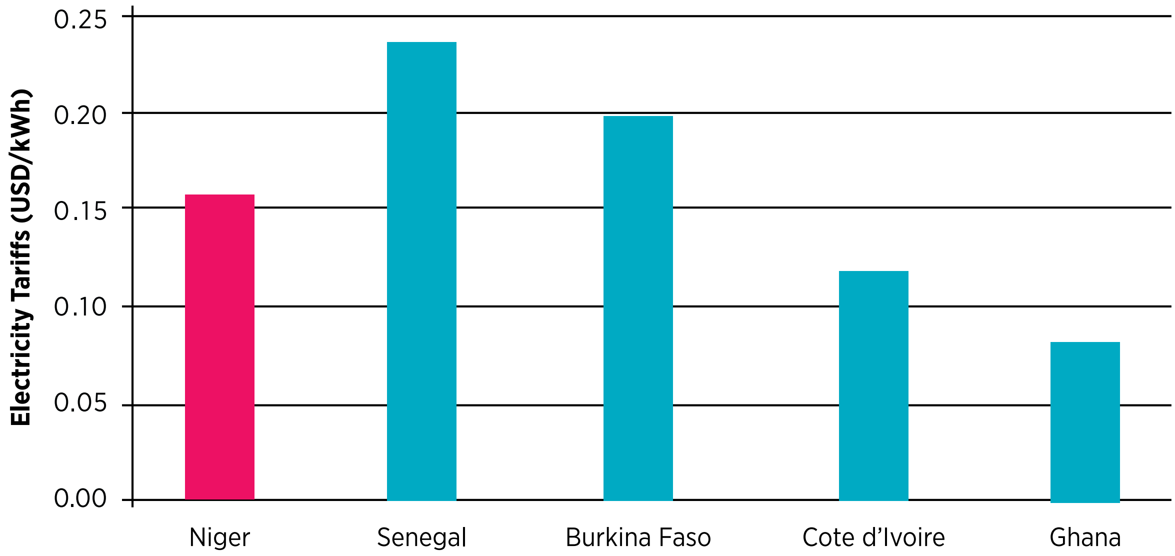
Given its geographic and climatic conditions, Niger could develop a diverse portfolio of renewable energy technologies. Niger has an excellent renewable energy resource profile. There are considerable solar energy resources and a moderate wind regime for electricity and mechanical power towards the North. There is modest hydro and biomass potential towards the South. A summary of the resource and potential for Niger is outlined below.

HYDROPOWER RESOURCES

Hydropower potential in Niger is estimated at about 400 MW (ECOWAS, 2006) and is only partially developed. Three potential medium and large hydropower sites along the river Niger and its tributaries have been identified. They would have a combined capacity of 268.5 MW and include:

- Kandadji Dam, a large multipurpose dam with a capacity of 130 MW (4 X 32.5 MW) and estimated annual generation rate of about 630 GWh. This high profile dam project will generate hydropower and regulate the flow of the river Niger, retaining water during the

Figure 8
Electricity tariffs comparison for selected West African countries



Source: World Bank, 2012

dry season and supporting irrigation initiatives downstream. Construction has started and is expected to be completed by 2017.

- Hydropower at Gambou and Dyodyonga, which could generate about 112.5 MW and 26 MW respectively, according to feasibility studies.

A number of mini-hydro sites have also been identified along the four tributaries of the Niger River (Mekrou, Tapoa, Gorouol and Sirba), amounting to a combined capacity of 8 MW. These will not require dams and will be quicker to install. They will have the strategic advantage of generating electricity close to consumption areas thus limiting costly power lines. Before moving ahead, further data need to be collected and analysed to ensure their potential and viability.

SOLAR ENERGY RESOURCES

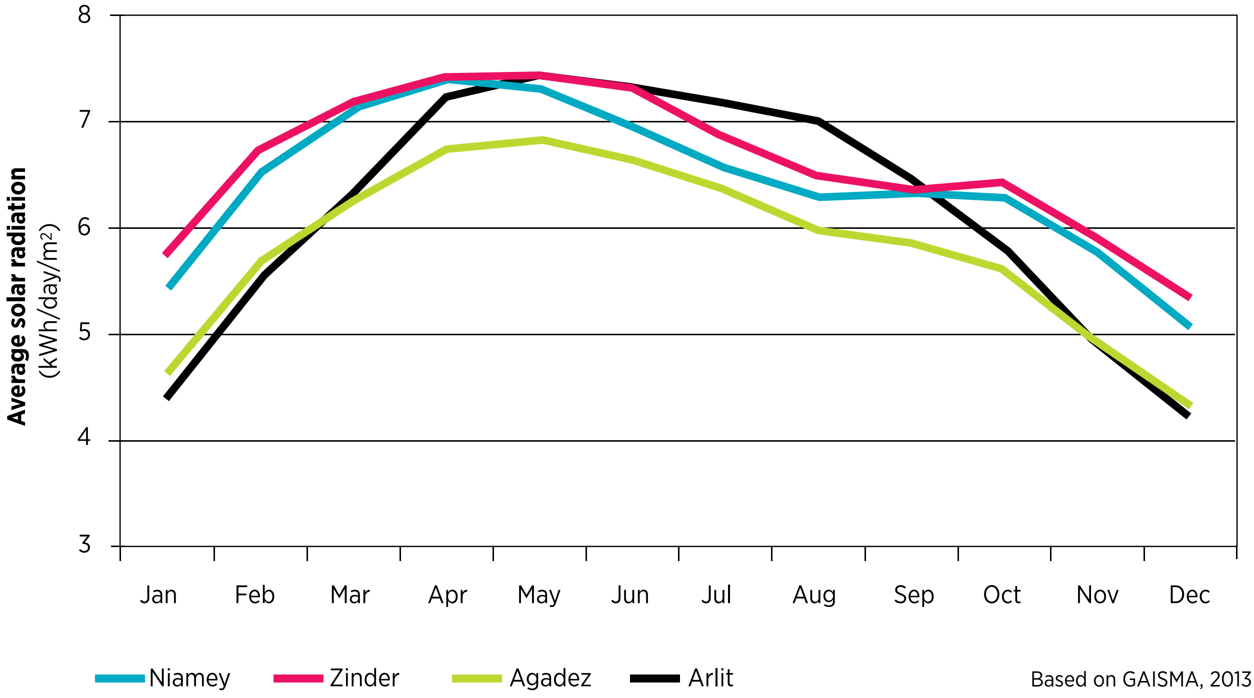
Niger enjoys high solar radiation conditions in all eight of its regions. Average solar radiation is 5-7 kWh/m^2 per day (figure 9), and there are seven to ten hours of sunshine per day on average. April to August is the period of high insolation, when the diurnal variation between minimum and maximum radiation values is small.

The lowest radiation values are observed in December and January. The rainy season coincides with the high solar radiation summer months. Although solar radiation levels are high in all four meteorological stations, there appears higher variability over the year in cities of Arlit and Agadez located in the northern and central regions respectively. Niamey and Zinder, located at lower latitudes, show less variability across the year, hence making them excellent locations for harnessing solar energy.

There is a long history of solar energy use in Niger. This began in the mid-1960s when the Centre National d'Énergie Solaire (National Solar Energy Centre; CNES) was established. Previously known as the Office de l'Energie Solaire (Solar Energy Office; ONERSOL), it had been set up to under-

Figure 9

Solar radiation in four cities in Niger



Based on GAISMA, 2013

take applied research on renewable energy and provide diagnostic studies on the use of renewable energy technologies for various sectors of the economy. It was also established to run training programmes in renewable energy systems. As part of this initiative, a factory was set up to assemble and produce various types of solar equipment that were distributed locally with strong government support.

Solar energy applications in use in Niger at present include PV for mini-grid and stand-alone applications, solar crop dryers and solar water heating for homes and community applications.

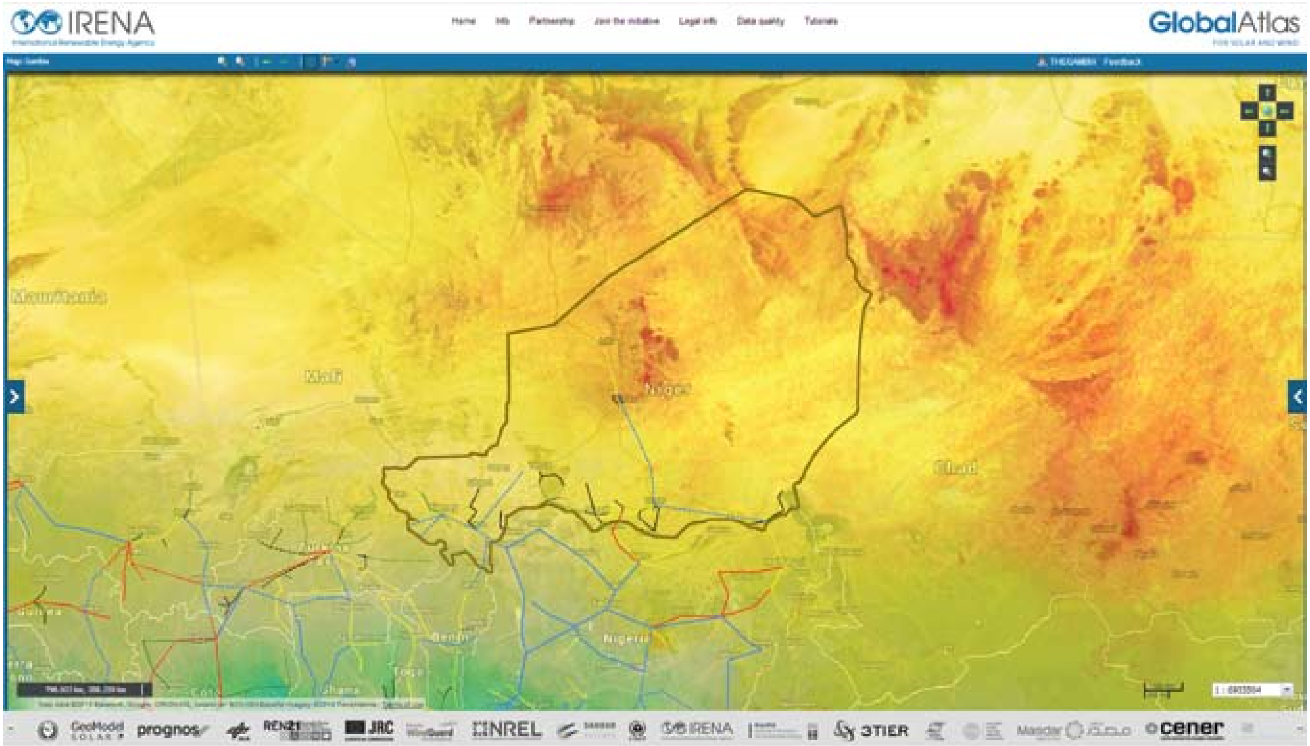
This programme continued with some force until the mid-1970s. However, it failed to maintain its promise due to high production costs, poor management and product quality control as well as its inability to compete against cheaper and better quality imports. Solar PV and other solar energy technologies continued to be promoted in Niger through various outlets, including the national school television programme. Solar technology installation also continued, largely in PV pumping areas and through education and health infrastructure electrification.

During the 1980s and 1990s, a two-phased Special Energy Programme was initiated by the Niger-German technical cooperation. Through ground-level projects, it popularised and promoted various renewable technologies such as PV systems, biodigesters and solar water heaters. Other smaller scale donor programmes also started up. However, much of this effort remained driven by donors with little national acceptance and did not lead to the development of a lasting renewables market in Niger.

At present, there is little in the way of private sector participation and incentives to draw investors in the development

Figure 10

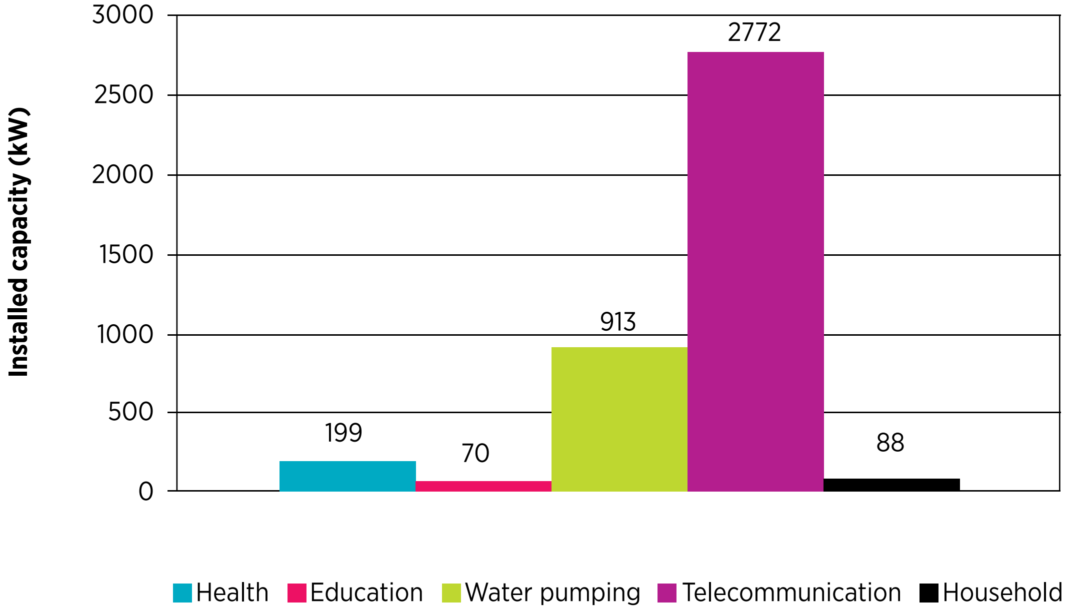
Niger Solar Irradiation (resolution 3 km)



and distribution of solar products in Niger. There are a few private sector players such as SunTotal and YASMA who dominate the national market, while policies have yet to excite wider commercial interest. Moreover, the market is limited by its small size. It is also partly constrained by taxes of over 52% (import tariffs and VAT), a lack of regulation on poor quality products smuggled from neighbouring countries, and the absence of a meaningful government renewables stimulus.

Still, in 2012 total installed PV capacity was over 4 MW (see figure 11), and there are some good examples worth scaling up. With financial assistance from the government of India, the villages of Moli Haoussa (commune rurale de Tamou) and Banigueti (commune de Torodi) have been electrified by solar PV. Moreover, a large rural PV electrification project is in progress in the Dosso and Tillabery region costing

Figure 11
Installed PV capacity in 2012



nearly USD 15m to meet basic services for about 150 villages. What makes this project interesting is that it is being co-financed by the ECOWAS Development Bank. This demonstrates that regional development banks are interested in renewable energy development.

There is growing investment interest in PV grid connection as the falling cost of PV in recent years brings the technology closer to grid parity in many parts of the world. Niger's high electricity generation cost is likely to provoke investor interest in introducing PV to the grid. The government of Niger is negotiating a PPA for a 20 MW solar plant with a French company. However, this project is facing opposition due to the proposed price of USD 0.165/kWh, which is significantly higher than imports from Nigeria but lower than the utility domestic generation costs.

With regards to other solar energy technologies, solar water heaters are used in Niger in some schools, clinics and households. The country also has domestically-produced water heaters and solar dryers that are cheaper than imported systems, but their quality is often of lower standard.

WIND ENERGY RESOURCES

A wind energy resource study was conducted in the 1990s by the University of Waterloo (Canada) and the Institut National de Recherche Agronomique du Niger (INRAN), the National Institute for Agronomy Research. The study concluded that average wind speeds of 2-6 metres per second (m/s) are obtained at a height of 10 metres, but wind speeds at hub height (*e.g.*, 50 metres) are usually 20-100% higher, warranting further investigation. Wind speed is moderate in the southeast of the country at less than 4 m/s, but rises to an average of over 5 m/s towards the northern part of the country (Figure 12). Wind regimes are very site-specific, requiring detailed site studies. However, it is clear that the relatively high wind speed in some parts of the country means electric-

Wind water pumping system in Chikal village
Courtesy: Ministry of Energy and Petroleum, Niger

ity production makes sense. The problem is that the high investment cost is not justified because many of these parts of Niger are uninhabited or sparsely populated and lack electricity infrastructure. However, further studies may identify favourable sites in the more populated parts of the south and southeast. For example, the general wind regime in Zinder, provided in figure 13, gives cause for conducting further evaluation.

There is no experience of wind energy projects in Niger. Much of the limited experience is restricted to rural water pumping projects. There are at present about 30 small-scale wind pumping installations, which are installed by donor funding and to a lesser extent community financing.

Figure 12
Wind speed in four Niger cities at 10m height

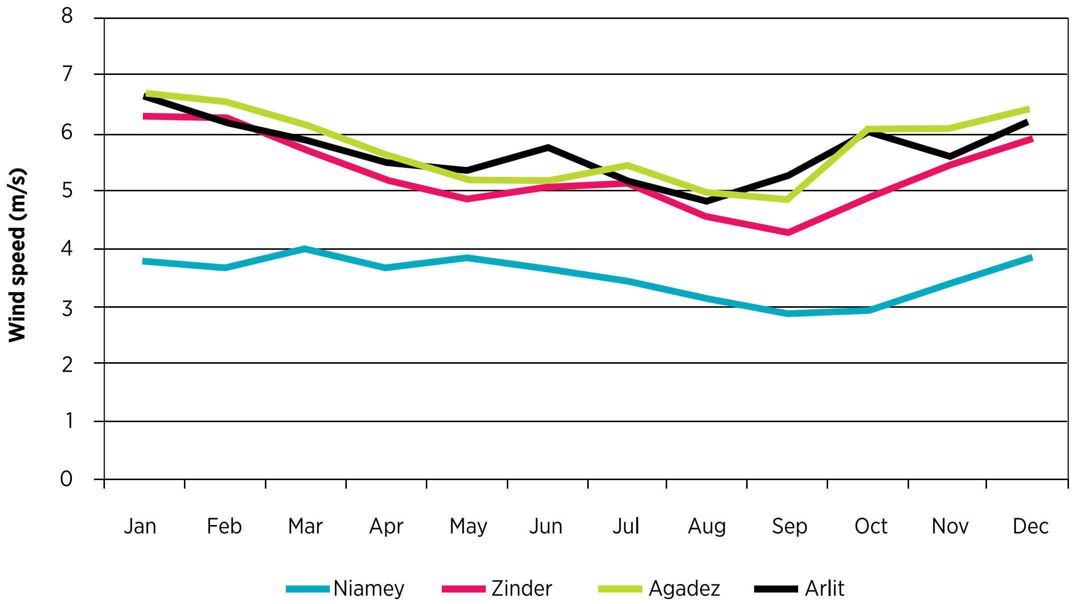
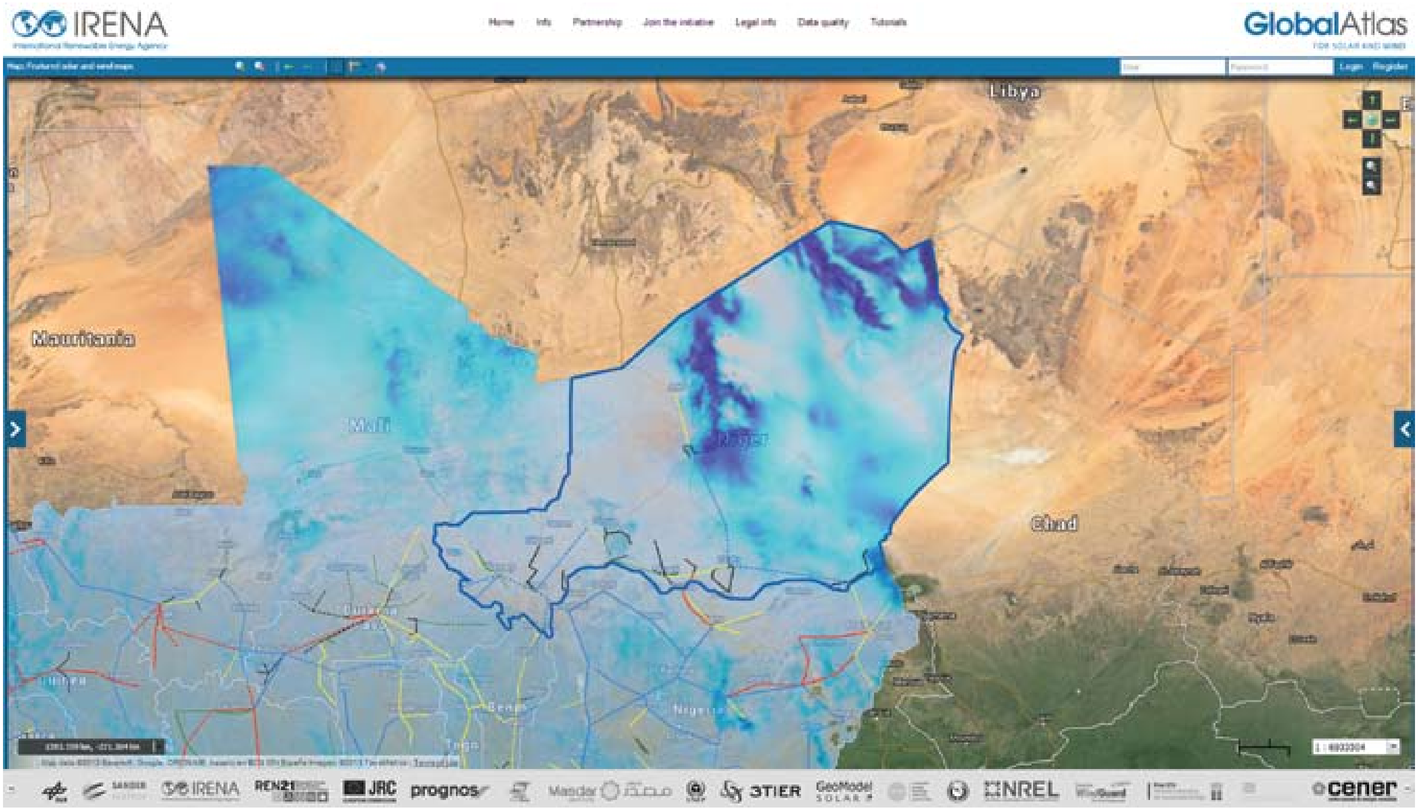


Figure 13
Wind Speed at 50m height in Niger



Transmission lines West Africa by ECREEE

- Kv < 50
- Kv < 50
- Kv 50-100
- Kv 50-100
- Kv 50-100
- Kv 100-200
- Kv 100-200
- Kv 200-300
- Kv 200-300
- Kv > 300
- Kv > 300

West Africa 10km by ECREEE

- 2.9 m/s at 50m
- 3 m/s at 50m
- 4.2 m/s at 50m
- 5.4 m/s at 50m
- 6.6 m/s at 50m
- 7.8 m/s at 50m
- 9 m/s at 50m

World Countries by Google maps

BIOMASS RESOURCES

Niger lacks adequate information on forest cover and biomass potential. Much of the data are either dated or fragmented, covering isolated mountain areas or river basins. Estimates by the Food and Agriculture Organisation (FAO), however, indicate a forest inventory of 16 million hectares (ha) or about 2% of the country's land area. Within this total, 600,000 ha accounts for natural forests, 4.4m ha for converted forest and 11m ha for marginal forest land (less than 5% forest cover). Woody biomass productivity is estimated at 0.1-1.5 m^3/ha per annum.

Given the dominance of energy biomass in Niger, often freely harvested from surrounding areas, only a portion of the forest capital can be regarded today as renewable. The pace of wood harvesting has long exceeded the replenishment rate.

Table 3
Potential agricultural residues and energy content

Product	Production 2012 (t)	Ratio residues/ grains	Amount waste (t)	Calorific value (GJ*/t)	Physical Potential (GJ/year)
Millet	3 702 370	2.00	7 404 740	10.9	
Sorghum	1 354 927	2.00	2 709 854	10.9	
Rice	5 031	^1.5	7 547	15.1	113 952
		^^0.15	755	9.9	11 999
Corn	7 610	3.00	22 830	10.9	399 525
Peanut	223 966	0.43	96 305	17	1637 191

^Straw ^^Ball *Gigajoules
Adapted from MoA, 2012

It is estimated that about 3m t of wood and agricultural residues are consumed domestically every year (Government of Niger, UNDP and Food and Agricultural Organisation (FAO), 2003). This trend shows a steady decrease in supply to meet a growing demand for wood energy. Other biomass energy resources are used in Niger too. Agricultural residues are widely used by rural households for livestock and energy purposes. This sometimes harms soil fertility as bio resources are diverted from agricultural land to meet energy needs. Nevertheless, the potential of agricultural residues to meet energy services can be significant, mainly in southern areas (Table 3). The production of biogas by anaerobic fermentation of agricultural and animal biomass (anaerobic digestion) has also been used in Niger, but no numbers have been recorded. Digesters require a large amount of water, which may limit the benefit of their widespread use in Niger or other Sahelian countries.

Truck with firewood
Photo: IRENA/H. Lucas

Solar water pumping system in Tondigameye Village, Niger
Photo: IRENA/G. Singh

III. ENABLING ENVIRONMENT FOR RENEWABLE ENERGY

KEY ENERGY STAKEHOLDERS AND INSTITUTIONAL STRUCTURES

The energy sector in Niger contains a multitude of stakeholders, which include government bodies and parastatal organisations, NGOs and associations as well as the private sector. Some of these play multiple roles in policy, regulation, finance, knowledge generation and advocacy.

Ministère de l'Energie et du Pétrole – MoEP, the Ministry of Energy and Petroleum, is in charge of the development, monitoring and implementation of the national energy policy in accordance with the guidelines set by the government. Within the ministry, Direction des Energies Renouvelable set Energies Domestiques – DERED, the Renewable and Domestic Energy Directorate, is tasked with the responsibility for renewable energy and household energy. It distributes and installs energy systems across the country to serve the needs of households. The ministry also oversees the work of various independent bodies, described below.

Under the supervision of the Office of the Prime Minister, Conseil National del' Environnement pour un Development Durable – CNEDD, National Council of the Environment for Sustainable Development,is composed of representatives of the government and civil society. It has a wide remit, coordinating and monitoring policy concerning the environment and sustainable development. CNEDD is also responsible for defining the objectives of the rural energy access programme. It coordinates the intervention of the different ministries and manages programme implementation.

Société Nigérienne d'Electricité – NIGELEC, is Niger's power utility, established in 1969 and responsible for electricity production, transmission and distribution. While IPPs are allowed to generate power, NIGELEC has a monopoly over power distribution across the country.

Centre National d'Energie Solaire – CNES, the National Centre for Solar Energy, was created in 1998 by Act 98-017. Its mandate is to conduct applied solar energy research and solar technology experimentation.

It also participates in diagnostic and prospective studies on renewable energy use and in training programmes and in promotion and communication of renewable energy technologies.

The High Commission on the Development of the Valley of the river Niger is responsible for the Kandadji Programme. This 130 MW hydroelectricity project is now under construction.

Institut National de la Recherche Agronomique du Niger – INRAN, the National Institute of Agronomy Research in Niger, carries out applied research on wind energy, biogas and biofuels.

Société Nigerienne du Charbon d'Anou Araren - SONICHAR, the Nigerien Anou Araren Coal Company, created in 1978, produces electricity from coal and distributes it to northern Niger. However, its sales are restricted to the mining companies at Arlit, and it sells the surplus to NIGELEC which feeds the cities of Agades, Arlit, and Tchirozerine with electricity. It works closely with Société Nigérienne de Carbonisation du Charbon Minéral (SNCC), the Nigerien Mineral Coal Company, which produces and sells mineral coal for industrial and household use.

Société Nigérienne des Produits Pétroliers - SONIDEP, Nigerien Petroleum Products Company, is responsible for distributing petroleum products, and Société de Raffinage de Zinder - SORAZ, Zinder Refining Company, established in 2010, refines crude oil produced in Niger.

Compagnie Miniere et Energetique du Niger – CMEN, Nigerien Energy and Mining Company, is in charge of the Salkadamna coal complex including the mine and a 200 MW coal-fired power plant extendable to 600 MW. It is also in charge of hightransmission lines and associated items as well as the production unit of a carbonised form of bulk briquettes used domestically

Agence Nationale de Financement des Collectivités Territoriales – ANFICT, the National Agency for Financing National Collectives, manages two funds. These include the fund supporting decentralisation and the equalisation fund, which welcomes development partner contributions to financing local authority investments.

Autorité de Régulation Multisectorielle – ARM, the Multi-Sector Regulatory Authority, addresses IPP licensing, the price of energy and the long-term stability of the sector. It has several mandates: to develop regulations, train stakeholders and communicate information. It also conducts audits, monitors and evaluates procurement and deals with bidder complaints. Finally, it prepares general administrative clauses and coordinates the draft of clause specifications.

Cellule pour le Partenariat Public Prive – PPP, the Public Private Partnership hub, was established with a mandate to suggest potential areas for PPP development. However, it is yet to be fully operational. This hub is intended to support technical ministries and public administration in developing, negotiating and monitoring PPP project implementation.

Abdou Moumouni University is mandated by the government to carry out basic research and offers a certificate of advanced studies in solar energy. It has a chair in renewable energy recently set up by UNESCO.

ENERGY POLICIES AND REGULATORY FRAMEWORK

To forge a strategic pathway, the Nigerien authorities need to reconcile short-term imperatives for solving urgent concerns with long-term plans capable of optimizing natural and human resources for sustainable development. Niger's new Plan de Développement Economiqueet Social 2012-2015 – PDES, the Economic and Social Development Plan, is the frame of reference for interventions under the government's medium-term development agenda. It is aligned with the Millennium Development Goals (MDGs). To this end, it builds on progress made in implementing the Accelerated Development and Poverty Reduction Strategy (ADPRS). Energy infrastructure to sustain long-term economic growth is one of the important pillars of PDES. Renewable energy deployment will help widen energy access for poverty reduction and develop local economies, particularly in rural areas.

There are four recent policies and strategies that directly affect the Nigerien energy sector. Declaration de Politique Energétiques – DPE, the 2004 Energy Policy Statement, the national electricity reform (2003-4), three national energy strategies on renewable energy, energy access and domestic energy (2004) and Programme National de Reference d'Accès aux Services Energétiques - PRASE, the 2010 National Reference Programme on Access to Energy Services.

Declaration de Politique Energétique 2004. This was adopted by Decree no. 2004-338/PRN/MME on 28 October 2004. It stipulates the need to ensure a reliable and adequate energy supply at affordable prices as an important component of the country's social and economic development. DPE highlights that Niger is endowed with its own significant energy resources and needs to mobilise internal and external resources to harness them. Specifically, the policy advocates

(i) the promotion of renewable energy and

(ii) national energy resource improvement to help raise household energy access particularly in rural areas. National strategies on domestic and renewable energy, rural electrification, oil research promotion, and potential hydropower assessments would support this process (MME, 2004b).

The policy has been a major step towards the introduction of renewable energy systems. A series of follow-up strategies were developed.

Electricity reform 2003-2004. The electricity sector was reformed in 2003-4 and the Electricity Code was enshrined into law through Decree no. 2003-2004. This was intended to govern the production, transmission, distribution, import and export of power. The terms of the code created the conditions for IPPs to play a role in the future development of the power sector. To this effect, the code asserts that 'the State may authorise one or more natural persons or corporate entities to build and to operate, to the satisfaction of their own needs, private electrical installations'.

This was intended to be the initial step towards privatising the power sector by allowing new players into the electricity market. However, Niger did not proceed with the privatisation process.

Three energy strategies followed up the energy policy. These include:

a) **Stratégie Nationale sur les Énergies Renouvelables – SNER**, National Strategy for Renewable Energy. This was designed to increase the renewable energy contribution to the national energy balance from less than 0.1% in 2003 to 10% by 2020.

   This was to be done by i) facilitating the promotion of renewable energy supply ii) reducing the impact on forest resources iii) promoting rural electrification on the basis of renewable energy resources iv) promoting education, training, research and development related to renewable energy technologies.

b) **Stratégie Nationale d'Accès aux Services Energétiques Modernes - SNASEM**, National Strategy for Access to Modernised Energy Services. This was designed to increase the proportion of the population with access to modernised energy services by 2015.

   This was to be done through i) access to modern cooking fuels ii) access to motive power for villages with 1,000–2,000 inhabitants iii) access to electricity for 66% of rural and semi-urban populations

c) **Stratégie Nationale des Energies Domestiques - SNED**, National Strategy for Household Energy. This was prepared to create a coherent framework for the domestic energy subsector by

i) ensuring the sustainable use of forest resources and better reforestation, promoting alternative energy sources (other than wood) and improving appliance efficiency

ii) strengthening the capacity of the main market players to better manage the sector

iii) educating and communicating information to stakeholders on domestic energy production and use.

PRASE is a national programme that resulted from the 2006 ECOWAS White Paper. It was set up by Comité National Multisectoriel Energie – CNME, the National Multisectoral Energy Committee. It involved stakeholders from multiple government bodies and civil society in recognition of the cross-cutting nature of energy. PRASE specifically meets the needs of five target clusters:

i) the infrastructure of utilities with a social impact (water, health and education)

ii) agricultural infrastructure (crop production, livestock and processing)

iii) communal infrastructure (town halls, markets, public lighting, and cultural centres)

iv) small economic production units (multifunctional platforms, agricultural product transformation, handicrafts, trade)

v) household electricity and modern cooking fuels. At the end of PRASE, it is anticipated that at least 40% of the population in rural areas will benefit from modernised energy services (MME, 2010).

FINANCING AND INVESTMENT

State-backed companies have primarily led finance and investment in the energy sector. These include NIGELEC and SONICHAR, self-generators such as SORAZ and SOMINA and the IPP Aggreko. The bulk of the funding sourced by state-backed companies is obtained through development partners and institutions. These include the African Development

Table 4
Funding sources for energy within the PDES

	Total cost (million USD)	Source of funding: National budget	Technical and Financial Partners
Revitalisation of institutional and regulatory framework	10	1.6	8.4
Diversification of energy production	278.184	7.17	271.024
TOTAL[1]	288.184	8.77	279.424

Source: MP/AT-DC, 2011

Bank, Islamic Development Bank, World Bank, West African Development Bank and other donors. Although the generation sector has been open to the private sector since 2003 with the enactment of the Electricity Code, only one IPP, Aggreko, has entered the market. That was in 2012. The lack of investment in power generation can be mainly attributed to the low cost of electricity imports (USD 0.04/kWh) from neighbouring Nigeria, accounting for about 70% of the national electricity grid mix.

A study was commissioned by the Executive Secretariat of CNEDD on the renewable energy sector. Its findings showed that the country experienced a cumulative solar PV investment amounting to USD 23.89m in 2005-2010. More than 90% of this investment was made by development partners. Meanwhile, investment in solar thermal and energy efficiency were entirely made by households and businesses. Each amounted to less than USD 1m over the same period.

Niger's tendency to rely on external financial resources to get the energy sector moving is confirmed in the PDES. The 2012–2015 energy priority action plan supporting the country's economic growth is expected to be mostly sourced from technical and financial partners (Table 4). However, the government began to allocate a national budget in 2012 for the promotion of rural electrification. It budgeted USD 0.8m for 2012 and 2013. This is expected to increase to USD 6m p.a until 2016.

Nevertheless, internal mechanisms to mobilise resources exist, such as the Energy Fund and the tax on electricity. The Energy Fund consists of monies collected through a levy of USD 0.007 on every litre of oil product sold at the pump.

This is at present used to subsidise LPG and oxygen in hospitals. The tax on electricity (TSE) established by Act 72-05 of February 12, 1972 was set at USD 0.004 per kWh consumed. Its aim is to contribute to financing grid extension. The resources collected through this tax are managed by ANFICT and amount to approximately USD 2m p.a.

A renewable energy law is currently being drafted under which the reallocation of part of these funds to rural electrification and renewable energy promotion is envisaged. The draft also considers ploughing a portion of revenues generated by mineral resource exploitation into the country's renewable energy programme.

1 These funds do not include the oil subsector, financing from NIGELEC, SONICHAR or loans made to these companies.

In 2012, a law on PPPs was adopted. This law allows a public entity to contract a private entity for the development of public infrastructure. A special office was opened within the Prime Minister's cabinet to supervise the implementation of the PPP law. The aim is to support technical ministries and public administration in elaborating and negotiating PPP projects.

INCENTIVES

The investment code grants continual legal protection to private investors in energy production involved in promoting programmes contributing to the social and economic development of the country. Under the code, foreign investments are protected against expropriation and/or nationalisation. The code provides three privileged regimes and advantages in the first five years, depending on the amount invested:

Category A (also known as the promotional category) is for investments of USD 100,000-200,000. Exemptions are divided in two areas, implementation and operations. During the implementation phase, investors are completely exempt from:

- Duties and taxes including VAT on imported materials and equipment, provided that these are not available locally
- Duties and taxes including VAT on consulting work and services related to the implementation of the approved investment programme. During the operational phase, investors are completely exempt from:
- Licence
- Property tax or estate tax
- Tax on industrial and commercial profits and the minimum tax

Category B (also known as the priority category) is for investments of USD 200,000-1,000,000. Investors in this category benefit from the same advantages as those in category A but are also accorded the following:

- Exemption from duties and taxes (excluding VAT) on raw materials, consumables and imported or locally produced packaging where there is no availability in the local market
- Exemption from duties and taxes on product exports

Category C (also known as the conventional category) is for investments of over USD 1,000,000.

Investors in this category may also benefit from the same advantages as the previous category. In addition, they have the possibility of claiming a 50% reduction on fuel duties and taxes and any other source of energy used in fixed equipment based on an annual agreement.

Solar dryers in Makalondi village
Photo: IRENA/H. Lucas

IV. OPPORTUNITIES FOR THE DEPLOYMENT OF RENEWABLE ENERGY IN NIGER

Opportunities to develop the renewables sector in Niger are explored in this section. The different subsections focus on different resources and conversion technologies, known here as service-resource pairs. In each subsection, the status of each particular subsector is reviewed. This is followed by the problems that need to be solved and concludes with a list of action points recommended by the RRA.

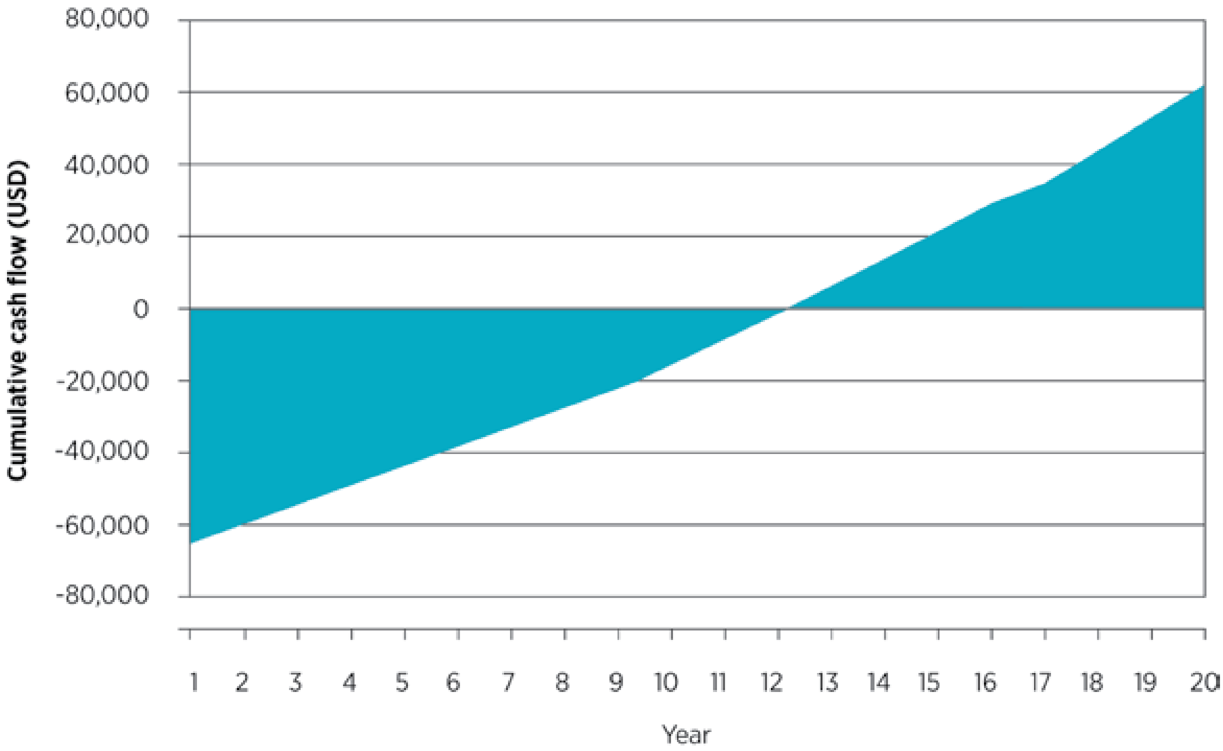
GRID-CONNECTED RENEWABLE ENERGY OPTIONS

Reliable and affordable electricity is a prerequisite for transformative development. The grid remains an important means for reaching large numbers of people cost-effectively, and extending the grid is by far the most common way to provide power to communities. In Niger, the grid offers a significant opportunity to broaden access to electricity, though formidable technical, institutional, resource and financial barriers remain. Less than 75% of people in urban and less than 2% in rural areas are served by the grid at present. This limits growth in critical productive sectors such as agro-processing and other small-scale industries. Globally, many of the renewable energy technologies are becoming increasingly cost-competitive. Their deployment would diversify the energy supply and build a stable and resilient power infrastructure. This section considers grid-based wind and PV technologies for Niger.

ON-GRID PV

Solar resource conditions in Niger are excellent, so utility-scale and distributed solar power generation shows significant promise all over the country. In recent years, the cost of PV systems has fallen sharply, making it possible for grid-based PV to achieve grid parity. It is, therefore, fast becoming a genuine alternative for countries to meet their energy access goals and cushion their economies from volatile fossil fuel prices. PV module prices have declined sharply from USD 3.70/Wp in 2009 to USD 1.20/Wp today. They may fall yet further to USD 0.5/Wp, making the Balance of System (BoS) a crucial determinant of solar PV system costs (IRENA, 2013b). These trends make PV a compelling product for end-users in countries such as Niger, which are yet to fully develop their energy infrastructure.

Figure 14
Cumulative cash flow and payback

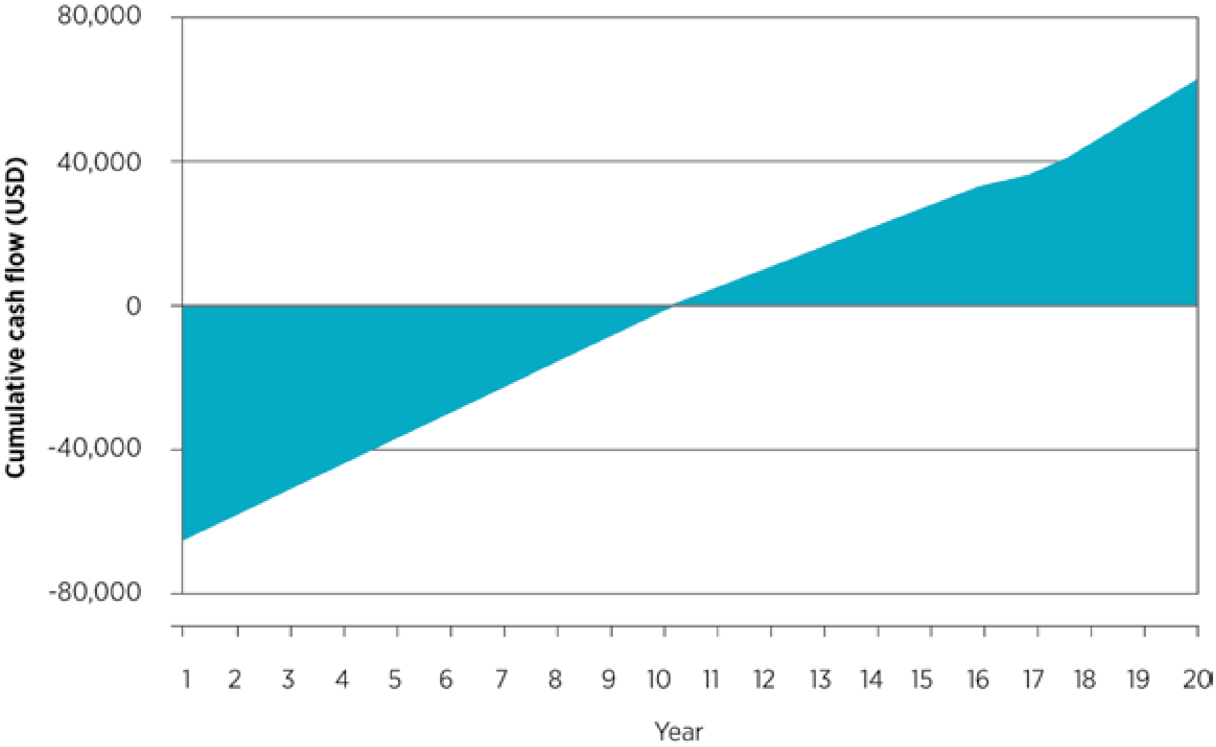


While there is considerable experience of PV systems in Niger, much of it is off-grid. There are no utility-scale PV systems. Nevertheless, there is growing interest in investor and policy-making circles in taking advantage of the potentially major economies of scale of PV-based grid developments. A financial analysis has been made as part of the pre-feasibility study of a 20 MW grid-connected solar PV system near Niamey under negotiation at present. It provides a concrete example of how grid-based systems are likely to perform under the resource and macroeconomic conditions prevalent in Niger. Cost figures from the project developer were used, and it was assumed that power would be supplied to NIGELEC at the current utility tariff of USD 0.158/kWh.

The analysis demonstrated a number of important features of PV grid systems in Niger. The payback period for the system is about 12 years (figure 14). This is also demonstrated in the levelised cost result of USD 0.10/kWh[2], illustrating that the large PV system can generate power at a rate competitive with conventional systems. Generation costs for NIGELEC are USD 0.22/kWh, which makes the PV option attractive from cost as well as security of fuel supply considerations. However, as the cost of PV systems continues to fall, their value as a reliable and cost-effective power

2 Assumptions: capital cost = USD 3,000/kW; annual O&M cost = USD 32/kW (for a 20 MW plant), inverter replacement at 8 and 15 yrs = USD 0.10/Wp, project time = 20 years, inflation = 2%, discount rate = 12%.

Figure 15
Cumulative cash flow and payback period at USD 2,000/kW



generation option increases, particularly for periods of peak electricity demand during the day. Furthermore, the bulk of the total cost of the PV systems is in the initial cost, while fossil-based systems have higher recurrent costs over their lifetime.

ON-GRID WIND

There are no grid-connected wind power generators in Niger. Windy areas suitable for wind power generation are generally located in the northern part of the country. However, these tend to be sparsely populated. Nevertheless, a few urban centres may benefit from wind power investment, and in these isolated cases, it may be possible to make the economic case for it.

A pre-feasibility study was carried out for grid-connected wind power generation in the relatively windy area of Agadez. Turbines would have a combined capacity of 20 MW with an annual generation rate of 45 GWh and system costs of USD 3,000/kW. The analysis showed a payback period of about 15 years for a system that will operate over 20 years, feeding the utility at USD 0.158/kWh. The levelised cost result was also encouraging at USD 0.10/kWh, illustrating that a large wind system can generate electricity at a rate competitive with the incumbent generation system. Further analysis was made using a more optimistic system cost scenario of USD 2,200/kW, yielding a payback period of about ten years and a levelised cost of USD 0.07/kWh (Figure 15)[3]. The Agadez Area draws electricity from a coal-fired system at the moment, and this is estimated to have a generation cost of about USD 0.12/kWh. This makes

3 Assumptions: capital range = USD 2,000-3,000/kW, annual O&M cost = USD 40/kW (for a 20 MW plant), inverter replacement at 8 and 15 yrs = USD 0.10/Wp, project time = 20 years, inflation =2%, discount rate =12%.

wind power a cost-competitive option in this part of Niger if only generation is taken into account. Naturally, other factors also need to be taken into account before an investment of this magnitude is considered. There may be other sites that combine favourable wind conditions with other factors such as high electricity demand and high density of settlement. However, wind data across Niger are scanty at best, and a detailed national wind energy assessment would go some way to identifying appropriate sites for wind power generation.

Wind power generation offers an opportunity to improve the electrification rate by harnessing and diversifying the use of locally available resources. It also meets the government's social and economic transformation aspirations as outlined in PDES. New business models are needed to address the frequently high capital cost of renewable energy systems and to reduce investment risk to meaningfully engage the investor community. This requires the creation of robust policies and an investment climate conducive to renewable energy development and implementation.

Appropriate regulations including waiver on import sales tax and favourable corporation tax for renewable energy developers would need to be part of the effort to stimulate investor confidence. Strong efforts will also be required to build efficient administration and management capacity in responsible government agencies. There is also a need to strengthen skills in engineering, business, finance and contract negotiations across the various actors in the private sector.

RECOMMENDATIONS

The RRA has highlighted several technical opportunities and barriers facing Niger renewable energy generation and transmission infrastructure. It also brought to light some of the institutional, financial and capacity issues associated with PV and wind-based power generation to feed the grid. These are discussed below.

RENEWABLE ENERGY RESOURCE ASSESSMENT

Lack of information on solar and wind energy resources is a major obstacle to investment due to the difficulties in developing robust project proposals. The RRA has recommended a set of steps the government of Niger should take. These include:

i) identify and analyse existing satellite data maps in the public domain

ii) identify and select areas of great interest in the country from the satellite data maps

iii) install and maintain monitoring stations in the selected areas

iv) compare new data with existing satellite data and refresh the calculation models

v) build a national inventory of renewable energy resources.

CNES could play a pivotal role as the data centre, a role it has played in the past before the programme was discontinued. Re-engaging CNES in this role would allow it to build the required human and technical capacity to undertake regular renewable energy assessments. This would be both on behalf of the government and other clients. If this does not work out, Niger has other options to consider. It could, for instance, engage IRENA and/or other partners to support its long-awaited solar and wind assessment programme.

IMPORTANCE OF A NATIONAL RENEWABLE ENERGY POLICY

Broadening energy access is a central national development objective in Niger. At present, less than 25% of the population enjoys access to electricity, and the picture in rural areas is less than 5%. Generation of electricity through renewables has long been viewed as an important way to close this gap. However, the focus on the renewables contribution to the grid has only emerged because new technologies are beginning to compete with conventional power generation. To this end, an energy policy is needed to embrace renewables as part of a longer-term energy vision. It requires a systematic roadmap for delivery supported by research and financial support.

Policy statements need to be translated into concrete action. Policy makers in Niger widely acknowledge the important role renewables can play in developing the power sector. Solar and wind are being promoted as reliable energy sources that can contribute to reducing dependence vis-à-vis imported electricity from Nigeria. A number of possibilities are being considered such as the 20 MW solar project near Niamey and a 5 MW PV plant in Zinder funded by an Indian loan. However, these do not give the impression they are part of a programme of action, moving beyond ad hoc projects.

Niger has been using auctions to select IPPs to provide power to the grid at competitive prices. Although these have for the most part been conventional (fossil fuel) generators, the country can capitalise on this experience to design renewable energy auctions supporting large-scale renewables deployment. Renewable energy auctions have already become a popular policy instrument in some countries. They help achieve large-scale deployment in a cost-efficient and regulated manner and allow price discovery of renewable energy based electricity due to the inherent price competition (IRENA, 2013c). Policy makers designing auctions should investigate the pros and cons of each type and determine the most appropriate for the country (sealed bid auctions, reverse clock auctions and hybrid auctions). They should also clearly determine the capacity to be deployed and the numbers of bid rounds to be conducted. This has an impact on the scale of competition. They also need to streamline and create clear, transparent administrative procedures for all bidders. Finally, they should provide guarantees and penalties to minimise risks including underbidding, delays and completion failure (*Ibid*).

LONG-TERM PLANNING

Work is about to begin on a master plan for the production and transmission of electricity, with the assistance of the World Bank. The principal objective of the master plan is to define short, medium and long-term investment priorities (2013-2035) for developing the power sector. This exercise offers a real opportunity for the architects of the master plan to integrate renewable energy into short, medium and long-term plans. This is likely to stimulate investment interest and acts as a basis for developing a portfolio of bankable projects. Meaningful integration of renewables into the plan would be useful to the private sector and also strengthen Niger's case for support from development partners.

SETTING RENEWABLE ENERGY TARGETS

The current strategy has set the objective of 10% renewables (excluding biomass) in the national energy mix by 2020. However, there are no specific guidelines or roadmap for reaching this target. This needs to be rectified to provide sufficient substance to these targets for the realisation of this goal. The RRA makes clear that the vision set out by the energy policy, and indeed the broader development policy of the country, needs to be complemented by concrete studies and analysis. These show how these targets would be achieved, who they will reach and what the cost implications are likely to be. The master planners should consider incorporating these requirements, since the RRA has demonstrated that they have strong political acceptance.

ENABLING ENVIRONMENT

Although Niger's power generation sector was opened to IPPs, renewable power projects have not come forward. The development and expansion of the country's renewable energy market partly depends on the creation of a favourable legal and regulatory framework. This would, among other things, reduce technical, legal and administrative barriers while increasing private sector confidence. An overarching renewable energy law would create the right conditions. It should provide guaranteed access to the grid and priority dispatch of renewable electricity generation. These are currently lacking in the grid code. Furthermore, the development of a standardised and bankable PPA would greatly support the evolution of renewable energy auctioning. Transaction costs due to lengthy permitting and administrative procedures could be greatly reduced by setting up a one-stop shop for the private sector when dealing with renewable energy projects. Niger needs to create a specialised office in charge of PPAs. This would define a framework for getting PPP contracts up and running. As the office in charge of the PPP has expressed the desire to promote solar power investment, the renewable energy law could mandate it to become the permitting and licensing structure for all renewable energy projects. It could also develop a bankable PPA model that would cut down on negotiations with private sector. A model of this kind could open the door to self-producers and IPPs wishing to feed their electricity into the grid. It could also let in producers who wish to collaborate with utilities to hybridise existing fossil fuel generators.

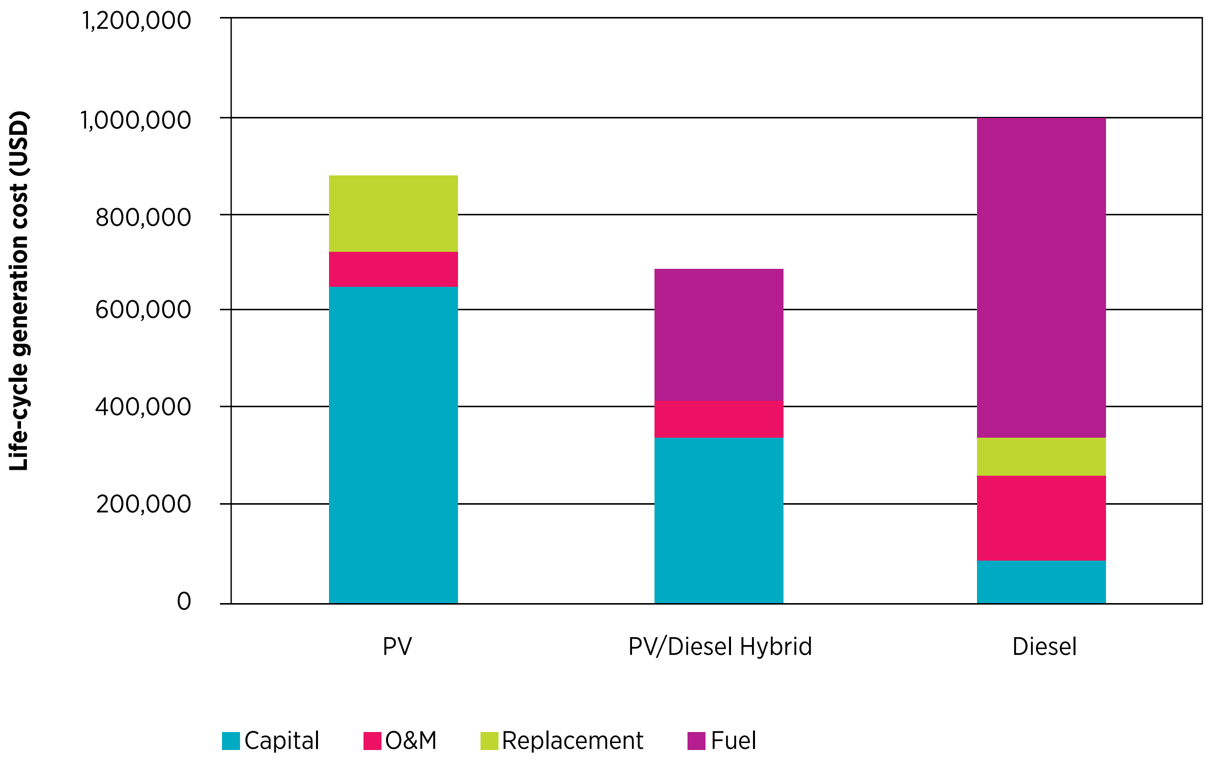
OFF-GRID RENEWABLE ENERGY OPTIONS

The Nigerien government considers energy a cross-cutting challenge, given the heavy reliance on traditional biomass using unsustainable appliances, increasing power demand for economic transformation and less than 2% rural energy access. Grid extension has been traditionally viewed as a 'silver bullet' for universal electricity access. However, it is increasingly becoming clear that the grid pathway on its own has limitations. High population dispersal, small loads and low load densities across large countries such as Niger are some of the limiting factors. Extending transmission

Table 5
PV installed capacity in 2013

	Installed Power (kWp)
CSI*	199.15
Lighting in schools	69.85
Pumping	913.00
Community radios	41.00
Telecommunications	2,772.33
Administrative & cultural centre	7.61
Fan for drying	3.46
Private Installations	14.63
Public lighting	21.16
TOTAL	4,042.19

Figure 16
Life-cycle cost comparison of PV, hybrid and diesel systems



lines to remote areas in Niger at a cost of USD 20,000-120,000/km will be financially prohibitive. Different small-scale renewable energy technologies like solar PV, wind energy and biomass systems are commercially maturing, along with new and innovative service delivery mechanisms. This means off-grid electrification has emerged as a viable alternative for rural electricity access.

There is considerable experience of off-grid PV electrification, water pumping and solar water heating systems in Niger. Each of these will be explored below.

OFF-GRID PV ELECTRICITY

The main decentralised renewable energy system being promoted in Niger for rural electricity is solar PV. It has been employed since the 1970s for a variety of end uses: water services (village water solar/wind pumping), education (lighting), health (lighting and refrigeration), telecommunications, agriculture and livestock. As of 2013, installed PV capacity for off-grid services amounted to over 4,000 kW (Table 5). Most of these are installed by government agencies, community-based organisations, telecommunication companies and NGOs.

There is considerable scope for deploying PV for rural electrification in Niger. Depending on the load characteristics and resource availability, this could take the form of stand-alone PV, mini-grids or hybrid PV-diesel systems. The stand-alone systems are generally suitable for small loads whereas the other two are generally for meeting larger loads at community scale. Such schemes are vital for rural productivity as they provide continuous electricity. They sometimes combine two or more different kinds of technologies for generating and distributing electricity to a range of consumer types through an independent grid. Combining different technologies with different energy sources means the comparative advantage of each technology is exploited.

For example, using renewable energy alongside a genset has proved to be the least cost option in many rural communities. This is because the benefits of each technology can be mutually complementary. A cost simulation was carried out for a typical village around Ayorou in Niger with a daily load of 585 kWh to meet a variety of end uses. These included community lighting, water pumps, lighting for homes, schools and clinics, and power for small businesses. Three options were evaluated[4]: PV grid (with battery storage) as well as diesel and hybrid (PV and diesel), using present Nigerien component and fuel prices. The life cycle cost result showed that both PV and the hybrid options compare favourably against the diesel option (Figure 16). This is true even at a low diesel price of USD 0.75 per litre (l).

Two observations can be made from the life cycle cost comparison. Firstly, the distribution of costs for the diesel option shows that 60% of total costs are in the operating costs (mainly fuel costs). For the PV option, on the other hand, over 75% of total costs are capital costs. Clearly, this has major implications for rural communities in acquiring finance for PV systems. It brings all the more urgency to new business models, sound policy development and supportive institutions. For the diesel option, the risk is put off to a time when rising or falling prices could expose the plant to changes beyond user community control. There is little resilience and stability in the system.

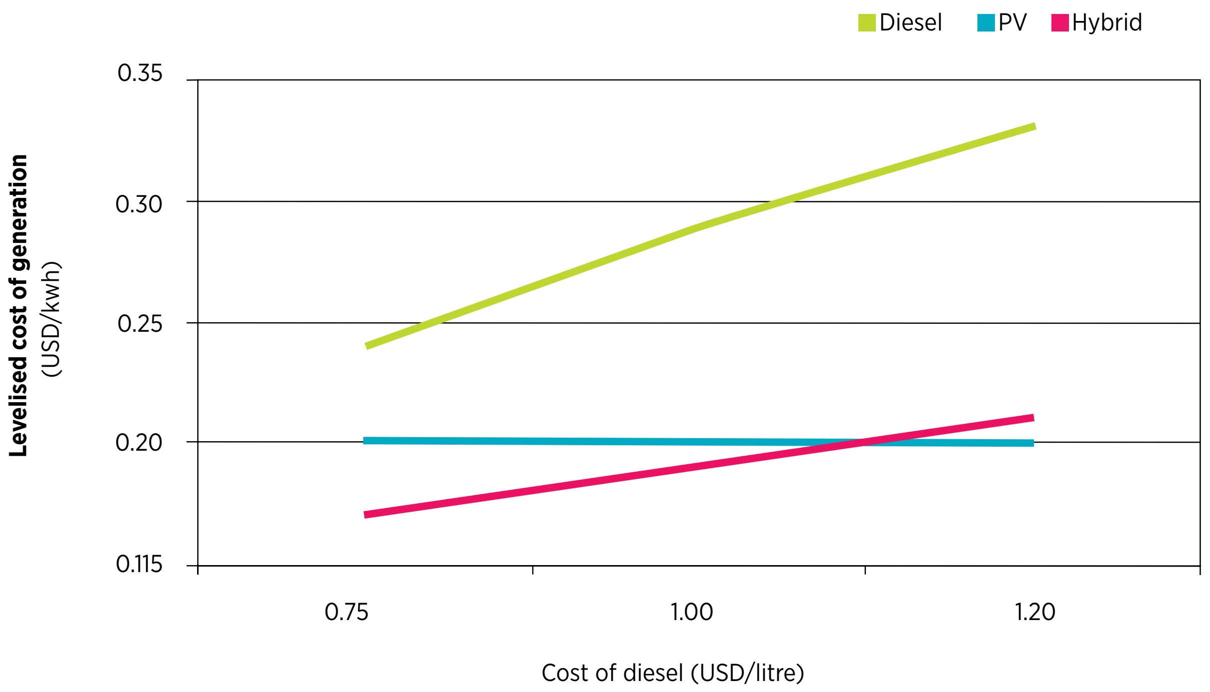
The second interesting observation relates to the hybrid system. This combines the best features of the two options. On the one hand, the reduced size of the PV system implies lower upfront costs. On the other, reduced diesel consumption means lower system vulnerability. In addition, the hybrid option (without storage) performs better. It has a levelised cost of USD 0.17/kWh against USD 0.20/kWh and USD 0.24/kWh for the PV and diesel options respectively.

It is worth noting here that the cost of diesel for electrification at USD 0.75/litre is below the pump selling price in Niger (USD 1.076) and the African average. This is at about USD 1.20/litre (World Bank, 2013c). An analysis against diesel costs shows that if prices increase in line with the selling price and average African levels, the levelised cost of generation using diesel rises sharply. However, the likely changes are relatively smooth and therefore easier to manage and adapt (figure 17). Of course, PV prices are also falling rapidly, and if further reductions are experienced in the market, the cost of PV generation only becomes more attractive. The government's import tariff at 52% will need to be reviewed so that Niger can fully benefit from global price changes.

Important new players are also entering the PV market, and their involvement and reach could be beneficial. Telecommunications companies such as Airtel and Orange fall into this category. In order to reduce their oil bill and improve the reliability of services, both Airtel and

4 Assumptions: capital cost = USD 3,200/kW for the PV module, battery size = 200/kW replaced every 8 years, inverter cost = USD 0.10/Wp replaced every 10 years, annual O&M cost = USD 20/kW, genset cost = USD 700/kW, installation cost for middle-sized genset = USD 30,000, O&M = USD 0.10/kW replaced every 5 years; fuel cost = USD 0.75/l, project time = 20 years; inflation = 2%, discount rate =12%.

Figure 17
Levelised cost against rising diesel prices



Orange are investing in solar PV to power their sites off the mains. By 2011, Airtel had equipped its 170 sites with PV; each site consisted of 36 panels (185 Wp each) for a system size of 6.7 kW per site. Airtel has thus far installed a total of 1.132 MW PV capacity. Prior to this initiative, all these sites used diesel and each had a monthly consumption of 1,500 litres. This amounted to 18,000 litres p.a. Migration to solar PV enables Airtel to save USD 16,700 per site or USD 2.84m p.a. The cost of the equipment amounts to USD 100,000 per site, so there is a payback period of about 5.5 years.

Orange started making a similar move in 2009. Currently, 250 sites located in remote areas are powered by solar PV with an installed capacity of 11 kW per site. The cost of the equipment by site is about USD 90,000 and replaces 600 litres of diesel consumption per month. Savings amount to USD 6,600 per site p.a. or about USD 1.7m for all 250 sites. The company's target is to reach 25% solar PV penetration in its overall energy consumption. The emergence of these powerful commercial players in the PV market indicates that the technology is reliable and low cost for generating electricity. It could go some way to helping the PV sector achieve some degree of visibility and credibility. They can also be useful partners in communicating the technology as a serious, mature alternative to be taken seriously by policy makers and the general public.

OFF-GRID WIND POWER

Wind power for rural electrification using stand-alone and mini-grid delivery systems has come a long way. Though this technology is not new, the learning curve in turbine and control technologies over the past two decades has been significant. As indicated in section 2, the favourable wind regime across Niger can provide much needed power for rural communities, especially in the northern part of the country. However, work needs to be done to improve wind intelligence for energy resource assessments. It is also important to recognise that Niger's experience is limited to a few cases of wind pumping. Wind energy for electrification is a new area for Niger. However, it could be significant if the country is able to prepare the ground for investment.

Using available data from Agadez (a northern urban area), a simple simulation was carried out to assess the potential that wind could play in off-grid electrification. The study looked at the cost involved to install a wind generator capable of delivering 1,000 kWh per day to a rural community with multiple loads. The study also looked different price scenarios (*i.e.* USD 2,000/kW and USD 3,000/kW) for a hybrid system combined with diesel over a 20-year timespan[5]. As illustrated in figure 18, the analysis demonstrated two points.

Firstly, wind systems can potentially be cost-effective options. Levelised costs are USD 0.17-0.23/kWh. However, a significant upfront cost is incurred, and financing it will remain a challenge. Secondly, the analysis showed that the hybrid system, with a levelised cost of USD 0.25/kWh, did not perform as well as wind systems on its own. The northern regions tend to enjoy fairly good windy conditions and thus hybrid systems may not offer better answers for rural electrification. Yet the hybrid option provides the important advantage of lower initial cost compared to a single resource renewable system. It is worth noting that the hybrid option may offer other advantages in regions where the wind is not as strong or with a high degree of intermittency. This is because it would improve power output stability.

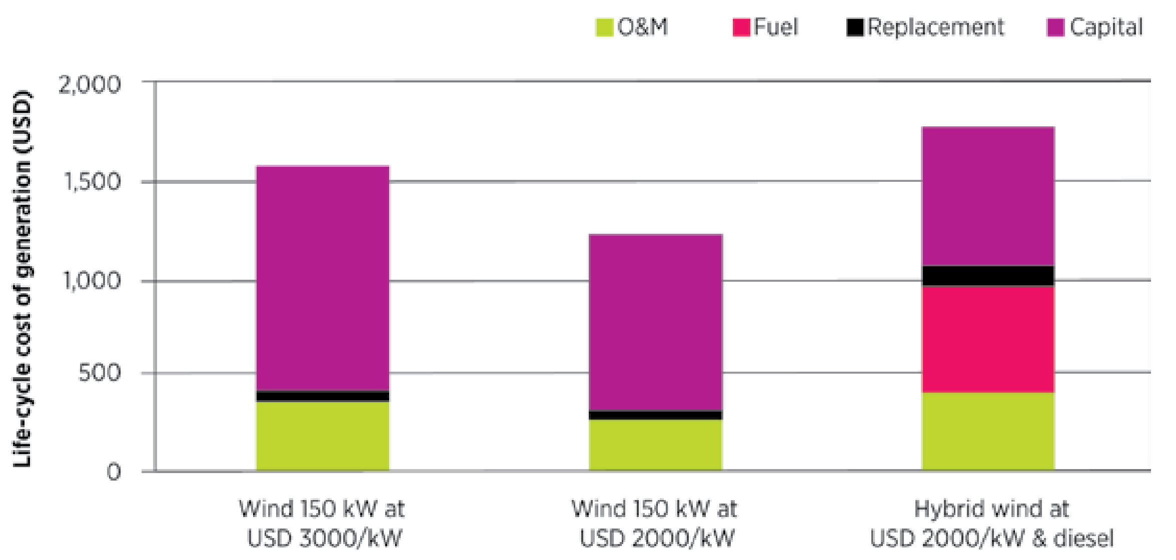
OFF-GRID PV WATER PUMPING

Access to an improved water source refers to the percentage of the population with least 20 litres per person per day within 1 km of the dwelling from an improved source. This could be a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. According to African Ministers' Council On Water (AMCOW) (2011), Niger is still a long way from achieving the MDG targets for water supply. At present, water coverage extends to 48% of the population - 39% of the rural population and 96% of the urban population. This leaves a water-related MDG target gap of 32%. Niger has an estimated 2.5bn m^3 of underground renewable water, but only 20% is currently exploited, according to the United Nations Children's Fund. Hence, Niger has the potential to achieve universal access to water and sanitation, but financial resources are limited and institutions to help deliver this goal are weak.

Hand pumps, diesel generators, PV systems and some wind pumps are in use. There are ongoing and upcoming projects in Niger to improve access to rural water services, and development partners and international institutions provide significant support to the government's efforts. The government also recognises that part of the water challenge is rooted in the lack of energy technologies for pumping water to the end-users. Hence, high water coverage requires the introduction of new technologies and improvement of existing ones. As PV technologies are coming down in price, PV pumps are rapidly becoming more attractive than the traditional power sources such as diesel and gasoline driven systems. A life-cycle cost analysis conducted for

5 Assumptions: Capital range = USD 2,000-3,000/kW, annual O&M cost = USD 15/kW, inverter and other replacements at 8 and 15 yrs = USD 0.40/Wp, genset cost = USD 700/kW, installation cost for middle-sized genset = USD 30,000, O&M = USD 0.10/kW replaced every 5 years, fuel cost = USD 0.75/l, project time = 20 years, inflation = 2%; discount rate = 12%.

Figure 18
Levelised cost against rising diesel prices



Niger using country-specific data showed that over the longer term PV performs better than diesel for the same service (Figure 19). It also provides a more stable water supply[6]. The high initial cost of the PV system compared to the diesel system is moderated when taking a longer-term perspective. This is because the running cost of the diesel system places a higher cost burden on users over the longer term. The levelised cost for the two PV system sizes indicated was USD 0.12-0.14/m3 of water delivered, while the diesel yielded USD 0.17-0.20/m^3. This illustrates how emerging trends in price and technology favours PV over diesel. This is likely to continue.

A large percentage of Niger's population works in subsistence farming, relying entirely on rainfall and therefore vulnerable to high climate variability. This form of agricultural practice is unsustainable as farmers are falling victim to recurrent droughts. Thus, the need to provide water services is not limited to the household sector. It also extends to the agricultural sector, which the government is eager to support to boost food security as well as diversify its trade. Thus the need for improved irrigation services will assume greater importance. Affordable and reliable energy for pumping water for irrigation could play a central role in improving the earnings of smallholders and transform rural economies.

SOLAR WATER HEATING

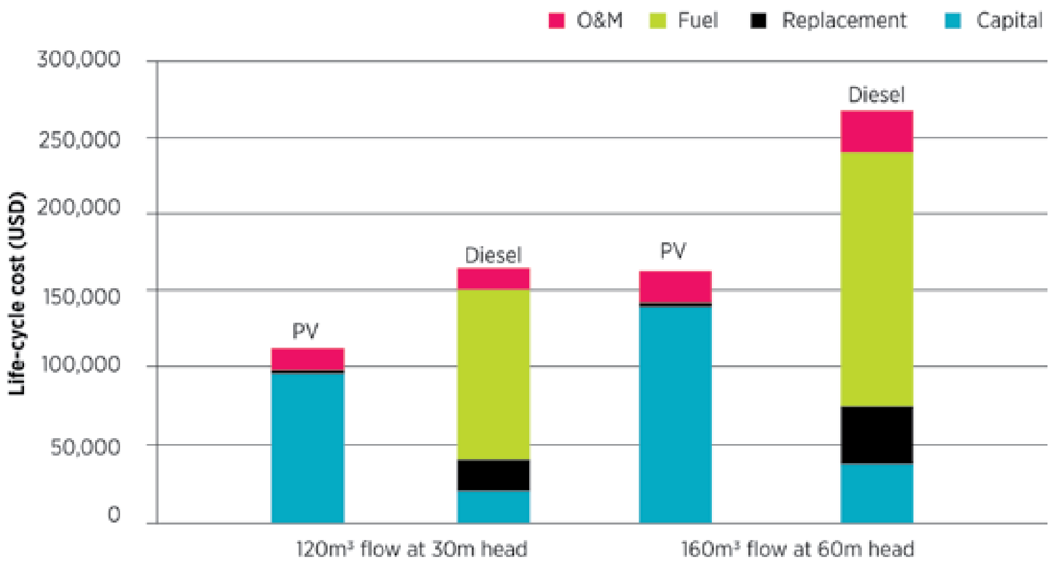
Solar water heating has a long history in Niger. CNES was a central player, installing some 508 solar water heaters in 1976-1997, with capacities of 200-1,000 litres per day.

Most of these were installed in homes. However, this programme could not be sustained as the local currency went through a devaluation for imported components. Maintenance quality and cost control

6 Assumptions: PV system cost = USD 96,000 for smaller system (120m3 @ 30m) and USD 140,000 for larger system (160m3 @60m); pump replacement every 7 years @USD 4,000/unit, annual O&M cost = USD 0.02 of capital cost, genset cost = USD 9,800 for smaller system (120m3 @ 30m) and USD 27,000 for larger system replaced every 5 years, fuel cost = USD 0.75/l, project time = 20 years, inflation = 2%, discount rate =12%.

Figure 19

Life-cycle cost comparison between PV and diesel for water pumping at different depths and flows



were other factors that led to the demise of this programme. However, there was never any doubt that solar water heating systems can contribute significant energy savings for businesses and large institutions. The technology is mature, simple to repair and replicate, and heats water cost-effectively.

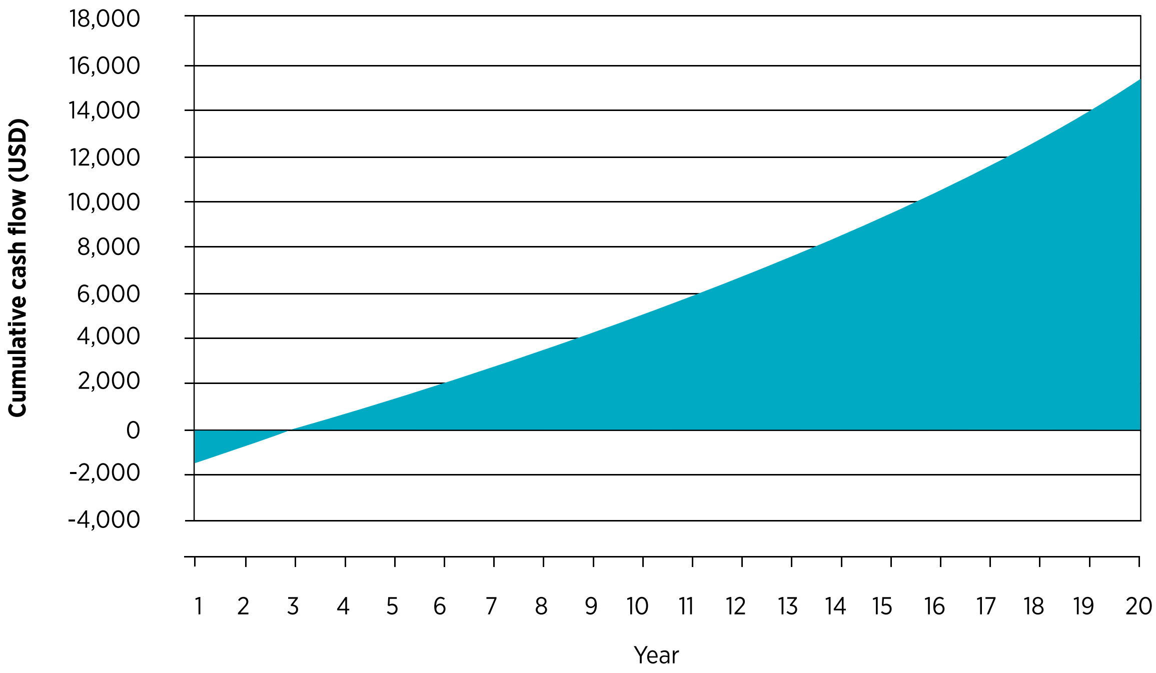
The CNES programme was motivated by the fact that major hot water users could make significant financial savings by switching from diesel and electric water heating to solar heating systems. The most common type of solar water heater in Niger incorporates a $2m^2$ flat-plate solar collector and a 200 litre storage tank. It has a payback period of less than 2-3 years.

Based on these experiences, the viability of solar water heaters in the resource and economic context of Niger is convincing. A domestically produced (refurbished) solar heater with a typical 200 litre load and capital cost of about USD 1,000 has a payback period of under three years. This is for a system with a 20-year lifetime (Figure 20). Imported systems, which fetch USD 2,000 in the Nigerien market, pay back within less than four years. Hence, continuing to rely on grid electricity or diesel means more expensive water heating services. A shift towards solar systems means grid electricity could be freed up for other end uses or could satisfy suppressed demand in various sectors.

The CNES experience indicates a robust national promotions programme and skills development is critical to mainstreaming the technology. Capacity development is not a single intervention but a process that needs to envisage the long-term picture and be integrated into a broader innovation policy. This requires long-term planning and investment. It has to be framed into a comprehensive policy framework stimulating the emergence of new regulations. These have a specific mandate for different sectors (industrial, tourism and households) to install solar water heaters.

Figure 20

Solar water heater: Cumulative cash flow and payback period



RECOMMENDATIONS

The RRA has highlighted that the contribution of off-grid renewable systems to the energy mix in Niger is growing. It is also important to note that decentralised renewable energy development in Niger will not provide all the answers to universal access. However, given the dispersed population and type of economic activities, decentralised systems are part of the solution. Some specific findings from the RRA relevant to decentralised energy systems in Niger are outlined below.

IMPORTANCE OF A COMPREHENSIVE ENERGY POLICY FOR RURAL ENERGY

Niger needs a comprehensive energy policy that puts the needs and demands of rural communities centre stage and provides clear guidance on how to make progress. The policy should also be explicit that rural communities need a bottom-up strategy due to their low energy demand and scattered nature. This would bring together local development plans and information on resources, finance and skills in order to design a coordinated plan of action sensitive to location.

The RRA underscored that institutional and financial support efforts need to clearly distinguish not only between grid-based and off-grid but also between urban and rural electrification. Rural electrification should centre around two main implementation axes:

i) promotion of the private sector as a major player in implementing rural electrification programmes and creation of the enabling environment for the private sector to flourish

ii) introduction of rural energy service concessions that would allow an entity (private sector, NGO, community-based organisation etc.) to exclusively serve one or more defined areas under a concessionary agreement.

IMPROVE THE REGULATORY ENVIRONMENT FOR RURAL ELECTRIFICATION

An organisation must be established to manage, develop and implement a rural renewable electrification strategy and programme. It must also create the enabling environment for the private sector, ensure effective implementation and maintain quality assurance.

This organisation needs to be a legal entity and could fill several important gaps. For example, it could:

i) stimulate the supply and demand of rural electrification services through communications with potential partners (both public and private);

ii) guide operators towards lowest cost innovative solutions;

iii) establish the annual rural electrification programme and ensure effective follow-up;

iv) manage relationships with donors and potential investors;

v) ensure effective implementation in accordance to enforced norms and standards.

This organisation must aim to optimise the use of resources for rural electrification and maintain mechanisms already in place through important principles. These include equity, technology neutrality, high technical standards, poverty eradication and the protection of investor interests. Furthermore, provision within the renewable energy law should be made to amend the country's current tax policies on renewable energy technologies. This can be done by reducing the current import duties and VAT that affect their competitiveness.

RAISE DOMESTIC FUNDS FOR RURAL ELECTRIFICATION

The rural electrification challenge is enormous and will require both external and domestic finance. The RRA drew attention to the importance of raising domestic finance to calibrate internal investment with wider development goals. It asserted that rural electrification should feature prominently within such a framework. Mozambique's FUNAE Fund is a case in point. Niger could consider following this example to raise funding from taxes collected from mineral and petroleum exploitation to promote rural electrification. This could include:

i) taxes on electricity concessions

ii) a rural electrification levy on electricity sold to end-users

iii) taxes on bulk electricity consumers

iv) taxes on oil and mining exploration

v) taxes related to the transport and marketing of petroleum products

vi) taxes on commercial licences

vii) annual budgetary allocation by the state

viii) funding obtained from development partners

ix) personal contributions from the operators and other donors.

ENERGY MASTER PLAN

Part of the difficulty of appreciating Niger's deep energy crisis is explained by almost non-existent national planning on current and future energy demands. The forthcoming master plan is welcome and long overdue. It needs to help define short, medium and long-term access targets supported by technology-specific targets within predefined geographic areas for off-grid electrification. The limited energy resource assessments already available show that Niger enjoys sufficient resources to make major progress in meeting energy access targets, especially solar and to some degree wind. Renewable energy options like solar and wind should feature prominently in the master plan.

IMPROVE R&D: REVITALISE CNES

Niger will rely on sourcing technologies from abroad for the foreseeable future. This will need to continue in tandem with efforts to upgrade innovation systems that will support domestic technology adoption and development. However, cheap solar panels and components are entering the Nigerien market from neighbouring countries, with no institutionalised quality assurance and standard schemes. This does not help the reputation of these technologies, still in their early stages, when systems break down. CNES could play an important role in supporting the development of renewable energy technology standards and certification schemes for installers as part of the industry's revitalisation. This increases end-user confidence in the technologies deployed. A programme of this kind would have the additional benefit of creating new skilled jobs throughout the value chain from small distributors to installers, maintainers and end-users.

LOAD SHEDDING: AN OPPORTUNITY FOR RENEWABLES

Power cuts are costly and weigh heavily on the economy, both in Niger and across the whole of Africa. The widespread response from wealthier households and businesses is to find alternative solutions – i.e. gensets. There has been a noticeable increase in the sales of gensets in Niger since 2010 due to recurrent load shedding and generation problems in Nigeria. However, there are no official data on the number of gensets in Nigerien households. This is a problem from the perspective of national energy planning. Lack of data on this suppressed demand makes it difficult to plan. But this presents an opportunity for PV systems because load shedding difficulties are deep-seated structural problems and unlikely to be resolved immediately. Many in Niamey are already using solar to cope with rolling blackouts. However, in most of these cases this is a form of crisis management rather than a more permanent solution to energy dilemmas. The electricity code (article 7) allows one or more natural persons or corporate entities to build and operate private electrical installations to the satisfaction of their own needs. Nigerien policy makers could encourage individuals and businesses to become self-producers. This would solve the user's immediate energy problems and help boost the renewable energy market. This market is under-estimated, both for its size and its potential as an important driver for scaling up renewables.

ASSESS THE ECONOMICS OF A RANGE OF TECHNOLOGIES

There is growing experience of a variety of technologies in Niger. It is important to document and assess the cost of single

Diesel power plant in Niamey
Source: www.nigelec.ne

and hybrid technologies in the different regions. This provides a dynamic data system that assembles data on the range of technologies and their performance under different conditions. The diesel based mini-grid operated by NIGELEC offers a compelling case for hybridisation with RE sources. Solar irradiation is abundant throughout the country. Detailed feasibility studies on hybridising the diesel mini-grids with solar PV would, therefore, help demonstrate the economics of these systems to potential investors.

PROVIDE SOFT LOAN SCHEMES OR OTHER CREDIT LINE FACILITIES FOR SOLAR PV

Despite their comparative advantage, decentralised renewables are not suitable for conventional financial mechanisms due to their high transaction costs. Rural communities with little disposable income hardly feature as natural clients for conventional financial institutions. Soft loans can be attractive when a small sum is paid as a down payment of the total price and the rest paid over a number of years. With bank interest rates at 13% in Niger, households and businesses are unlikely to take out loans to meet renewable energy costs. However, grants from multilateral agencies or donors could be ring-fenced to mobilise soft loan schemes for household or community electrification. While this cannot be considered a long-term solution to the challenge of raising funding, it could provide energy for social development needs. It may also serve to stimulate the renewables market in rural areas.

CAPACITY DEVELOPMENT AND MOBILISATION

Niger suffers from capacity deficit in the energy sector in general. With the establishment of CNES as long ago as the 1960s, it was one of the first movers in renewable energy. However, that was not sustained, though there is some capacity to build on in PV and water heating applications. The RRA has identified capacity development

Niger River near Niamey
Photo: IRENA/H. Lucas

for planning, financing and implementing off-grid and on-grid programmes as a top policy priority. Only then will the promise of renewable energy development be fulfilled

BIOMASS FOR COOKING AND HEATING

Energy for cooking is a major preoccupation in Niger. It is one aspect of the energy picture in Niger and other parts of the Sahel that has confounded experts. The solutions to problems associated with biomass, such as indoor air pollution and the extensive time and energy needed for its collection, appear straightforward. Yet most studies indicate that biomass energy (or fuel wood) will remain an important source of household energy. This is due to a whole range of obstacles. For instance, LPG and other petroleum fuels are not affordable to many people, other energy sources are remote, non-biomass appliances have a high investment cost, the technology is unsuitable for local conditions.

There have been significant recent developments that may transform the cooking and heating landscape. This is the emergence of important players like the Global Alliance for Clean Cookstoves (GACC). This is beginning to mobilise global and national institutions and resources to solve this problem. At the same time, a new generation of advanced and more effective biomass cookstoves is showing signs of commercial viability. Meanwhile, new business models are coming through that will generate new sales.

These developments show plenty of promise, but the path to large-scale adoption faces many barriers. These include institutional, technical, consumer, finance and national development priorities. These all exist in Niger to a varying degree depending on the social and economic group.

BIOGAS AS A POTENTIAL COOKING RESOURCE

Numerous discussions and initiatives exist in Niger involving improved cookstoves, sustainable wood harvesting and biofuels. However, the RRA focused on biogas, largely because there is positive experience in this technology, and biogas offers benefits beyond cooking.

Nigerien experience in biogas dates as far back as 1980 under a project by INRAN. Ten facilities were installed by INRAN in collaboration with the French organisation GERDAT. Another five were installed through Chinese cooperation to produce biogas for cooking, lighting and electricity in combination with diesel fuel for electricity production. These facilities were abandoned by the beneficiaries due to lack of maintenance. The failures observed were of a technical and socio-economic nature.

A feasibility study was carried out in Niger to set up a national biogas programme. This planned to establish 15,000 rural biodigesters over five years for a total of USD 3.45m around the river Niger, rich in water resources. The following financial arrangement was planned: a grant of 40% from the Dutch Cooperation, 55% from recipients who had to be engaged with a microfinance institution and 5% from the state. Unfortunately this programme failed to materialise because the microfinance institutions did not want to engage in the energy sector. They asked for a guarantee from the state to back the risk if their investment did not yield the expected returns.

In trying to understand the potential of biogas in rural areas, it is worth analysing the economic impacts by calculating and comparing the cooking costs. The analysis below makes a comparison of the costs of various stove types where the value of the fuel used is calculated first. The comparison is between collected fuelwood and biogas. In the case of wood, the average fuel collection time per month is multiplied by the national wage rate using a per capita income estimate for Niger. World Bank figures of USD 160 p.a. per capita assuming 40 working hours per week produce a maximum labour rate of USD 0.08/hour. The number of hours spent collecting wood for traditional stoves amounts to USD 41.6 p.a. and USD 20.8 p.a. for the new generation of stoves. Stove costs are estimated by dividing the stove price by its average lifetime. The biogas cost is estimated at USD 916 for a 6m^3 plant (ten-year lifetime) while costs for traditional stoves are USD 6 (three-year lifetime). New generation stoves are assumed to cost USD 25 (five-year lifetime). Thus, the total cooking cost is worked out by adding together the fuel cash cost, the value of fuel collection time and the stove costs.

Using the above assumptions, a profile of comparative cooking costs is constructed. These estimates suggest the new stoves perform best at USD 0.17/kg of wood equivalent, traditional stoves at USD 0.28/kg and biogas at USD 0.64/kg of wood equivalent. These estimates are for illustrative purposes to highlight the cost of labour (mainly women and children) for fuelwood collection as the defining variable in this comparison.

But there is a caveat here. When other aspects such as health impacts and environmental externalities are considered, the picture is likely to look different. Furthermore, if the national wage triples to USD 480 — still very low — and wood collection hours remain constant, the cost comparison shifts in favour of biogas. This suggests that the higher cost of labour increases the economic cost of using collected biomass beyond the biogas-biomass break-even point. This rather rough analysis indicates that biogas could have a wider appeal in future. It could therefore be worth investing in a robust biogas programme as in parts of Asia. This would also bring down the cost of biogas plants as they move from their current niche status into the mass market. This has occurred in various Asian countries such as India, Nepal and China.

Other biofuel production possibilities mainly involve crop waste. This includes crops specifically intended for human consumption grown during the winter season (millet, sorghum, maize, rice, cowpea) and cash crops (peanut, cotton, sesame, sugarcane, moringa). It also includes forest species that grow naturally such as jatrophacurcas, neem and balanites. For the moment there is no biodiesel production in Niger, and the different oils such as peanut oil and shea butter that can be used to generate biodiesel are mainly used for food. There is little experience in Niger of using crops like these for bioenergy.

RECOMMENDATIONS

During the RRA, the discussion focused mainly on biogas and improved cookstoves. A number of opportunities and problems were identified that are specific to the biomass sector. They include:

i) The absence of a clearly defined policy on the use of biomass, including biogas

ii) Lack of institutional coordination and collaboration between financial institutions and other stakeholders

iii) Importance of standards for biogas and other biomass fuel types. Some specific interventions areas were identified during the RRA.

EMPHASIS ON BIOGAS

This biomass sector has delivered excellent results and supported rural development in various parts of Asia. In Africa, Rwanda now has a promising programme. The National Biogas Programme of Rwanda has reached an important milestone in that it has successfully set up a commercially viable biogas industry.

This will contribute to the well-being of the country's population while reducing pressure on natural resources. The RRA recognised the potential of biogas in Niger, and the Niger biogas feasibility study has been conclusive. There is good reason to develop a business model that would bring microfinance institutions to the negotiating table.

CRITICAL NEED FOR FINANCE

Nepal is an excellent example of how multiple innovation nodes are critical to successful biogas programmes. The central elements of this programme have been innovation in financial engineering as well as the judicious distribution of grants to beneficiaries. Furthermore, the Nepal programme successfully motivated the external and domestic banks to sculpt a well-structured loan and grant programme for small-scale farmers and medium-sized rural enterprises.

Niger could emulate the Nepalese programme. However, bringing together stakeholders such as these requires lobbying by potential project developers.

OPPORTUNITIES AND CONSTRAINTS FOR SCALING UP RENEWABLE ENERGY DEPLOYMENT

POLICY STAGNATION

Policies need to be dynamic because they often have side effects or unintended consequences. Part of the problem in Niger, and indeed in much of Africa, is that energy policies are a static list of goals or laws. They do not undergo periodic reviews to evaluate their effectiveness and help guide operational decisions. Policy tends to evolve with changing contexts, so formal policy needs to be periodically adjusted. The government of Niger should carry out a review of existing policies and strategies and revise them.

They need to be compatible with the country's development goal of supporting social welfare, and enhance income-generating activities. The renewable energy law and master plan are important steps to embedding energy service provision into development needs. After the formal presentation of the renewable energy law, dialogue with the whole range of stakeholders should be maintained.

TRACK RECORD IN AUCTIONS

Niger has been using auctions as an instrument to select IPPs for providing conventional power at competitive prices to the grid. As far as renewable power generation is concerned, it can capitalise on this experience to design renewable energy auctions. This could be applied to both large-scale grid-connected power plants but also for hybridising bundles of decentralised power plants. Policy makers and executives should be equipped with the knowledge of the intricacies of designing renewable energy auctions and ensure they are successfully conducted.

WAPP EFFECT

West African regional power development work is progressing, and a number of transmission and rehabilitation projects have already been completed. Niger is expected to benefit from power imports and exports as a way to stabilise its power sector and create greater supply reliability. Moreover, renewable energy technologies can play a major role in developing an integrated power pool. This is because their share in the region could reach 52% by 2030 if the cost of these technologies continues to fall and if fossil fuel prices remain volatile (IRENA, 2013a).

For low consumption countries such as Niger, this could represent a reduction in the long-run marginal cost (LRMC) of power by USD 0.02-0.07/kWh (Eberhard *et al.*, 2011). WAPP promises to usher in an era of cheaper and more secure power. That should be welcome, but cross-border power transmission will still require considerable investment, a high degree of collective ownership and coordination. This is new territory for public policy with limited precedence in Africa. Niger has mixed experiences of its electricity imports from Nigeria. The effect of an emerging highly interconnected power infrastructure on costs and reliability is uncertain. It is also important to consider the effect WAPP will have on rural areas, as most will continue to rely on decentralised systems. Further assessment will be needed to guide Nigerien policy makers on the benefits and costs of the WAPP interconnection system. They can then plan appropriately.

POLITICAL FRAGMENTATION

Energy supports development and therefore cuts across ministerial and sector boundaries. Policy makers face energy supply and cost challenges as they aim to deliver positive outcomes for their respective sectors. The fractured responsibilities within Niger's energy policy make the different government entities prone to turf battles. This indicates a lack of coordination among the departments involved. This tension is expected to rise with the discovery of oil and gas. There may be power struggles between those who see the transformative potential of renewables and those who supervise the fossil-fuel sector.

This calls for a comprehensive energy policy that places sector requirements within a coherent framework. It requires policy makers to appreciate that a mix of technologies at different scales is the foundation for healthy energy governance in Niger, and to act on that basis. Central to the success of any energy policy is getting the governance structure right. Government players need to be willing to be part of a wider inter-ministerial dialogue on energy matters and build appropriate institutions that deliver results on the ground.

Clearly, this will require some degree of policy experimentation and learning through doing. Ultimately, the success of the country's energy development mission will be judged by the quality of its results and scale of improvements in livelihoods. Renewable energy applications across Niger have been linked to excellent social development outcomes. The cost of renewables is at an all-time low, especially PV. If they are to support productive sectors in rural areas, stronger coordination between all stakeholders is required.

DECENTRALISATION

Experience in Niger demonstrates that off-grid energy systems can play a significant role in rural energy programmes. However, more work is needed to ensure that prices become competitive and affordable for which the range of pro-poor financing mechanisms can be tested and evaluated. The renewable energy law and master plan will have to come up with potential recommendations to bring costs down for both potential suppliers and end-users. They will need to consider the financial measures often necessary in the first stages of technology diffusion. At that point, there are few market players and the opportunities to develop economies of scale are limited. Furthermore, it is important to build an inventory of experiences in Niger in terms of the range of delivery mechanisms and business models. It is also important to assess how emerging regulatory frameworks could impact on mainstreaming decentralised renewable energy options.

UNIQUE KNOWLEDGE STORE

Energy knowledge generation of this kind could help develop a dynamic techno-economic assessment framework for decentralised electricity and heat system design. It could take materials sourcing, installation costs, available energy resources, energy storage options, design robustness and social acceptance into consideration. Building this store of knowledge would help Niger develop its energy strategy using informed and tailored technical and business models. These would be compatible with local resources, institutions and economic factors. Institutionalising energy knowledge in this way would give ample confidence to policy makers, social entrepreneurs and private sector players. This is because it would provide them with up-to-date information about various technologies in the context of Niger.

V. SUMMARY OF RECOMMENDED ACTIONS

The RRA process identified and recommended the action below. The six points, which apply to all the priority resource-service pairs, are not given in any order of importance. A list of action points from a rapid assessment is unlikely to be exhaustive. A more detailed list is contained in the Annex.

ACTION	STEPS
Develop national renewable energy policy and action plan	• Conduct thorough renewable energy resource assessment with ground measurements • Set up targets for different renewable energy applications • Include solar and wind in national generation and transmission master plan
Develop renewable energy law and devise support mechanisms	• Develop renewable energy law to establish legal, economic and institutional basis for renewable energy • Devise support mechanisms such as net metering, competitive bidding, and standardised bankable PPAs
Create institutional and regulatory framework to facilitate renewable energy deployment in rural areas	• Establish organisation in charge of rural electrification using latest renewable energy technologies • Set up funding mechanism to support renewable energy deployment (revolving funds, guarantee funds, credit lines, *etc*.)

Support energy component in the strategic PPP framework	• Develop appropriate PPP model for solar PV
Allow CNES to flourish as lead technical institution for renewable energy R&D	• Strengthen CNES capacity to conduct detailed wind and solar assessments across the country and build a comprehensive database • CNES to spearhead R&D, including standard development and quality control procedures for solar and wind equipment • Develop installer certification schemes and facilitate training
Create conditions for developing rural biogas industry	• Develop appropriate business model for biogas uptake for both domestic and productive use

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ANNEX: DETAILED DESCRIPTION OF RECOMMENDED ACTIONS

The RRA process identified and recommended the action below. It is not given in any order of priority, and the list of action points from a rapid assessment is unlikely to be exhaustive. This action could improve the Niger's readiness to scale up its renewables deployment. It is designed to be taken in the short- to medium-term, largely through decisions made by the Government of Niger.

Action 1: Develop a national Renewable Energy Policy and action plan

Action	Develop a national Renewable Energy Policy and action plan
Resource-Service Pair(s)	Centralised and decentralised grid electricity, all RE resources
Description	There is wide acknowledgement among policy makers in Niger about the important role renewables can play in the development of the power sector. The Ministry of Energy and Petroleum (MoEP) is to be responsible for developing a national renewable energy policy and action plan which will set up the guidelines for the broad utilisation of country RE potential mainly solar and wind being seen as reliable energy sources that can contribute to reducing dependence vis-à-vis imported electricity from Nigeria. While the National Centre for Solar Energy (CNES) is to play a pivotal role in serving as the data centre by conducting thorough assessment of solar and wind energy resources through ground measurements. MoEP will set up achievable targets for the existing RE resources based on the results of the assessment and coordinate with the High Commission for the Development of Niger Valley (HCDNV) and all relevant stakeholders the integration of renewables into the on-going master plan for power generation and transmission.
Stakeholders	MoEP, CNES, HCDNV, donors and all other stakeholders

Timing	End of 2014
Keys to success	The development of the policy will be backed up by the results of the renewable energy resources assessment. The effectiveness of the policy will depend on the results of the assessment as well as the extent to which it attracts investment interest, and a basis for the development of a portfolio of bankable projects.

Action 2: Develop a Renewable Energy law and supporting mechanisms

Action	Develop a Renewable Energy law and supporting mechanisms
Resource-Service Pair(s)	Centralised and decentralised grid electricity, all RE resources
Description	Niger's power generation sector although having been opened to IPPs has not attracted renewables based power generation projects to come forward. A precondition to the development and expansion of the country's renewable energy market is the creation of a favourable legal and regulatory framework that would among other reduce technical, legal and administrative barriers while increasing private sector confidence in the sector. The MoEP is to be responsible of coordinating the development of an overarching renewable energy law which will include provision for guaranteed access to the grid, priority dispatch of renewable based electricity generation which are currently missing in the grid code. Furthermore, the MoEP will consider in cooperation with all relevant stakeholders, the development of a standardised and bankable PPA for supporting the drafting of RE auctions.
Stakeholders	MoEP, NIGELEC, relevant stakeholders and potential investors (private companies, utilities and commercial banks).
Timing	Mid-2014
Keys to success	Engagement with organisations with similar experience in other countries and regions (*e.g.,* The Gambia, Ghana, Egypt)

Action 3: Create an institutional and regulatory framework to facilitate the deployment of renewable energy in rural areas

Action	Create an institutional and regulatory framework to facilitate the deployment of renewable energy in rural areas
Resource-Service Pair(s)	Decentralised electricity, all RE resources
Description	In Niger, rural electrification challenge is enormous, with less than 2% electricity access in rural areas, heavy reliance on traditional biomass using unsustainable appliances, and increasing demand for power to drive economic transformation. The MoEP is to trigger the establishment of a body in charge of developing and implementing a renewable energy based rural electrification strategy/programme as well as creating the enabling condition for private sector involvement and effective implementation of programmes and maintains quality assurance. This structure must aim to optimize the use of resources for rural electrification and sustain the mechanisms already in place through important principles such as equity, technological neutrality, high-levels of technical standards, poverty eradication, and the protection of the interests of investors. Furthermore, the MoEP in cooperation with relevant stakeholders will set up a resource mobilisation (both internal and external) framework for financing rural electrification. The rural electrification body will advocate for raising domestic finance in order to calibrate internal investment with the wider development goals, featuring the rural electrification prominently within such a framework.
Stakeholders	MoEP, Cabinet, National Assembly, donors and all other stakeholders.
Timing	End of 2014
Keys to success	Engagement with organisations with similar experience in other countries and regions (*e.g.,* Mozambique, Morocco)

Action 4: Support the energy component of the Public Private Partnership strategic framework

Action	Support the energy component of the Public Private Partnership strategic framework
Resource-Service Pair(s)	Centralised and decentralised grid electricity, all RE resources
Description	In Niger transaction costs created by long permitting and lengthy administrative procedures could be greatly reduced by setting up a one stop shop for the private sector to engage with when dealing with renewable energy projects. Recently the country has defined a framework to operationalis e public-private partnership (PPP) contracts by creating a specialized office in charge of the latter (CPPP). CPPP will be mandated to become the permitting and licensing structure for all renewable energy projects as well as developing a bankable PPA model that would reduce negotiation with private sector. Such a model could open the doors to self-producers, IPPs wishing to feed in their electricity into the grid as well as those who wish to collaborate in with utility to hybridize existing fossil fuel generation facilities.
Stakeholders	CPPP, MoEP, NIGELEC, ARM, and potential investors (private companies, utilities and commercial banks).
Timing	End of 2014
Keys to success	Engagement with organisations with similar experience in other countries and regions (*e.g.,* Morocco, Egypt)

Action 5: Enable the National Centre for Solar Energy (CNES) to fully play its role as the lead technical institution for renewable energy research and development

Action	Enable the National Centre for Solar Energy (CNES) to fully play its role as the lead technical institution for renewable energy research and development
Resource-Service Pair(s)	Centralised and decentralised grid electricity, all RE resources
Description	Niger rely on sourcing technologies from abroad and this will need to continue in parallel with efforts to upgrade innovation systems that will support domestic technology adoption and development. However, cheap solar panels and components are entering Nigerien market from neighbouring countries, with no institutionalised quality assurance and standard schemes which does not help the reputation of these technologies, still in the early stages of their being established, when systems breakdown. CNES will play an important role as part of its revitalisation in supporting the development of RETs standards and certification schemes for installers in order to increase end user confidence in the technologies deployed. Such a programme would have the co-benefit of creating new skilled jobs throughout the value chain starting with small distributors, installers, and maintainers to beneficiaries.
Stakeholders	MoEP, Cabinet, CNES, ARM, all other relevant stakeholders
Timing	Early 2015
Keys to success	Engagement of an RE expert with a good track record in research, improved staffing, donor assistance to equip the centre and ensure adequate continuous funding.

Action 6: Create conditions for the development of a rural biogas industry

Action	Create conditions for the development of a rural biogas industry
Resource-service Pair(s)	Biomass for cooking and heating.
Description	The experiences of Niger in biogas date as far back as 1980. However all biogas facilities have been abandoned by the beneficiaries due to lack of maintenance. The observed failures were technical and socio-economic. The country is endowed with good potential for biogas, and the feasibility study of the biogas Niger programme has been conclusive. There is good reason to believe in developing a "business model" that would bring the micro finance institutions to the negotiating table. The MEP, Ministry of Agriculture (MOA), Ministry of Health (MOH) and other relevant stakeholders will work on developing sound business model for setting up a commercially viable biogas sector to contribute to the well-being of the country's population while reducing the pressure on natural resources based on successful experiences from other countries such as Nepal, Vietnam and Rwanda.
Stakeholders	MEP, MOA, MOH, MFIs, CNES, project developers, and donors
Timing	End of 2015
Keys to success	Engagement with organisations with similar experience in other countries and regions (*e.g.,* Nepal, Rwanda)

Solar PV system for telecom tower
Source: Airtel Niger

Biomass plantation and firewood storage in Mossipaga village
Photo: IRENA/H. Lucas

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