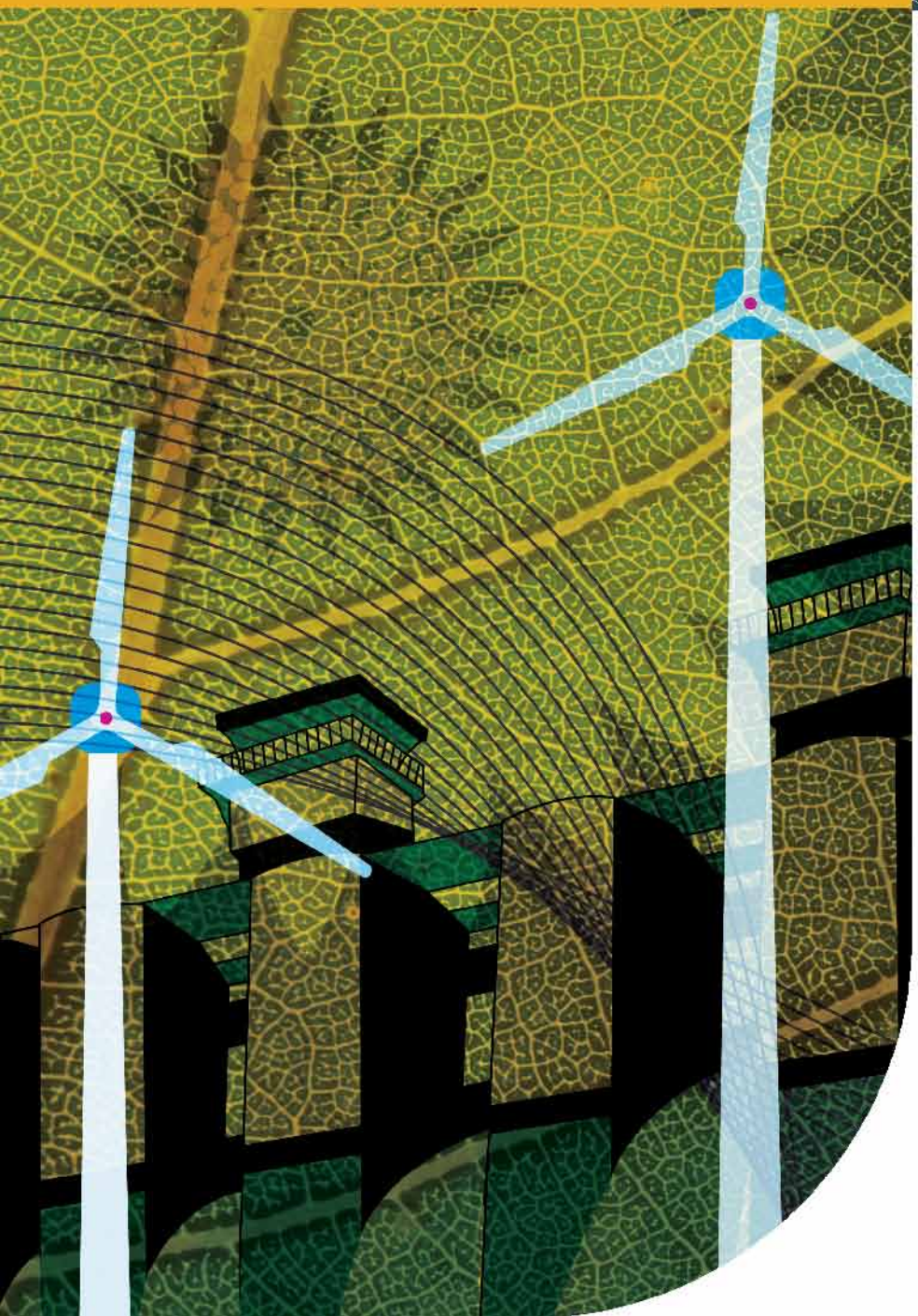
IRENA
International Renewable Energy Agency

DJIBOUTI

RENEWABLES READINESS ASSESSMENT



May 2015

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.

Authors: Gauri Singh (IRENA), Safiatou Alzouma Nouhou (IRENA) and Mohamed Youba Sokona (IRENA)

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For further information or to provide feedback, please contact: SAlzouma@irena.org or publications@irena.org

DJIBOUTI

RENEWABLES READINESS ASSESSMENT

FOREWORD

from the Minister of Energy in charge of Natural Resources

The renewable energy sector is recognised as a national priority and plays an important role in Djibouti's strategy for economic development. Our energy policy aims primarily to diversify and reduce dependence on imported oil products, increasing the share of renewable energy and biofuels to make Djibouti the first African nation using 100% green energy .

In that regard, the Ministry of Energy in charge of Natural Resources has reviewed the potential of renewables for reliable clean, low-cost power generation, developing a strategy for the next decade and an action plan for the coming five years. That study has led to the creation of a legislative and regulatory framework for renewable-based power generation. Moreover, ongoing institutional reform has led to the establishment of an agency dedicated exclusively to the promotion of renewable energy, "Djiboutian Agency for Energy Management" (ADME).

This new structure aims to develop synergies for effective collaboration between researchers from the public and private sectors and nurture small and medium enterprises (SMEs) to manufacture specific components of renewable energy technology locally. ADME is also responsible for identifying internal assets and financial mechanisms to support alternative energy, boost renewable power generation for self-consumption, and set appropriate incentives to make purchases of green power and related equipment more affordable.

Executing these tasks will obviously require bilateral and multilateral cooperation. In that regard, we welcome the initiative of the International Renewable Energy Agency (IRENA) to facilitate a Renewables Readiness Assessment (RRA) in Djibouti. The RRA consultations have helped in highlighting our strengths and weaknesses for rapid renewable energy deployment based on various options, both on-grid and off-grid, including the use of biofuels.

The outcomes of the RRA will contribute significantly to the deployment of renewable energy in Djibouti, and their implementation could result in effective diversification of our country's energy mix.

We do believe that with international support and cooperation, including that of IRENA, Djibouti will soon reach its objectives of promoting and developing renewable energy. Djibouti fully supports IRENA's mission, and our experts are available to assist other countries in conducting their own RRAs.

Ali Yacob Mahamoud
Minister of Energy in charge of
Natural Resources, Djibouti

FOREWORD

from the IRENA Director-General

The Africa High-level Consultative Forum held by the International Renewable Energy Agency (IRENA) in July 2011 highlighted the need for technical support to be provided to African countries and regions to identify their readiness to scale up renewable energy. IRENA's Renewables Readiness Assessment (RRA) process, initiated as part of the outcome of the forum, involves a holistic evaluation of a country's conditions and the actions needed to overcome barriers to 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 20 countries in Africa, the Middle East, Latin America and the Caribbean, Asia and the Pacific have undertaken the RRA process, which generates knowledge of best practices and supports international cooperation around the accelerated deployment of renewable energy technologies. Djibouti, a strong and consistent supporter of IRENA's mission, is one of those countries.

Heavily dependent on imported fossil fuels, Djibouti remains exposed to oil price volatility. The country's power infrastructure must be rehabilitated to curb voltage fluctuations, blackouts and other disruptions that affect industrial, commercial and residential consumers alike. As power demand increases to meet ambitious economic development goals, Djibouti needs to look into power generation options that are more affordable, reliable and predictable.

Djibouti has significant geothermal, wind and solar energy resources that could be developed to address its twin concerns of energy access and energy security. Developing these renewable resources would reduce dependence on imported fossil fuels and boost employment. As an active participant in IRENA's Africa Clean Energy Corridor initiative, Djibouti has the opportunity to position itself as an intercontinental transmission link, helping to decarbonise the power sector in the Arabian Peninsula as well as strengthening African energy security.

IRENA wishes to thank Minister Ali Yacob Mahamoud and his team at the Ministry of Energy for their dedication and generosity in hosting this study. We are grateful for their positive engagement and valuable input, which has given us additional insights for further RRAs in Africa and beyond.

I sincerely hope that the outcomes of the RRA consultations will empower Djibouti to pursue accelerated renewable energy deployment. IRENA stands ready to provide continuing support to the country in implementing the actions identified, in the pursuit of an energy sector transformation that ultimately reaches across continents.

Adnan Z. Amin
Director-General, IRENA

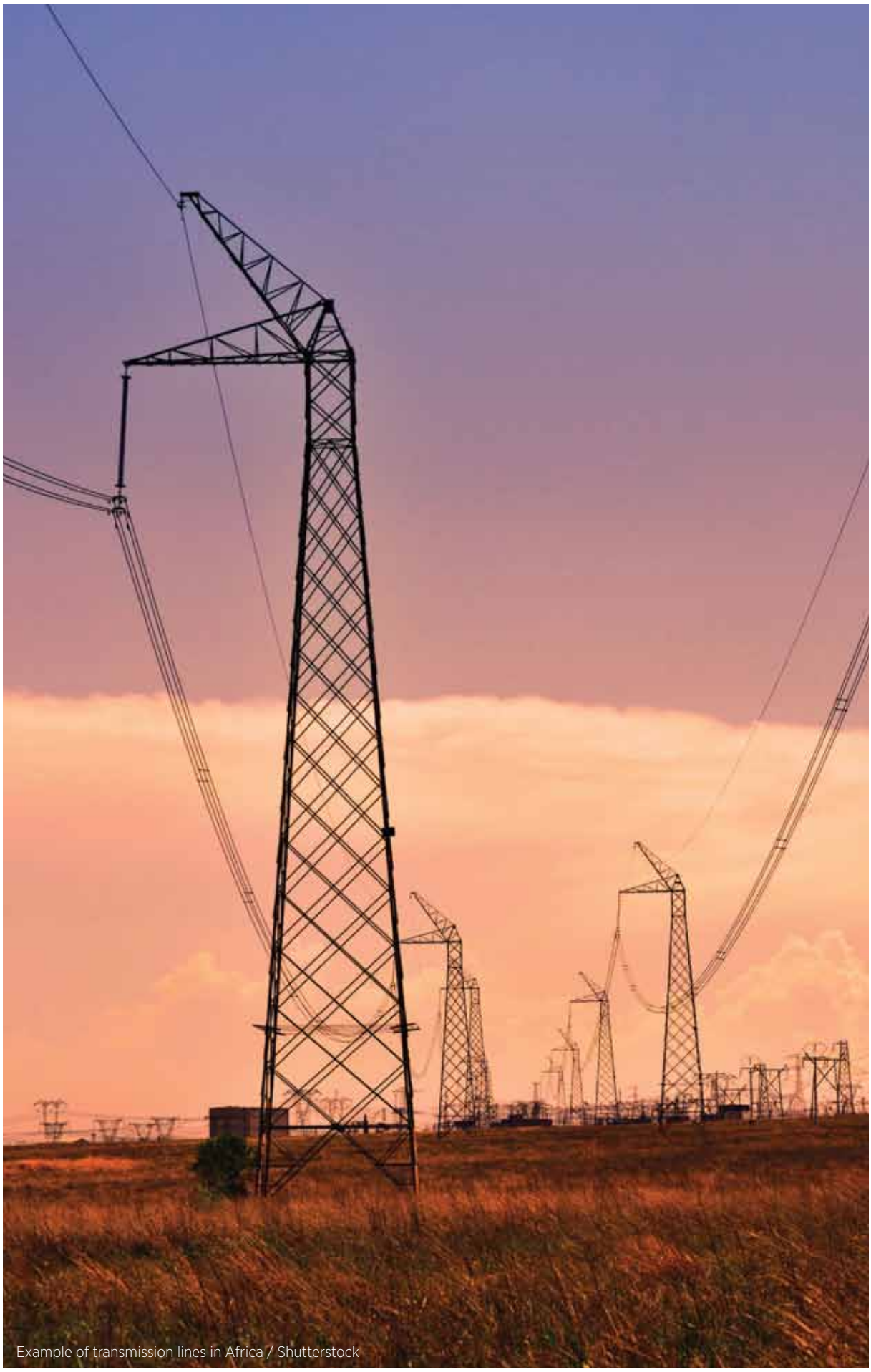
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ADDS	Djibouti Social Development Agency (Agence Djiboutienne de Developpement Sociale)
AfDB	African Development Bank
ADME	Agency for Energy Management (Agence Djiboutienne de Maîtrise de l'Energie)
CERD	Centre for Studies and Scientific Research of Djibouti (Centre des Etudes et de Recherche de Djibouti)
C&I	Construction and installation
EAPP	East African Power Pool
EdD	Djibouti Electricity Company (Electricité de Djibouti)
EUEI PDF	European Union Energy Initiative Partnership Dialogue Facility
EU	European Union
FiT	Feed-in Tariff
GCC	Gulf Cooperation Council
GHI	Global Horizontal Irradiance
GDP	Gross Domestic Product
GWh	gigawatt-hour
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
kWh	kilowatt-hour
km	kilometre
kV	kilovolt
MERN	Ministry of Energy and Natural Resources (Ministère de l'Energie et des Ressources Naturelles)
m/s	metres per second
MW	megawatt
MWh	megawatt-hour
NGO	non-governmental organisation
O&M	operation and maintenance
PPA	Power Purchase Agreement
PV	photovoltaic
TWh	terawatt-hour
UNDP	United Nations Development Programme
US	United States
USD	US Dollar/cent
VAT	value added tax



Example of transmission lines in Africa / Shutterstock

EXECUTIVE SUMMARY

The Republic of Djibouti stands at a crossroad, faced with a number of critical challenges associated with energy generation, distribution and use. The country remains heavily dependent on imported fossil fuels and power. This exposes it to fluctuating oil prices, creating uncertainties affecting economic and social development.

Both quality of and access to electricity are key challenges. The existing power infrastructure in Djibouti urgently needs to be modernised and upgraded. Voltage fluctuation, spikes, blackouts, brownouts and other disruptions have significant impacts on industrial, commercial and residential consumers. The continued dependence on imported fuel for generating electricity is also taking its toll on the wider economy in Djibouti. It uses up precious financial resources that would otherwise be spent on addressing urgent social development challenges.

The energy system in Djibouti has become a major burden to the economic and social system, and the status quo is unsustainable. To this end, Djibouti needs to explore and develop its indigenous resources in its quest for new solutions to the problem of dependency on volatile international energy markets. In its ambitious Vision 2035 long-term development plan, the Government of Djibouti recognises the importance of developing these resources to meet both its economic and social development objectives. It is in the process of crafting the policies and regulatory frameworks that would help harness these resources. However, the government has made clear that its objective is to meet 100% of domestic energy demand through renewable energy by 2020. This vision can be realised for the following reasons:

The Republic of Djibouti has significant renewable energy resources, relative to the size of its population and scale of its economy. Djibouti's abundant geothermal, wind and solar energy resources can be developed to bring higher quality energy services to populations across the country.

Renewable energy can meet the twin goals of improving energy access and energy security in Djibouti. The development of local renewable resources can reduce the country's dependence on imported and expensive fossil fuels. As the country's demand for electric power increases to meet the ambitious economic development programme outlined in Vision 2035, Djibouti would need to look into affordable and reliable options.

Renewable energy costs have fallen significantly and are likely to continue on a downward trend. An increased demand globally for fossil resources is likely to push energy prices up, while increased deployment of renewable technologies pushes energy prices down in line with progress in technology and economies of scale. This offers an opportunity for Djibouti to rethink its energy strategy, develop policies and build institutions that would make Vision 2035 into a reality.

Renewable energy is the only viable source of energy for the electricity grid in Djibouti. Power produced through renewable-based systems can be fed into the grid, providing clean and a more secure power supply. The country has a highly urban population and can achieve universal electrification with relative ease compared to countries in the region. However, the government needs to create the regulatory frameworks and modalities for Power Purchase Agreements (PPAs) that would enable healthy cooperation between public and private entities to develop Djibouti's power sector.

Off-grid renewable power can meet demand in unserved rural areas in Djibouti and can replace existing diesel systems. Djibouti is yet to build its electricity infrastructure in a planned and systematic manner. At the moment, much of its rural electrification programme relies on government funds, international donors and the country's utility, which is struggling to maintain service to existing clients. As a distributed and scalable resource, renewable energy technologies are well suited to meet the need for power in remote areas. However, it is also important to design flexible mini-grids that can be integrated into the wider grid in due course.

Djibouti has the opportunity to position itself as a transcontinental transmission hub between the power pools in Africa and the Arabian Peninsula (Yemen in the short term). By also becoming an outlet for clean energy, Djibouti can create better energy security conditions for itself and play a part in decarbonising the power sector in Yemen and beyond.

Djibouti is in dire need of rapidly building its technical and regulatory capacity. The level of skills in Djibouti does not match the magnitude of its energy challenge. The government will need to strengthen existing technical institutions and build new ones to ensure the country indigenises

its knowledge system in technology development, finance, regulation and management.

Renewable energy could help meet Djibouti's employment creation challenge. It is now widely recognised that the renewable energy sector employs more people on a megawatt-hour (MWh) basis than the conventional energy sector. Djibouti is well placed to capitalise on this opportunity and reduce its high rate of unemployment, currently at 60%.

This report discusses the energy context for Djibouti, explores enabling environments for renewables, details opportunities to develop the renewables sector, and concludes with recommendations for further action. The report details the role renewable energy has had to date in Djibouti and the policies implemented to support renewable energy deployment. It aims to provide information on the potential for renewable energy technologies to become integrated into the Djiboutian energy mix in a manner servicing the country's development priorities and goals. This work fits well with ongoing policy and research initiatives of the Djibouti Government. As the Renewables Readiness Assessment (RRA) outcome is implemented over the coming months, this work will be developed further to a greater level of detail. It will increase the focus on other important aspects of sustainable energy transition, including energy efficiency.

The fault at Fiale Caldera
Photograph: Government of Djibouti

1. INTRODUCTION

1.1 COUNTRY BACKGROUND

Djibouti lies at the southern entrance to the Red Sea and covers a surface area of 23 000 square kilometres (km^2). It has 370 km of maritime coastlines, and shares borders with Eritrea, Ethiopia and Somalia. The country has a semi-arid climate, mainly stony semi-desert, with scattered plateau and highlands. This makes it very sensitive to drought and water scarcity risks. It has a highly variable and low precipitation regime with an annual rainfall of 50-300 millimetres (mm). Temperatures are high at 20-30°C during the cool season and 30-45°C during the hot season in May to September. This contributes to high levels of evapotranspiration equivalent to 2 000 mm per year. Historical records show the Djibouti climate clearly experiences high hydrological uncertainty, frequent dry spells and chronic water stress. These features are likely to be worsened by climate change, with wide-ranging implications for the national economy, food security and human development.

Djibouti has an estimated population of 900 000 people according to the United Nations Development Programme (UNDP, 2014), growing at 2.9% per annum. More than 70% of the population lives in urban areas, with nearly 60% in the capital, Djibouti City. This demographic distribution is quite distinct from other countries in the region, where the proportion of the rural population is larger. The relatively high concentration of people in urban areas presents its own challenges and opportunities, especially as it relates to the provision of services like water, sanitation and energy.

The Republic of Djibouti's strategic importance has been enhanced recently owing to a series of interlinked developments. Most notable of these is the increased inward investment, structural transformation and growth of Ethiopia's economy. Moreover, the security challenges faced across the region have created opportunities for Djibouti and raised its strategic importance globally. This is marked by the presence of the United States and other powerful countries.

Djibouti's economy grew steadily at an annual average of 4.8% in 2000-2010, peaking to nearly 6% in 2008 before the financial crisis. In 2012, Djibouti registered 4.5% growth according to the African Development Bank (AfDB, 2012). Djibouti's economy is characterised by an extreme dualism. The modern, commercial, export-oriented urban sector contrasts with the rural sector, which is a subsistence economy based on pastoralism, with very limited access to infrastructure, services and markets according to the International Monetary Fund (IMF, 2013).

The structure of the economy is dominated by the service sector - transport, communications, commerce and tourism. These contribute to more than 80% of Djibouti's gross domestic product (GDP), and employ about 60% of the active population (IMF, 2013). The primary sector (agriculture and fisheries) contributes to about 3%, while the industrial and manufacturing sector accounts for 17% of GDP. The country witnessed major structural changes in 2004-2009 as a result of a substantial inflow of foreign direct investment in capital-intensive activities like port infrastructure, roads, buildings and hotels.

Transport and related logistical services remain the backbone of the economy. The government launched a programme to increase port activity in 2012 by building two ports as well as road corridors. Much of this is intended to meet the needs of the growing Ethiopian economy. Landlocked Ethiopia, which has a population approaching 100 million, is the primary user of Djibouti's port, and currently generates 85% of the trade that moves through its container terminal. The recent high growth experienced in Ethiopia has helped transform Djibouti's economy, and integrated the two economies even further.

While the activities relating to the service sector are progressing well, the primary (*e.g.*, agriculture) and secondary sectors (*e.g.*, manufacturing) continue to lag behind. Industrial development is still held back by high production costs, although these constraints could soon ease with important new water and energy infrastructure projects.

Unemployment in Djibouti is high at 60%, and poverty remains pervasive with nearly 42% of the population living below the absolute poverty line (AfDB, 2013). Djibouti has among the lowest health, education and other social indicators in the world and was ranked 147th out of 187 countries in the 2014 UN Human Development Index (UNDP, 2014). Enhancing employment opportunities and improving social indicators is thus given a high national priority. The National Initiative for Social Development (Initiative Nationale pour le Développement Social) was launched in 2007 to improve access to water and basic services to poor people.

The country has performed well in addressing the macro economic challenge it faces, but a great deal needs to be done to maintain the momentum and improve social development through education, health and water services. The way the energy system is structured and maintained will be critical for realising these economic and social outcomes.

1.2 THE ROLE OF ENERGY FOR DEVELOPMENT IN DJIBOUTI

In 2014, Djibouti launched an ambitious long-term development plan, known as Vision 2035. The planning strategy aims to place the country on a sustainable development pathway by strengthening the country's human capital, developing its private sector and reforming its systems of governance. The ambitious plan covers social and economic aspects with a focus on education, tourism, fisheries, new information and communication technologies, transport and logistics, industry, and energy. Djibouti aims to make a power sector transition, moving from 100% fossil thermal in 2010 to 100% renewable electricity sources by 2020. This would be sourced mainly from geothermal, wind and solar, as well as interconnecting with the Ethiopian grid, which is based on hydropower.

Vision 2035 acknowledges the importance of energy as a crucial input to economic development, and has made energy access and energy security a strategic focus. However, significant effort is required for Djibouti to become energy secure and address the energy access challenge. At present, per capita annual electricity consumption is about 330 kilowatt-hours (kWh) against an African average of over 575 kWh and a global average of over 2 770 kWh. This makes the average Djiboutian citizen among the lowest consumers of electricity in the world. Moreover, about 55% of the population does not have access to electricity, and the level of unmet demand in the country's power sector is significant. This suggests Djibouti needs to close the gap between electricity demand and what it is able to supply to its citizens. Lack of reliable and affordable energy is thus a major obstacle the ambitious aims in Djibouti's economic development plans. Households in Djibouti rely heavily on kerosene and traditional biomass to meet their basic energy needs.

Djibouti is endowed with ample energy resources, considered sufficient for the size of its population and the scale of its economic activities. The country has significant geothermal energy resources for generating electricity, estimated at 300-500 megawatt (MW) capacity. It also has some excellent wind energy sites as well as good solar energy resources. These can be successfully harnessed for power generation and for other energy services like water pumping and micro generation to meet urban and rural energy needs. Djibouti thus has the opportunity to take advantage of the recent technical advances in clean energy technologies and significant reduction in their cost to meet its growing energy demand. This would go some way to reducing energy import bills (*e.g.*, oil, natural gas, etc.). However, there is little experience of this apart from isolated solar photovoltaic (PV) installations in rural villages.

Djibouti is at the heart of some of the major regional integration programmes including the Intergovernmental Authority for Development. The Djibouti Government has major plans to expand these activities. A similarly ambitious effort is under way for Djibouti to benefit from the considerable hydro-energy initiatives in Ethiopia. Already, Djibouti draws some 60%-65% of its power from this bilateral power arrangements, with further expansion planned to enhance the reliability and quantity of imported power. Djibouti is not yet a member of the East African Power Pool (EAPP), but has submitted its application and plans to become an important regional power platform.

Lake Assal
Photograph: IRENA/M. Sokona

1.3 RENEWABLES READINESS ASSESSMENT

The RRA in Djibouti was led by the Ministry of Energy and Natural Resources (Ministère de l'Energie et des Ressources Naturelles) (MERN) in close cooperation with the Agency for Energy Management (ADME). It acted as an interface between the RRA support team: the country consultant, international consultant, International Renewable Energy Agency (IRENA) and the key local stakeholders. Experts drawn from key government, private sector and civil society institutions were invited to a kick-off meeting. The consultant explained the nature and purpose of the RRA process and introduced the Djibouti RRA country team members. Several workshops were conducted throughout the RRA. Workshop activities included identifying renewable energy service-resource pairs and prioritisation criteria, and filling in a set of templates for each service-resource pair. A final RRA workshop organised on 17 May 2014 finalised the service-resource pairs and defined the practical action that will set these renewable energy subsectors in motion.

This report is structured into five sections. The first presents the introduction covering country background and the RRA process in Djibouti. The second presents an overview of the regional energy setting, and contextualises Djibouti's national energy sector, the challenges it faces and an overview of renewable energy potential and use. It provides a detailed discussion of the electricity sector. The third section identifies institutions playing a role in Djibouti's energy sector and defines key energy policies and regulatory frameworks, as well as the finance and investment conditions in Djibouti. The fourth discusses the RRA findings related to emerging concerns and enabling conditions for scaling up the service-resource pairs identified. It sums up the related opportunities and constraints. Finally, the fifth section presents the recommended action necessary for scaling up renewable energy in Djibouti.

Separation between the Arabian and African tectonic plates
Photograph: IRENA/M. Sokona

II. ENERGY CONTEXT

2.1 REGIONAL CONTEXT

The recent economic resurgence of countries in East Africa has aroused a great deal of optimism about economic transformation. Fast growth in Rwanda and Ethiopia, and good economic performance in Kenya, Djibouti, Uganda, Tanzania and Burundi have created a positive sub regional outlook. Concerns remain about the inclusiveness and broad-based nature of such growth in the sub region, but per capita GDP figures show strong improvements over the last decade. Sustaining this growth trajectory requires high energy inputs. The Common Market for Eastern and Southern Africa (COMESA) region faces an electricity supply deficit of about 20% (UN Economic Commission for Africa (UNECA), 2011).

The state of energy access in the sub region is generally quite low, ranging from 1% in South Sudan, 2% in Burundi, 11% in Democratic Republic of the Congo to 12% in Uganda. The performance of Comoros (46%), Djibouti (55%) and Seychelles (96%) is better.

Whilst East Africa benefits from a variety of energy resources, they are unevenly distributed. For example, Ethiopia has significant hydropower resources as well as wind and geothermal. Kenya has wind and geothermal resources. Tanzania has natural gas, and Djibouti has geothermal, solar and wind. Furthermore, the region is experiencing vigorous oil and gas exploration. The diversity and abundance of this resource base means these resources can be developed on a larger scale and integrated into a regional power grid, contributing to poverty reduction in the region (World Bank, 2012). However, having the resources is one thing, but converting them into real use is another. Despite the benefits of integration, only a few projects are in progress, though the numbers are growing. They include the now complete 150 MW interconnector from Ethiopia to Djibouti and a 100 MW interconnector from Ethiopia to Sudan. A line has recently gone live between Kenya and Uganda, as well as a second interconnector from Ethiopia to Djibouti (UNECA, 2013). In addition, Burundi, Democratic Republic of the Congo and Rwanda are introducing power interconnections expected to be operational by 2015, while the Kenya-Tanzania interconnector project has secured finance to begin engineering work. Tanzania and Zambia are also working on an interconnector which, upon completion, will connect the Southern Africa and East Africa regional grids (EAPP, 2012). Together with the older Kenya-Uganda, Egypt-Libya and Burundi-Democratic Republic of the Congo-Rwanda interconnections, the pipeline projects will stimulate connections across East Africa, involving all current members.

Given that resources are unevenly distributed, power grid integration in the sub-region can help improve reliability and reduce the cost of power supply in the region. This has been amply demonstrated by the significantly reduced price of electricity coming through the Ethiopia-Djibouti interconnection.

Djibouti is not yet a member of EAPP. However, its bilateral engagement with Ethiopia, like other bilateral power agreements in the region, will shape the development of EAPP. Since 2011, the Ethiopia-Djibouti interconnection has enabled Djibouti to draw about 65% of its electricity needs from Ethiopia. Over 98% of Ethiopia's electricity is from renewable sources. Prior to this, 100% of Djibouti's power generation came from oil products. The cost of electricity at seven US cents (USD 0.07/kWh) from this new regional source compares favourably with USD 0.30/kWh from oil. Out of the total power supply, 154.97 gigawatt-hours (GWh) was imported from Ethiopia in 2012 (Africa EU Energy Partnership (AEEP), 2013), which roughly equates to savings of about USD 36 million. Ethiopian imports are regulated by a bilateral contract establishing maximum energy trading of 243 GWh per year in 2012-2015 and up to 70% of the Djiboutian load up to 2019. A second transmission line is

planned to increase the volume of electricity from Ethiopia. The interconnection has had three interesting effects:

i. Djibouti decreased its domestic power production by over 37% in 2010-2011 once the Ethiopian interconnector was commissioned.

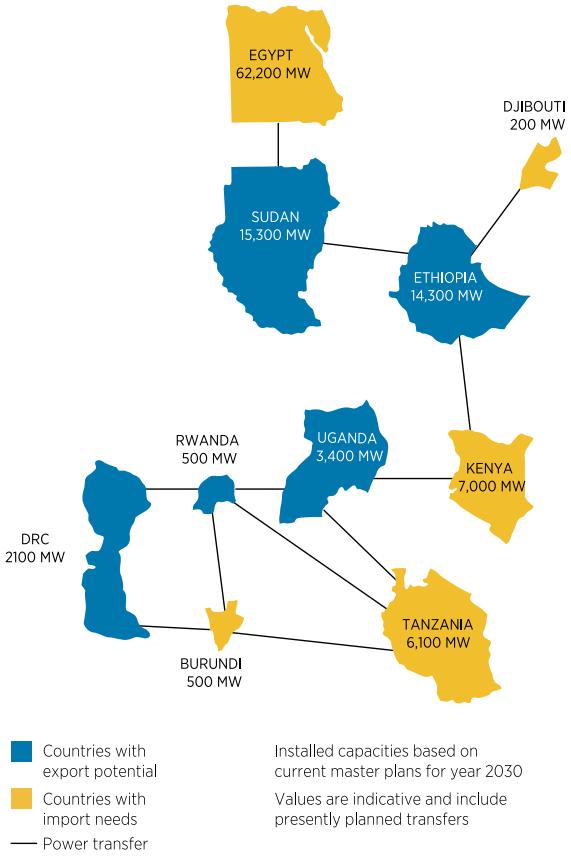
ii. Income from value added tax (VAT) and the domestic consumption tax, both on oil products, declined sharply. This was due to electricity imports that reduced the state power company, Electricité de Djibouti's (EdD), use of oil. The government obtained a bank loan to meet the budget deficit, but the deficit appears to have been paid off.

iii. The new electricity supply from Ethiopia since 2011 has also cut inflation because fewer oil imports are needed for power generation. Inflation fell to an average of 3.7% in 2012 from 5.1% in 2011 (AfDB, 2012).

The sub region's aggregate electricity demand is expected to grow from about 20 terawatt-hours (TWh) today to 50 TWh in 2018 and 120 TWh in 2030. This means the countries in the sub region will need to seriously scale up the development of their energy resources (UNECA, 2013). To date, lack of installed capacity has forced many countries to resort to expensive emergency power generation, often operating as base load to mitigate the consequences of load shedding. Meanwhile, other countries have had excess capacity. An interconnected system would help to smooth out this surplus-deficit imbalance and seasonal variability of energy resources like hydropower. In addition, it would create significant savings in foreign exchange, allowing countries to free up these resources to be used for pressing development investments.

Eberhard, *et al.* (2011) have shown that, from a purely economic standpoint, several countries would benefit from the opportunity to reduce costs by importing more than half their power. Savings for countries such as Guinea-Bissau, Liberia and Niger could range from USD 0.05-0.08/kWh. The largest beneficiaries of regional trade would be smaller nations that lack domestic hydropower resources. It is estimated that the cost savings by these countries generated by regional trade could repay the requisite investment in cross-border transmission in less than a year. This depends on neighbouring countries developing sufficient surplus power to export. The experience of Djibouti is consistent with this analysis.

Figure 1: Country resources and potential interconnections



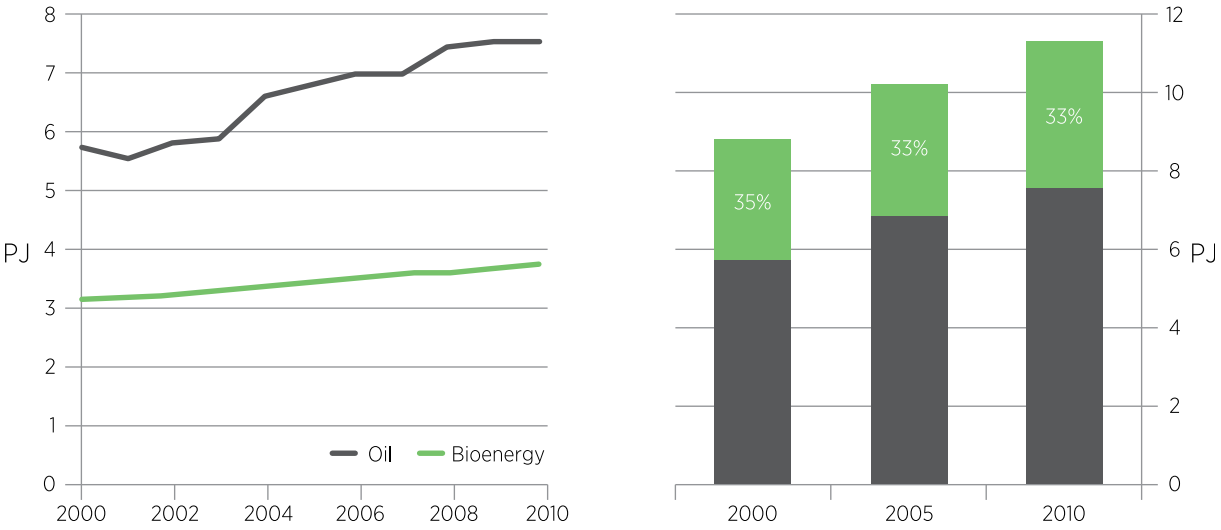
Source: SNC Lavalin & Parsons Brinkerhoff, 2011

2.2 ENERGY SUPPLY AND DEMAND IN DJIBOUTI

Djibouti is a small country with a fast growing economy. It has a dual energy system with co-existing traditional and modern energy and practice, although the traditional system composed of biomass has been shrinking over time. Most people live in towns, which influences the nature of energy consumption in favour of modern fuels such as electricity, kerosene and Liquid Petroleum Gas. Almost all energy used in Djibouti is imported.

Total Primary Energy Supply in Djibouti is dominated by biomass, accounting for about 67%, with the remaining share from oil products in 2010. Over the last decade, Total Primary Energy Supply has increased at a faster rate, as shown in Figure 2. The per capita energy consumption in 2012 was about 440 kilogrammes (kg) of oil equivalent. Biomass use has progressively decreased in urban areas as a proportion of the total. Kerosene has replaced biomass in Djiboutian homes, and renewables account for negligible amounts of energy consumed across the whole country. However, better data are needed to improve the assessment of the biomass contribution to the overall energy mix.

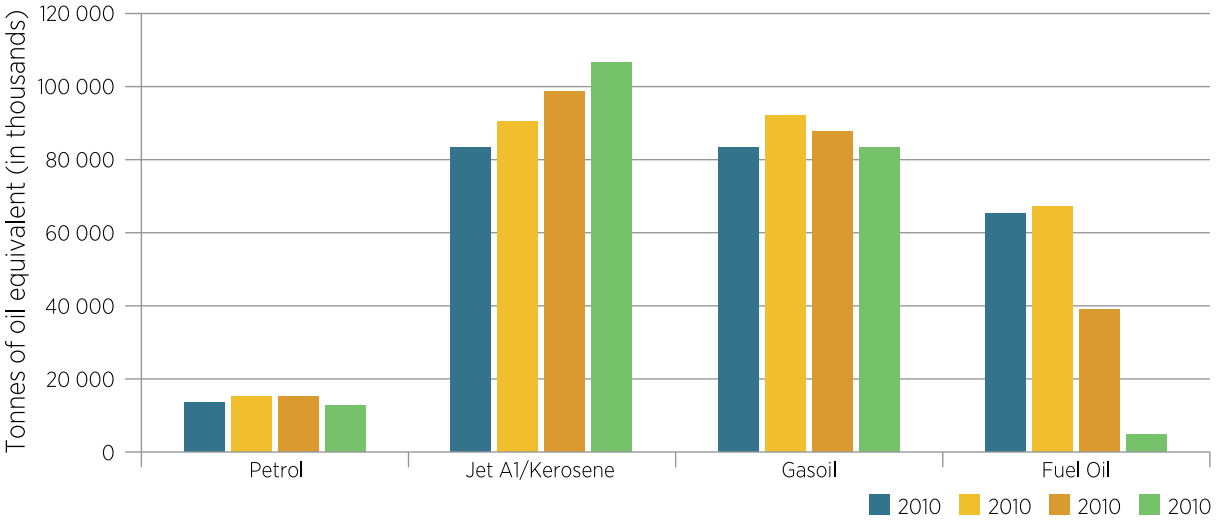
Figure 2: Total Primary Energy Supply 2000-2010



Source: IRENA, based on data from United Nations Statistics Division (excludes electricity trade)

Petroleum product consumption has been on the rise since 2005, particularly diesel and kerosene. This is needed by the transport and household sectors. In 2012, Djibouti imported nearly 390 000 tonnes of oil equivalent. As also indicated clearly in figure 3, fuel oil consumption has reduced since 2011 as a result of the interconnection with Ethiopia (Government of Djibouti Société Internationale des Hydrocarbures (GoD SIDH) data, 2014).

Figure 3: Petroleum product consumption over time



Source: GoD SIDH (2014)

Petroleum imports cause major problems for the Djibouti economy as they use up significant proportions of its foreign exchange. This trend has been increasing in 2000-2012, during which import bills have grown fivefold. In 2012, the country spent nearly USD 200 million in petroleum imports, which amounts to about 20% of total imports. The energy intensity of Djibouti, as measured in terms of energy consumption per unit of GDP, has been declining over the past five years, while it has remained unchanged in much of the East African sub region (Energy Information Administration (EIA), 2013). Despite this decrease, Djibouti's energy intensity is still higher than the regional average, and certainly higher than that in developed and emerging economies. The high energy intensity points to ample opportunities for Djibouti to improve the efficiency of its energy system from production to end-use.

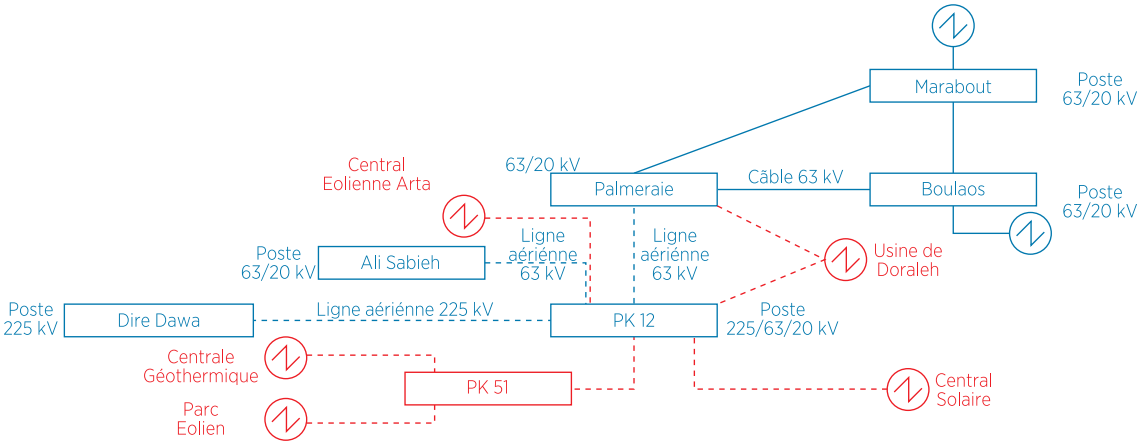
[1] Energy intensity is a measure of the value of goods and services generated per unit of energy used, which allows the energy efficiency of the whole economy to be evaluated. It also reflects the structure of the economy.

The energy access challenge in Djibouti remains a major obstacle to the country's development. At about 55%, Djibouti electricity access is better than most countries in the region. Furthermore, rural and urban areas differ greatly in terms of access to modern energy services (both electricity and heat for cooking). Urban areas enjoy better conditions for improving access. Three important characteristics of the energy sector in Djibouti. These include: i) diversification of the energy mix to reduce the country's dependence on imported fuel and electricity, enhancing the country's resilience and opportunities for the development of new assets ii) continued dominance of energy for heating and cooling in the country's energy balance against a backdrop of opportunities to improve efficiency and fuel substitution iii) low access to modernised energy services, especially in rural areas, where implementing well planned mini-grid and stand-alone energy programmes can bring considerable wellbeing.

2.3 ELECTRICITY GENERATION, TRANSMISSION AND DISTRIBUTION

Djibouti relies entirely on imported electricity and fossil fuel for electricity generation. This is mainly heavy fuel oil for the main power plants and diesel for the provincial power stations. These are operated by public utility company EdD, which manages approximately 38 000 connections for the metropolitan area Djibouti City. The network is based on a 5 km, 63 kilovolt (kV) cable connecting the Boulaos and Marabout stations, and a 225 kV amp interconnection line from Ethiopia which covers about 65% of the national domestic needs during the summer months (figure 4). The distribution system within the city is at 20 kV. Electricity is supplied to the customers through around 300 distribution substations. The isolated system grids are based on lower voltage distribution networks. Electricity access in Djibouti is about 55%.

Figure 4: Transmission network in Djibouti



Source: Electricité de Djibouti

Effective installed capacity in Djibouti is around 126 MW (table 1). Domestically generated power consists of EdD thermal capacities, which rely primarily on ageing generation capacity running on expensive imported fuel oil to produce baseload electricity. The utility has 18 generating units running on heavy fuel oil in Boulaos and Marabout. One 15 MW generator is less than five years old, having started up in 2007. Meanwhile, 14 generators with a combined capacity of 78 MW are between 5 and 15 years old. The remaining capacity is at least 20 years old (AfDB, 2013). Due to the unreliability of older generators, EdD effective generation capacity is limited to 57 MW of the 126 MW installed.

Table 1: Installed electricity generation capacity in 2011

	Power plant location	Monthly fixed charge (Price/kWh)*	Total capacity (MW)
Main grid	Boulaos Marabout Tadjoura	15 6 6	108.2 14.4 2.2
Interconnection	-	-	-
Isolated	Obock	5	1.2
Total			126.0

Source: AEEP (2013)
* Variable transmission

Djibouti is struggling to meet its growing electricity demand. Over the past ten years, electricity consumption has increased by about 75%. Even with this increase it is judged that effective demand is significantly higher (table 2). According to a study by the European Union Energy Initiative Partnership Dialogue Facility (EUEI PDF, 2013), production has been growing at an estimated annual rate of 5.7% over the last 40 years, but more slowly than demand. Random and scheduled power cuts are the consequence of this imbalance. In 2009 and 2010, for instance, 13-14 GWh of demand could not be met through the grid. Since the interconnection with Ethiopia, this figure has decreased to just under 9 GWh in 2011. This has improved security of electricity supply. The same study highlighted that Djibouti's demand will maintain its high growth rate. Power demand for the main grid is expected to rise by 70%-75% in 2011-2035, while demand for the isolated networks of Tadjoura and Obock is expected to increase by 62.5% and 49.5% respectively over that period. Clearly, Djibouti will need to scale up its efforts to generate more power from domestic sources and/or aim to import power from Ethiopia either bilaterally or through EAPP.

Approximately 37% of electricity is consumed by big industry and activity related to the sea port, airport, free zone and military camps. Residential consumers, including a social consumer category, account for 38%. The remaining 25% is consumed by large retailers, public offices and government offices (World Bank and Parsons Brinckerhoff, 2009). The service sector and domestic load components dominate peak demand. There are two daily peaks between May and October, largely concentrated during the afternoon office opening hours and in the early hours of the morning when air conditioning systems are in use. Table 2 summarises the evolution of the structure of the electricity market in 2007-2011 in terms of consumer population, power sales, system losses, power demand and energy demand.

Table 2: Status of the electricity market

ITEMS	2007	2008	2009	2010	2011	2012
Customer population	37 766	39 246	40 756	41 888	41 888	70 000
System losses consumption (%)	21	22	22	23	16	16
Power demand MW	56	57	63	64	70	77
Energy demand MWh	322 970	325 650	354 520	385 270	395 700	422 418
Energy demand growth rate (%)		0.8	8.1	7.9	2.6	6.3
Power demand growth rate (%)		1.7	9.5	1.5	8.6	9.0

Source: World Bank and Parsons Brinckerhoff (2009); EdD web page

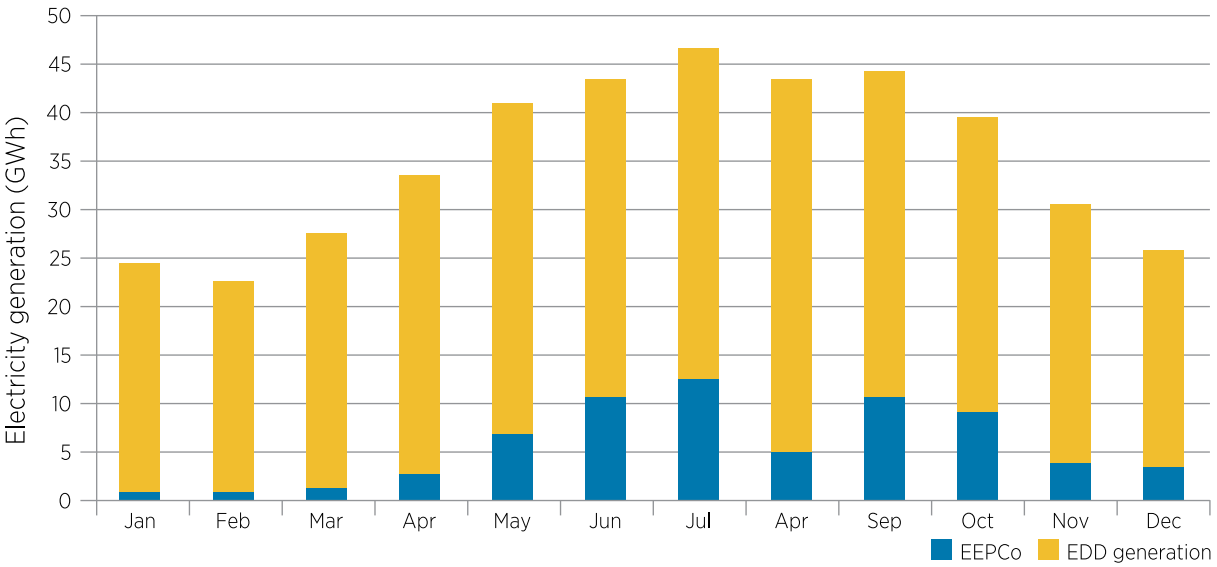
Load shedding was especially frequent before the interconnection from Ethiopia came on stream (table 2), and still continues. In 2011, grid losses represented about 16% of electricity produced due to the poor state of the grid and illegal connections. It was common practice for many businesses, hotels and health facilities to rely on private generation units on site. They ran these plants at high cost, with implications for the business. Data on these backup off-grid systems are not available. The resulting effect of this system underperformance is high tariffs for consumers and a rise in the number of high cost on-site private generation units, which also weakened the financial position of EdD. For example, the free zone has invested in its own diesel generator plant with the associated separate infrastructure. This has also had a knock-on effect of reducing EdD capability to raise sufficient revenue for expanding the electricity system, with wider economic implications. The lack of reliable, affordable power and the high cost of energy are seriously limiting investment in Djibouti, thereby curtailing growth in productive sectors such as manufacturing.

To meet future electricity generation capacity, Djibouti is building the Jaban heavy fuel oil generation plant with support from the Kuwaiti Government. New capacity amounting to 45 MW is due to be installed in 2015, and there are plans to expand this to 140 MW by 2030. Moreover, AfDB has approved funding to expand the Ethiopia-Djibouti interconnector by constructing a second 230 KV line, expected to start up in 2017. The present PPA between the utility Ethiopian Electric Power Corporation and EdD is governed by Ethiopia's daily loads. The arrangement does not include electricity sales during the dry season in Ethiopia. The supply of electricity is dependent on hydrological conditions in Ethiopia's hydroelectric dams and the availability of surplus energy. This arrangement works well for the two countries.

During the summer months — the rainy season in Ethiopia — hydroelectricity production in Ethiopia exceeds demand. It correlates with the high electricity demand season in Djibouti when significant energy is required for cooling (figure 5). Conversely, weak demand in Djibouti during the winter months coincides with the dry season in Ethiopia.

The electricity supply from Ethiopia is not provided under a guaranteed capacity agreement, so that power may not necessarily be available when Djibouti needs it most. An agreement that gives a higher degree of guarantee to Djibouti over a longer term would create better energy security conditions. It would reduce the sense of vulnerability felt by development planners in Djibouti. Indeed, Djibouti would need to invest in its own generation capacity in order to minimise its exposure to potential future price increases or disruptions of power from Ethiopia, for whatever reason.

Figure 5: Power generation by Ethiopian Electric Power Corporation and EdD (2012)



Source: EdD

Costs and tariffs

Electricity tariffs remain in the hands of the government, and are set by ministerial decree from the Ministry of Economy and Finance in charge of planning. They are subject to review by MERN. Tariffs are set according to number of factors, such as electricity production cost (including operation cost), social cost and other political economy criteria. Electricity tariffs in Djibouti are high and average USD 0.32/kWh, mainly as a result of increased oil prices and technical and non-technical inefficiencies. The EdD 2012 tariffs range from a social price of USD 0.153/kWh (lifeline tariff) to USD 0.426/kWh paid by industry and construction sites. Retailers and government buildings are charged USD 0.397/kWh for their electricity (World Bank, 2012). The cost of electricity in Djibouti is very high compared to USD 0.05/kWh in Ethiopia and USD 0.10/kWh in Kenya, mainly because Djibouti's primary electricity production sources depend on petroleum products. As part of the effort to increase electricity access by low income households, a new law is under preparation to lower connection fees from their present levels of USD 280-350.

The overwhelming majority of people unserved by the grid live in rural villages very distant from national grid lines. The cost to a utility of connecting these communities, which have low electricity demand, would be prohibitive at this stage. Djibouti will need substantial investments to modernise its system as well as build new generation plants. A parallel strategy will be required to meet the energy needs of communities located far from the grid. Djibouti can achieve universal electricity access with relative ease compared to other countries in the region given that it has a small rural population scattered across small settlements. It has considerable renewable energy resource potential and therefore has the opportunity to create a more cost-effective grid and off-grid renewable energy supply system. However, the Djibouti Government will need to speed up its policy formulation and appropriate regulatory framework development to create the appropriate incentives for new investment, especially in the renewables area.

2.4 RENEWABLE ENERGY RESOURCES: POTENTIAL AND USE IN DJIBOUTI

The energy sector in Djibouti faces several challenges. The country continues to struggle to meet resource constraints due to its dependence on imported fuel and weak supply infrastructure. This is especially pronounced in rural areas where levels of access to adequate and reliable energy services are limited due to low incomes, low demand and greater distance from grid lines. To this end, decentralised energy systems could be developed to meet energy service shortfalls and future energy needs. The deployment of indigenous resources for the grid is important, given the significant suppressed demand for electricity.

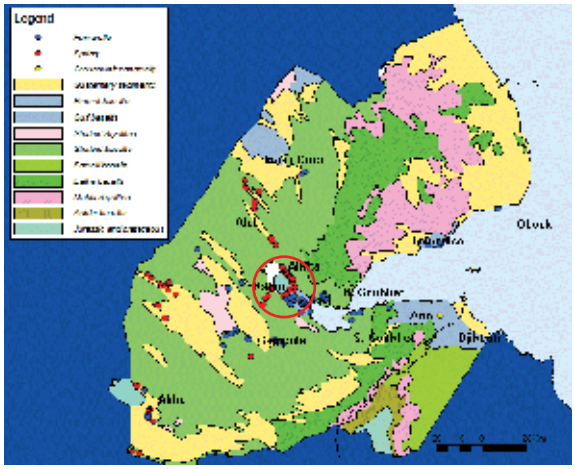
Given its climate and geography, Djibouti has the potential and opportunity to develop a portfolio of diversified renewable energy technologies at different scales. Djibouti benefits from good renewable energy resources, especially geothermal, wind and solar energy. These currently provide negligible amounts of energy to the overall mix. Djibouti's significant untapped potential resources offer opportunities for both urban and rural energy development. The government could capitalise on global developments in energy innovations that could create new industries, jobs and capacities. A summary of the resources and potential available in the country is provided below.

Geothermal energy resources

The Republic of Djibouti is located within the Afar Depression. This is a geological triple junction structure formed by the intersection of the Red Sea, the Gulf of Aden and the East African rifts (World Bank, 2012). Volcanic and tectonic activity at this intersection has been occurring for 30 million years. A number of countries along this tectonically active region are exploring geothermal energy as an option to meet their energy requirements. Kenya has already installed capacity, and Ethiopia is actively working towards developing its geothermal field. One important advantage of developing geothermal energy is the flexibility it provides in comparison to other renewable energy systems. Most renewables are variable in nature and thus need to be paired with other technologies that can provide the baseload. Geothermal, however, provides secure baseload power, and is hence better suited to replacing the existing heavy fuel oil baseload power.

In Djibouti, various exploration activities since the 1970s have demonstrated the existence of significant geothermal resources in the Assal Rift Zone. The Assal rift, which includes the exploratory drilling focus of the Geothermal Power Generation Project, is located west of the Gulf of Aden rift in Djibouti (figure 6). The figure also displays the geology of Djibouti and the main geothermal prospects. Approximately 12 geothermal provinces have been identified in Djibouti based on locations of surface hydrothermal manifestations. More exploratory work is required before the fields are developed to produce energy. However, it is clear the various geothermal fields in Djibouti can provide a low cost, reliable and renewable base load energy supply.

Figure 6: Geological map of Djibouti



Source: World Bank, 2012

Djibouti has experienced stop/start geothermal exploration. Nevertheless, the work completed so far has built up enough of a picture to attract significant policy attention and exploratory activity. Some of this outlined below.

- 1970-1975: the two wells Asal 1 and 2 were shown to have good temperatures, but only Asal 1 has produced geothermal fluid with high salinity.
- 1980-1985: a detailed general inventory of geothermal resources was conducted by the Djibouti Government and identified more areas of interest.
- 1987-1990: deep geothermal exploration completed, consisting of i) two drilling wells in Hanle (Hanle 1 and 2) ii) four other wells in the Assal Rift (Asal 3, 4, 5, 6) and iii) a scaling and corrosion study was performed on Asal 3, intended to assess the effects from deposits and corrosion.
- 2007: the Government of Iceland pledged support to develop Djibouti's geothermal resource in the form of a proposal by Reykjavik Energy Invest. It would take total project risk including exploration risk as an Independent Power Producer (IPP) developer and recoup investment and associated return through a 20-year electric tariff.

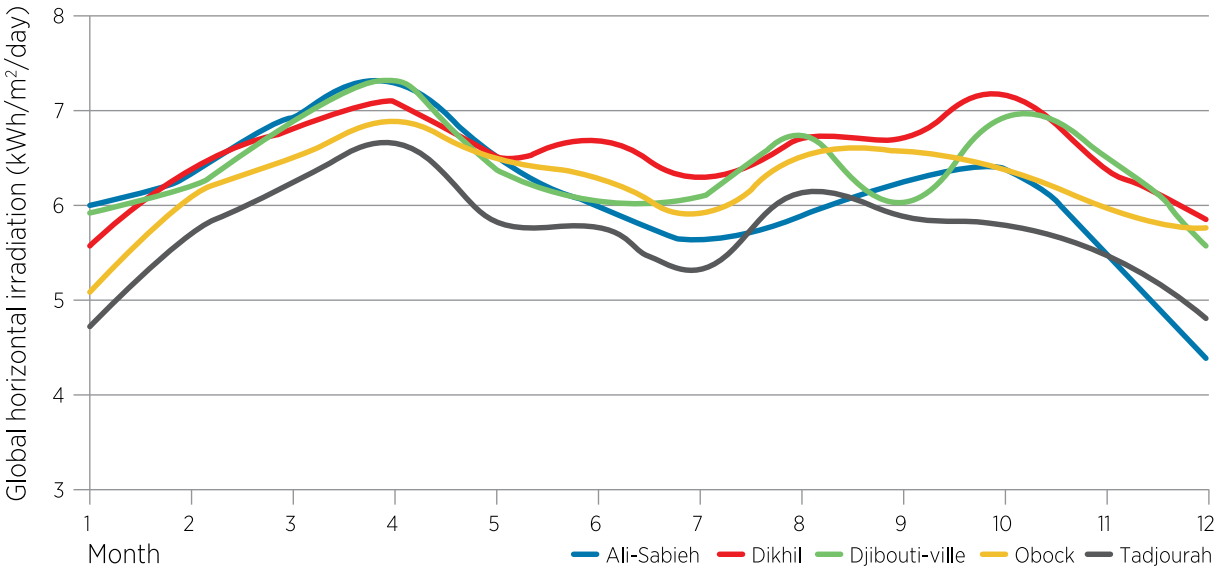
The technically exploitable geothermal energy potential is estimated at 350-650 MWe (AEEP, 2013). Assal-Ghoubbet is the only individual region with an economically exploitable potential of more than 150 MWe (Ahmed Aye, 2009).

Solar energy resource

Djibouti shows tremendous solar potential. As illustrated in figure 7, Global Horizontal Irradiance (GHI), is 4.5-7.3 kWh per square metre per day (m^2/day) throughout most of the country. By comparison, Germany, which has nearly half the world's installed solar PV capacity, has few locations with a GHI above 3.5 kWh/m^2/day. Phoenix, Arizona — a city in the US Southwest famed for its solar potential — has an average GHI of 5.7 kWh/m^2/day.

Djibouti has two peak periods of insolation (March to April and September to October) with low diurnal variation between maximum and minimum radiation values. The lowest radiation values are observed from June to August, coinciding with the hot and humid season. However, even during these periods, the country receives enough solar radiation (about 5-6 kWh/m^2/day) to make use of solar energy applications. According to Pillot, *et al.* (2013), about 82% of the country receives annual mean global radiation of over 2 000 kWh/m^2. This amounts to 4.84 x 1013 kWh or about 20 000 times Djibouti's annual electricity consumption. While this resource regime is appropriate for the deployment of large and small-scale PV systems, further research is required into Concentrated Solar Power in Djibouti. According to IRENA (2012), Concentrated Solar Power plants require abundant direct solar radiation for strong sunlight to be concentrated to the temperatures required for electricity generation. For the technology to be cost-effective, direct normal irradiance levels of 2 000 kWh/m^2 or more would be required. Lower levels could work under some circumstances, and annual direct normal irradiance levels of 1 400 kWh/m^2 for Djibouti need to be explored further.

Figure 7: Global Horizontal Irradiance for five stations in Djibouti (kWh/m^2/day)



Source: Higher Institute for Scientific and Technical Research (Institut Supérieur d'Etudes et de Recherches Scientifiques et Techniques) (ISERST, 1984)

Solar energy applications in use in Djibouti include PV for off-grid applications in rural lighting, communications, refrigeration, water pumping and other services such as refrigeration. There is also a pilot 300 kW grid-connected PV system. Off-grid PV systems have been in use in Djibouti for over 30 years. Government and donors have funded most of Djibouti's PV investments.

More recently, PV systems are the subject of considerable interest in Djibouti, both for off-grid and on-grid applications. A PV rural electrification study funded by the World Bank Public Private Infrastructure Advisory Facility (2014), was undertaken between 2011 and 2013 to assess rural electrification based on PV. The aim was to evaluate the opportunities and barriers to launching a programme of mini-grids and stand-alone PV kits for 25 villages. In the end, 19 villages were selected. The study employed two economic models: a non-concessional market for PV products and a Public Private Partnership for mini-grids. It delivered the main guidelines for implementing a solar electrification programme through renewable energy.

A 300 kilowatt-peak (kWp) grid-connected PV plant has been installed with the support of the Japanese Government, costing an estimated JPN 610 million or 1 billion Djibouti Francs. The solar park occupies an area of 5 200 m^2 and consists of 1 440 PV panels. It started up in January 2012, meeting the needs of the campus of the Centre for Studies and Scientific Research of Djibouti (Centre des Etudes et de Recherche de Djibouti) (CERD). Surplus power is fed into the EdD network. During the first year of operation, the plant produced 508 MWh of electricity. This was 10% more than initially planned. Output peaked in October 2012 at about 47 MWh. Reduced energy output was recorded for June, July and August due to relatively high ambient temperatures and high levels of the Khamsin, a hot dry wind.[2]

There is little private sector activity in the solar PV sector, and active commercial markets are yet to develop in Djibouti. There are a few private sector players. Moreover, the market is limited by its small size. It is partly constrained by high import tariffs and VAT amounting to over 33%, lack of regulation on quality assurance and the absence of supportive government incentives and policies.

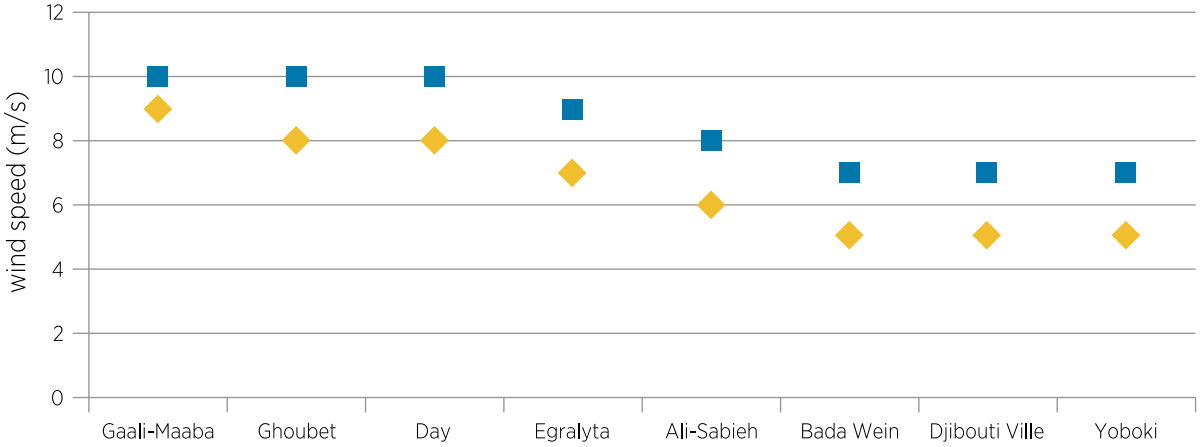
The falling PV cost in recent years brings the technology closer to grid parity in many parts of the world, providing potential for investment in grid-connected PV in Djibouti too. Djibouti's high electricity generation cost offers an important incentive for investors to play a role in grid-based PV. However, it is important to recognise that this is still a capital-intensive venture. It will require government direction to create the appropriate institutional and regulatory framework as part of the effort to lower investment risks to encourage private sector players to come forth.

Wind energy resource

Since 2000, the Government of Djibouti has explored the potential wind energy resource in Djibouti in a variety of studies. For instance, CERD carried out an assessment in 2002. It selected 14 sites where 40 m NRG Systems towers were installed, and from which wind speed and wind direction data were recorded for one year. Finally, a wind pre-feasibility study was launched in 2005. This data gathering campaign involved virtually the whole country. It helped quantify the resources and key strategic issues relating to grid-connected wind farms, as well as rural energy applications like rural electrification and water pumping. These investigations have concluded that wind is a good potential source of electricity production.

Figure 8 shows the wind resource distribution across Djibouti. Average wind speeds of 9-10 metres per second (m/s) (standard deviation = 0.7) are recorded at the coastal areas around the Gulf of Ghoubet. Sites like Ghoubet, Gaali-Maaba and Day also experience consistently high wind speeds throughout the year with exploitable potential of 4 000 hours. This offers opportunities for grid-connected power generation, provided that suitable wind turbine technology is selected and wind power wisely integrated to the existing grid. A grid stability study would be useful in the first instance to understand the impact of fluctuating power supply to the national grid. These coastal areas are influenced by the Khamsin. It blows from the West between July and September when the wind is at its lowest levels but still high enough for power generation.

Figure 8: Average wind speed of various sites in Djibouti at 40m

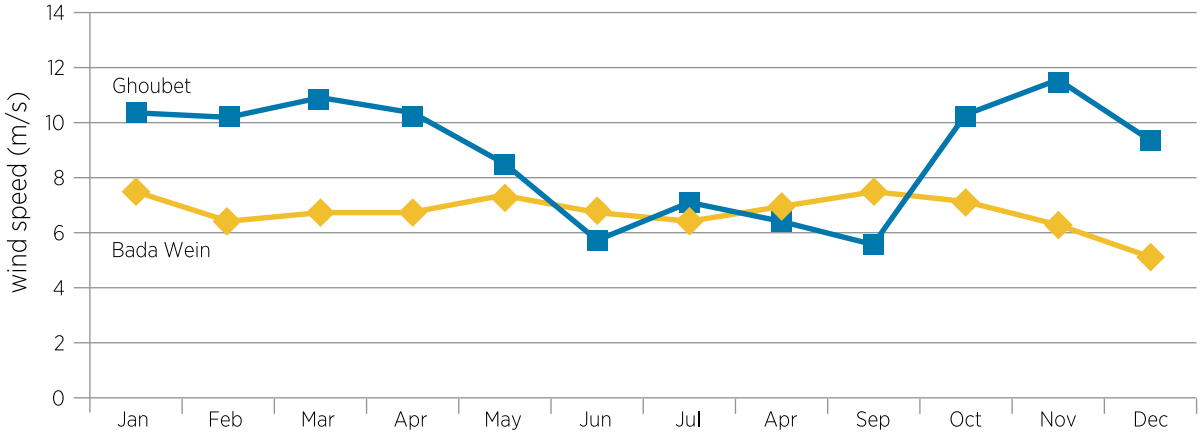


Source: CERD, 2006

[2] The Khamsin is powerful seasonal wind storm that often carries large quantities of sand and dust. It is generally experienced about 50 times in Djibouti between June and August.

The inland districts of Ali Sabieh, Tadjourah and Dikhil show lower wind speeds during most months, averaging at 6 m/s. This is illustrated in figure 9 by a comparison between a coastal and inland site. In the southern section, represented by Bada Wein, the regime over the year shows fairly constant winds along the Northeast and Southeast respectively. Average monthly wind speeds there are 6-7 m/s. Although this is lower than the coastal site of Ghoubet, Bada Wein nevertheless shows attractive wind resources for electricity generation to supply both the main grid and mini-grids.

Figure 9: wind speed at two different sites as a comparison



Source: CERD

There is limited experience of wind energy projects in Djibouti. Much of the experience of wind energy is in water pumping, but that has remained at the pilot stage or for private use. Due to this limited experience, operation and maintenance (O&M) capacity is undeveloped, much like the picture in other parts of Africa.

In recent years, wind energy for electricity generation has attracted some interest from the Djibouti Government, multilateral institutions, donors and private investors. The Ghoubet site in particular has received considerable attention, and the European Commission is considering a 20 MW wind park there. The plant is intended to provide power for sea water desalination. Meanwhile, China and Djibouti have signed an agreement to develop wind resources in the Ghoubet area. However, the distance of this area from urban settlements and the grid lines has obstructed this plan. If the geothermal plant in Lake Abbe goes ahead, it is hoped that the two plants could share the same interconnection. This would make the wind plant cost-effective. Wind power projects have also been proposed in other areas, including wind farms of at least 5 MW in Ali Sabieh, Bada Wein, Egralyta and Djibouti City. Smaller systems of less than 1 MW have been identified for Hol-Hol and Yoboki. Small wind systems have also been proposed for isolated areas, although the policy weight in wind tends to back larger-scale projects.

III. ENABLING ENVIRONMENT FOR RENEWABLE ENERGY

3.1 KEY ENERGY STAKEHOLDERS AND INSTITUTIONAL ARRANGEMENTS

The energy sector in Djibouti contains a multitude of players: government bodies and utilities, research institutions, non-governmental organisations (NGOs) and associations as well as the private sector. Some of these play several roles in policy, regulation, financing, knowledge generation and advocacy.

Government/public sector institutions
Ministry of Energy and Natural Resources (MERN), under the Office of the President, is responsible for designing, defining and developing government policy on energy and natural resources. It defines rules, regulations, statutory instruments and legislation for the energy sector including electricity, petroleum products and renewable energy. MERN oversees two important government bodies, EdD and International Hydrocarbon Company (Société Internationale des Hydrocarbures).

Ministry of Economy and Finance (Ministére de L'Economie et des Finances, Charge de L'Industrie et de la Planification) is in charge of industry and planning and sets the electricity tariff. The Directorate of External Finance is responsible for implementing and monitoring new projects. The ministry is also involved in regulating and stabilising oil prices under a liberalised regime.

Electricity of Djibouti (Electricité de Djibouti) (EdD), established in 1960, is a utility owned and run by the state, and has a monopoly on electricity generation, transmission, and distribution. EdD status and duties are defined in decree 83-071/PWEDD of 2 February, 1983. The decree specifies that the State of Djibouti is ultimately responsible for EdD obligations vis-à-vis third parties and suppliers. It also says that the electricity distributed by EdD can either be produced by the utility or by facilities owned by third parties. Electricity tariffs offered by EdD are defined by a decree from the Ministry of Economy and Finance, and subject to MERN review.

International Hydrocarbon Company (Société Internationale des Hydrocarbures), under MERN supervision, is responsible for hydrocarbon imports, processing and operations. Imports are dominated by three international oil companies - Shell, Total and Oil Libya.

Djibouti Social Development Agency (Agence Djiboutienne de Developpement Sociale) (ADDS) was created in 2007. Under the Secretary of State for National Solidarity, ADDS is a financially autonomous public legal entity that implements the National Development Initiative for poverty reduction. ADDS is responsible for the implementation of rural electrification objectives in areas not covered by the EdD grid. The energy component of ADDS work is managed by the Directorate for Rural Electrification.

Djiboutian Agency for Energy Management (Agence Djiboutienne de Maîtrise de l'Energie) (ADME) is a public institution whose mission is to promote energy efficiency and renewable energy in all economic sectors. ADME is responsible for several activities. It communicates knowledge relating to policy development on the rational use of energy. It proposes solutions for reducing the energy bills of

state institutions and homes, recommending best practice. It assists industry in energy demand management, and integrates energy efficiency into industrial management systems. It encourages scientific research and assistance to reduce energy losses. Finally, it develops and ensures compliance with thermal standards for new buildings and old building renovation.

The Ministry of Agriculture (Ministère de l'Agriculture) is in charge of drilling wells in the geothermal sector for instance, as well as for using solar pumps for groundwater wells.

The Geothermal Energy Development Office (Office Djiboutien de Développement de l'Energie Géothermique - ODDEG) established by law 32/AN/13/7ème L January 20, 2014 under the President's office with the aim identifying the various types of geothermal resources of the country, carrying out the exploration work, recognition and study.

The National Energy Commission (Commission Nationale de l'Energie - CNE) was established by a Presidential Decree 11 2009-0218/MERN October 2009. Its job is to help the government plan, implement and monitor the Djibouti National Energy Master Plan, and to update the energy map of the country.

Private sector institutions

A few small private sector suppliers of renewable systems and installers are operating in Djibouti.

The Djibouti Chamber of Commerce (Chambre de Commerce de Djibouti) was established in 1970 by a group of local businesses. It has since evolved to become the principal representative institution of the private sector at the national level. Its main tasks are to represent the viewpoints of economic players, present their opinions and proposals supporting economic prosperity and poverty reduction, and promote development in the Republic of Djibouti. The Djibouti Chamber of Commerce also facilitates trade engagements and helps raise awareness of issues that help strengthen domestic markets among relevant private sector players. It also carries out relevant studies and data collection. It has three departments: consulting, technical assistance and training. All economic sectors are represented in the decision-making body through the General Assembly of 44 elected members and eight executive members who support the president of the Chamber of Commerce. Energy features strongly in the organisation's strategic focus.

The National Investment Promotion Agency (Agence Nationale de Promotion des Investissements - ANPI) was established in 2001. Its goal is to encourage investment promotion in Djibouti through a policy of flexibility in investment operations and development of an enabling regulatory framework and regulatory procedures. As part of its investment promotion and knowledge development role, the ANPI is responsible for promoting investment opportunities and the incentive environment of the Republic of Djibouti. Within its investment remit, renewable energy is seen as an important area to boost economic development and create high quality employment for the economy.

Universities and research institutions

Centre for Studies and Scientific Research of Djibouti (Centre des Etudes et la Recherche de Djibouti) (CERD) is a public scientific institution. It is directly attached to the Office of the President through the Ministry of Presidential Affairs, and provides an institutional framework for researchers, scientists and academics from all specialisms. It conducts studies to evaluate renewable energy potential in Djibouti and carries out pilot research that can feed into the energy knowledge system. The CERD solar laboratory, working under the authority of the Institute of Earth Sciences, has installed a grid-connected 300 kW PV plant, which it monitors and uses for scientific testing.

The University of Djibouti (UNiversité de Djibouti) is responsible for offering training programmes in courses related to energy. It has recently established an engineering department, and is expected to expand its limited training and research capabilities.

3.2 ENERGY POLICIES AND REGULATORY FRAMEWORK

The Republic of Djibouti's Vision 2035 was launched in 2014. This medium and long-term development strategy lays the foundation for future action. It is built on five main pillars: peace and national unity, good governance, a diverse and competitive economy, stronger human capital and regional integration. It takes into account socially important and promising sectors such as education, tourism, fisheries, new technologies and industry. The urgent need to improve and modernise Djibouti's infrastructure is an important aspect of Vision 2035. This would be achieved using public and private sector investments in transport, energy and information and communications technology. In line with previous development strategies, the vision has established a goal to promote renewable energy resource use for electricity generation. The aim is to actively pursue fuel switching measures from fossil to renewable energy. Government objectives include the following:

- increase electrification rates to 60% by 2015
- increase share of renewable energy technologies to 87%-100% of energy mix
- reform the electricity utility
- refurbish and extend the power grid
- establish new interconnections

Off-grid rural electrification objectives in rural areas include the following:

- solar water pumping
- PV and small wind for community services (health and education)
- household PV (30% of rural electrification from solar PV planned by 2017)

Djibouti has no comprehensive energy policy. Policies are under consideration to resolve the country's growing energy needs and its potential to deliver energy from renewables.

Decree 83-0171/PREDD of 2 February 1983 established the specifications for EdD. These set out details concerning production, transportation and distribution, and operation. This was further reinforced by decree 77-079/PR/PM1 of 20 December 1997.

Ethiopian Electric Power Corporation and EdD have a joint PPA. Supply is in the form of power only, and there is no capacity element. The agreement stipulates that the volume of electricity transferred must amount to 246 GWh (2010 consumption). The agreed tariffs for 2011 were USD 0.06-0.07/kWh, depending on time of day and season in Ethiopia (wet or dry).

The EUEI-PDF is conducting two important studies that will contribute to the development of the power sector and the legal framework to underpin its governance. These are outlined below.

A ten-year National Strategy and five-year Action Plan for the development of the electricity sector is under development. This strategy focuses on the approach, responsibilities and sources of finance for conventional and decentralised electrification and for promoting renewable energy sources. Capacity building in the private as well as the public sector at MERN, EdD and ADDS, among others, is considered a central activity to ensure the strategy and action plan is successfully implemented.

The Electricity Law is under preparation. This will have two important functions. It will develop appropriate regulations to promote cost-effective generation, transmission and distribution of electricity. It will set standards for electricity services, determine appropriate tariffs and open up the generation sector to IPPs. This would focus mainly on the design of adequate PPA schemes for the renewable energy sector. Its second function is to define the roles and responsibilities of the various stakeholders, including institutions responsible for their promotion, incentive measures and financing.

The landscape of Lake Assal
Photograph: Government of Djibouti

3.3 FINANCING AND INVESTMENT

Donor assistance funds the majority of the energy sector investments in Djibouti. Eight separate projects are at various stages of preparation/ implementation. These are divided into the following sets of energy sector development programmes: generation, transmission and distribution, and renewable energy development. Many financing institutions fund these projects. These include the Islamic Development Bank, the Investment and Development Bank of the Economic Community of West African States, and the Organization of the Petroleum Exporting Countries (OPEC) Fund for International Development. The African Development Bank, World Bank, UNDP, EU, French Development Agency (AFD), Japanese Government and Global Environment Facility also fund these projects. Government contributions towards these projects take the form of counterpart funding mainly arising from internally generated sources like direct and indirect tax, international trade tax and non-tax revenues. The government also regularly borrows from the international and local financial markets to finance energy projects.

Private player incentives are minimal. Organisations are allowed to produce power for their own use but are not allowed to sell power to any end-user other than EdD. Efforts are under way to set up the regulatory framework and laws to encourage the private sector to enter the renewable energy market. However, more time and confidence building is required to encourage the private sector in Djibouti to invest to renewable energy. Local banks and microfinance institutions are averse to building a portfolio of renewable energy projects since their understanding of and tolerance for technology risk is limited. Moreover, most local banks lack the capacity to plan, structure and appraise a renewable energy project with appropriate financial instruments. Combined with inadequate awareness, this reinforces the perception that renewable energy technologies are too expensive, unreliable and thus too risky an investment.

This may change when the Energy Law comes into force. It may lead to the introduction of a renewable energy fund for providing financial incentives, capital subsidies, production subsidies and equity participation to renewable electricity projects. The sources of finance for the fund will include the National Budget, multilateral and bilateral donors, donations, and various levies.

Finance from the renewable energy fund would also be available for promoting renewable energy projects, for instance, including capacity building for renewable energy development. This would enable the Government of Djibouti to take the opportunity to build the technical capacities of local financial institutions, the private sector and civil society on the business opportunities within the renewable energy sector.

IV. EMERGING ISSUES AFFECTING RENEWABLE ENERGY DEPLOYMENT

Opportunities to develop the renewables sector in Djibouti are explored in this section, which is divided into four subsections. Each focuses on different resources and conversion technologies, known here as service-resource pairs. The status of each particular subsector is reviewed, followed by the issues that need to be resolved. It then concludes with a list of actions recommended by the RRA process.

4.1 GRID-CONNECTED RENEWABLE ENERGY OPTIONS

Reliable and affordable electricity is critical for economic development. This means the grid remains an important means to transform Djibouti's economy and reach large numbers of people at lower cost. Djibouti has particular advantages since its predominantly urban human settlement pattern lends itself to exploiting the grid to widen reliable electricity access. However, as in a number of African countries, the grid in Djibouti faces formidable technical, institutional and financial barriers. The lack of reliable, affordable power is seriously obstructing investment in Djibouti. It limits the growth of critical productive sectors such as industry and fishing. Over the past few years, several renewable energy technologies have become increasingly cost-competitive. Their development represents an important opportunity for countries like Djibouti to diversify their supply options. This section considers geothermal, wind and PV technologies for Djibouti's power sector, as they offer high short-term deployment potential.

Geothermal power

Exploration of geothermal energy in Djibouti goes back a long way, as it has the potential to solve the country's long-standing power generation problem. However, geothermal energy has yet to be developed to provide electricity in Djibouti. In 1987, the World Bank carried out some exploratory drilling along with the Government of Italy, AfDB, UNDP, United States Agency for International Development and the OPEC Fund. It produced follow-up plans to develop and construct the geothermal power plant that Djibouti needed because of a failure to achieve consensus on project design. In the latest effort to develop the country's geothermal potential some 25 years later, a number of lessons were learnt from the aborted 1987 geothermal project. One is to smooth donor activity coordination and produce a highly developed but simplified project design to ensure co-financing. Another is to put in place assurances that guarantee payments to the IPP. Since 1987, progress has been made in geothermal power technology. This means conditions in the Assal Rift in Djibouti are more viable, and enables more advanced and complete field testing in the area. The World Bank recently financed the Menengai geothermal project in Kenya with a capacity of 400 MW. This large-scale geothermal project could have a catalytic effect on geothermal resource development in the East African rift system. Djibouti is building strong technical capacity that can be deployed to serve the sector's human resource needs.

Djibouti's plan to construct a geothermal power station with a total capacity of 50 MW is one of the projects currently planned across the sub region. In assessing the commercial viability of the project, the assumptions used by the World Bank to

undertake the financial analysis are provided in table 3. The exploratory stage of the project, amounting to about USD 31 million, is funded by AfDB, World Bank, OPEC Fund, the Energy Sector Management Assistance Program, Global Environment Facility and AFD. This finance will cover the riskiest part of the geothermal power generation project with concessionary funds to ascertain the commercial viability of the resource in the Lake Assal area. This could provide the necessary incentives for an IPP to develop the 50 MW power plant. However, it is not yet clear whether the government will underwrite this sunk cost to encourage IPPs to take the project forward.

Although Djibouti is importing about 60% of its power from Ethiopia, it still relies on imported oil to generate about 30%-40% of its power needs. Table 3 shows that geothermal power plants could significantly reduce the cost of generation by a margin of nearly USD 0.20/kWh, compared to the heavy fuel and diesel now in use in Djibouti. Geothermal projects produce energy for decades at stable, affordable prices, which reduces price volatility. This helps avoid the price spikes and energy crises that often impose severe economic penalties on business and local communities.

Table 3: Costs and assumptions for financial analysis[3]

Activities	Costs and assumptions
Exploratory drilling over a three-year time frame	USD 31.2 million
Capital expenditure for geothermal field development for a 50 MW plant (*i.e.*, USD 3.62 million per MW installed). Includes expenditure for the first three years of exploration.	USD 181 million
Capital structure of the IPP: base case Interest on the debt portion	70:30 debt-equity ratio 6% per year over 15 years
Required rate of return on equity	15%-25%, with the main case for the prospective IPP project being 20%
Geothermal plant capacity factor	90% capacity factor = 394.2 GWh
Operation and maintenance costs	USD 9.2 million per year
Depreciation of capital assets	30 years
Initial working capital	USD 5.4 million
Taxes	Ten-year tax holiday, and a corporate income tax of 25% applying in subsequent years
IPP to break even at an electricity tariff	USD 0.0875-0.0910/kWh

Source: World Bank (2013)

In addition to its low environmental impact compared to other baseload power sources, a number of other attributes make geothermal energy attractive. Its high capacity value and capacity factor are very reliable. The history of successful geothermal exploitation in other parts of the world demonstrates both the reliability of the resource and the dependability of the technology.

Geothermal power production creates a variety of jobs across the project chain. A recent study by IRENA (2013) and Rutovitz and Harris (2012) provided further details on employment factors[4] and regional multipliers.[5] Employment factors for geothermal plants for manufacturing, construction and installation (C&I), and O&M are 3.9, 6.8 and 0.40 job-years/MW respectively. To account for variations in labour productivity, regional multipliers can be used. The multiplier for Africa is 4.3.

[3] It is important to remember that Djibouti has no experience of geothermal power generation. A 50 MW overall project in the Philippines will cost at least USD 250 million, and that is a mature and experienced geothermal environment. Since Djibouti has never developed a geothermal project and has had payment problems in the past, the debt-equity ratio could be around a 60:40. With higher capital expenditure, the IPP break-even point could rise to USD 0.11-0.13/kWh.

[4] This covers the number of jobs necessary to manufacture, construct and install one unit of renewable energy generation capacity. The number of jobs per unit of capacity is typically much lower for O&M than for manufacturing, construction and Installation, although this will vary according to technology.

[5] Regional multipliers, relative to OECD countries, are used to account for differences in labour productivity between different regions of the world (IRENA, 2013; Rutovitz and Harris, 2012).

Using the above employment factor without the regional multiplier for Africa, a 50 MW geothermal plant could generate no less than 1 462 job-years in C&I and 35 jobs in O&M[6] in Djibouti. Achieving Djibouti's geothermal potential of 300 MW could deliver 8 770 job-years in C&I and 210 jobs in O&M. In a country like Djibouti where unemployment is very high at about 60%, geothermal energy and other renewable energy projects can provide benefits beyond energy service provision. A stable and reliable energy supply base and affordable energy market can have a significant impact on the wider economy, both by creating indirect jobs and cutting energy costs for businesses.

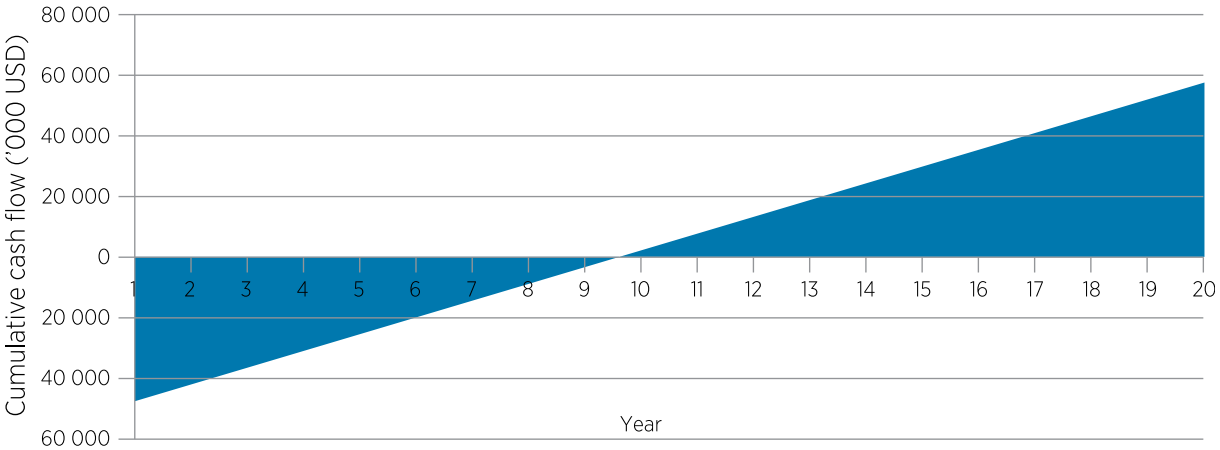
Improving its self-generation capability enables Djibouti to enter the regional power market as a power seller as well as purchaser, strengthening its strategic position. Geothermal and other renewable energy resource development provide Djibouti with a route to sell baseload geothermal power to Ethiopia during the dry season. This is when Ethiopia's hydropower generation is restricted and thermal generation may be required to meet dry season power demands. As indicated above, Ethiopia's dry season corresponds to Djibouti's low demand winter season. This creates a potential market for Djibouti's geothermal power through Ethiopia to other foreign markets connected to Ethiopian grid generation.

On-grid wind

There are no grid-connected wind power generators in Djibouti. However, recent wind resource studies have confirmed that it hosts several excellent wind energy sites. Four of these show excellent potential, and the economic case for investing in them is being made at the moment. Two projects in the pipeline are worth discussing. The first is an agreement between Qatar Petroleum International and the Government of Djibouti to build a 60 MW wind farm. A memorandum of understanding was signed in late 2013 to evaluate the plans for this project. The second project is known as Producing Safe Drinking Water and Renewable Energy (Projet d'Eau Potable et de l'Energie Renouvelable). It relates to the agreement through which the EU provides 90% funding for a EUR 46 million (USD 55 million) wind energy and water desalination plant in Djibouti. The plant will initially have a capacity of 22 500 m^3/day, which will be expanded to 45 000 m^3/day during the follow-up phase. The new plant should provide sufficient water for 200 000 people, over one quarter of the population. Further initiatives are planned, including a memorandum of understanding with Ethiopia for the exploration and import of water. From an energy standpoint, the interesting aspect of the desalination initiative is the 20 MW wind farm, which is expected to supply much of the power. It will be built during the second phase of the project.

Given the relatively good wind regime in Goubet, a pre-feasibility analysis for grid-connected wind power generation was carried out by the project developers. It had a reference capacity of 20 MW (63 kilovolt amps) with an annual generation rate of 82 GWh and system cost of USD 2 500/kW.[7] The analysis showed a payback period of about 10.7 years for a system that will operate for 20 years, feeding the grid at the cost of USD 0.075/kWh (see figure 10). The levelised cost

Figure 10: Cumulative cash flow and payback period



[6] Manufacturing has been omitted from this calculation given that much of the technology is likely to be imported, at least in the short term.

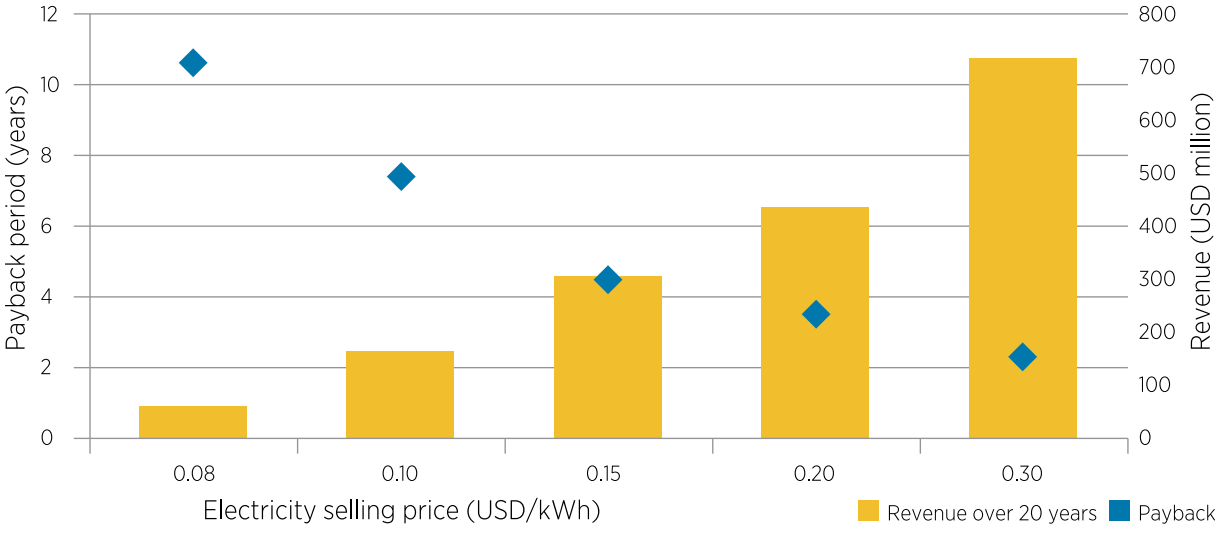
[7] **Assumptions:** capital range = USD 2 500 to USD 3 100/kW; annual O&M cost = USD 105/kW (for 20 MW plant); project time = 20 years; inflation =2%; discount rate =12%.

result was also encouraging at USD 0.056/kWh. This illustrates that the large wind system can generate electricity at a rate competitive with the incumbent generation system. However, the payback period is on the high side, which means the IPP would take longer to recover its investment. Shortening the payback period may require increasing consumer electricity tariffs.

Further analysis was made using two separate scenarios where the system is connected to the 230 kV transmission and to a new 63 kV system. In both cases, the capital cost would rise to around USD 3 100/kW and USD 2 900/kW respectively. This yields a payback period of about 13.1 years for the 230 kV and 12.4 years for the new 63 kV system, and levelised costs of USD 0.065/kWh and USD 0.060/kWh respectively. Alternatively, the system would continue to depend on cheap but not entirely reliable electricity from the Ethiopian interconnection or through the EdD thermal plants, which are costly ways of generating power. The wind system solves the twin problems of reliability and cost.

The financial viability of IPPs depends on the agreed price at which they can sell power to the national grid or end-users. At the moment, there is no arrangement in Djibouti allowing organisations to produce power to sell as their core business activity. Figure 11 shows that the payback period for the 20 MW wind power system varies significantly according to the selling price of power. The same applies to revenue that can be generated under different pricing regimes working on the basis of predetermined stipulations over a number of years. Strong offtake agreements enable operators to make sufficient money to service their debts and operate their systems. Clearly, such agreements need to strike a balance between affordability for businesses and the general public, and financial stability for private operators. This must not only allow them to stay in business but also generate enough revenue to invest in upgrades and expansions. These will be critical concerns as the Government of Djibouti prepares its electricity laws and energy strategies in line with Vision 2035.

Figure 11: Cumulative revenue and payback period at different electricity selling prices (in USD)



Wind power in Djibouti can be harnessed to support a range of productive sectors such as fishing. This remains underdeveloped in Djibouti largely due to a lack of energy services for cooling and processing. Ice-making and chilling is energy-intensive, but Djibouti has the energy resources to kick-start an industry that could generate much needed employment opportunities and significant economic benefits.

Wind power generation offers an opportunity to improve the electrification rate by diversifying and harnessing the use of locally available resources. This is aligned with the government's aspirations in Vision 2035 to boost the energy infrastructure to transform social and economic conditions. Djibouti has considerable wind and other renewable resources but has yet to develop policies or an investment climate adapted to renewable energy development and implementation. Initiatives to stimulate investor confidence would need to include appropriate measures like a Feed-in Tariff (FiT), a waiver on import sales tax and corporation tax breaks for renewable energy developers. Major efforts will be needed to build an efficient administration and management capacity in government agencies, and to strengthen engineering, business, finance and contract negotiations skills across the knowledge institutions. The much awaited new Energy Law is expected to resolve some of these fundamental shortcomings.

Lake Abhé
Photograph: Government of Djibouti

Wind can create some direct employment, although much of this will remain in the manufacturing stage of the energy value chain. Employment factors for wind plants in manufacturing, C&I and O&M are 6.1 job-years/MW, 2.5 job-years/MW and 0.20 jobs/MW respectively. Using these factors and the regional multiplier for Africa of 4.3, a 20 MW wind plant can generate as much as 215 job-years in C&I and 17 jobs in O&M[8] in Djibouti. Djibouti has major potential for significantly scaled up wind energy development. This could bring further benefits in terms of direct and indirect jobs, but also to the wider economy. However, the effect of local weather conditions[9] on wind turbines should be carefully considered when deciding on the size of systems and type of turbines.

[8] Manufacturing has been omitted from this calculation given that much of the technology is likely to be imported, at least in the short term.
[9] Djibouti experiences strong dust and sandstorms during the summer months. Dust, sand and temperature extremes can cause failures and increase the frequency of repairs and maintenance to wind turbines.

Box 1. Djibouti: From energy importer to transcontinental transmission hub

Djibouti intersects two continents linked by history and trade. Energy could be traded across the Red Sea, and Djibouti could become the bridge between two important power interconnections, EAPP and the Gulf Cooperation Council (GCC) interconnection. The objective of the interconnection is clear. It is intended to increase diversity both in generating stock and in timing energy demand by the load. Larger systems require proportionately lower percentages of reserve margin. They are able to take advantage of any load diversity that may be brought about by differences in the industrial or residential energy use patterns (Tabors, 2009).

A number of developments bring into sharp focus the potential role Djibouti could play in transcontinental power trade. These are outlined below.

- EAPP launched its master plan in 2011. This pointed to 12 new interconnection projects and an additional 20 000 MW planned for the medium term (53% from renewables). This does not include the Inga dam in Democratic Republic of the Congo.
- In 2010, cross-border electrical trading through the interconnection network took place for the first time in the GCC region. This involved Saudi Arabia, Kuwait, United Arab Emirates, Bahrain, Oman and Qatar but not Yemen.
- Electricity demand in GCC countries has risen rapidly over the past 20 years and will continue to rise sharply. Power is mostly generated from oil and gas plants.
- GCC greenhouse gas emissions have rapidly increased in the last 20 years. The rapid rise in energy demand and predominance of fossil fuels in the electricity mix has been largely responsible for these increases.
- The majority of the utilities within the GCC have heavily subsidised retail electricity rates. Except for Qatar, this places countries under extreme pressure as natural gas becomes increasingly valuable in the international market. Some countries have even begun to import coal. Marginal cost of peak electricity varies by country: for Kuwait it is USD 0.19/kWh, Saudi Arabia USD 0.22/kWh, Bahrain USD 0.10/kWh, Qatar USD 0.09/kWh and Oman USD 0.23/kWh.
- Discussions have recently started for Ethiopia to supply power to Yemen through a submarine transmission line via Djibouti. Yemen has an installed capacity of about 1 200 MW but delivers around 840 MW. This amounts to a 30% loss due to an ageing distribution grid. Power is heavily subsidised. The average tariff is around USD 0.06/kWh, but average operating costs for the utility are around USD 0.12/kWh. Furthermore, capacity will need to grow to over 3 000 MW by 2020 to meet demand. Only 30% of Yemenis currently have access to electricity.

Energy access and security in Yemen, fuel trade-offs and high carbon emissions in the rest of the GCC are important concerns relating to individual national circumstances. The interconnection could improve energy security and reduce greenhouse gas emissions, providing that electricity is generated from renewable sources or other low emission options. Herein lies the opportunity for Djibouti to serve as a transcontinental transmission hub. This would further enhance the nation's strategic significance in regional energy and integration, and strengthen its negotiating hand on matters related to energy. African countries with surplus power will benefit from a new market opening up for green energy and become important players in the decarbonisation effort of Arabian Peninsula countries. GCC countries in particular would benefit by improving their climate change record while acquiring affordable electricity, especially for Yemen. This initiative has all the hallmarks of a win-win situation, but further studies are required to map out the benefits and costs for each player. Scenario work would also go some way to gain a better understanding of the dynamics between a range of variables.

On-grid PV

Djibouti has outstanding solar resource conditions and thus offers the opportunity for deploying a range of solar technologies as utility-scale plants as well as in distributed end-use applications. The cost of PV technology has rapidly fallen across the world, enabling grid-based PV to achieve grid parity in a number of markets. It is fast becoming a genuine alternative for countries faced with the twin challenges of energy access and energy security. PV module prices have declined sharply from USD 3.70/kW in 2009 to USD 1.20/kW in 2012. They may fall yet further to USD 0.5/kW, making the balance of system a crucial determinant of solar PV system costs (IRENA, 2013). These trends make PV a compelling product for end-users in countries like Djibouti looking to diversify their energy sources and build resilience into their energy system.

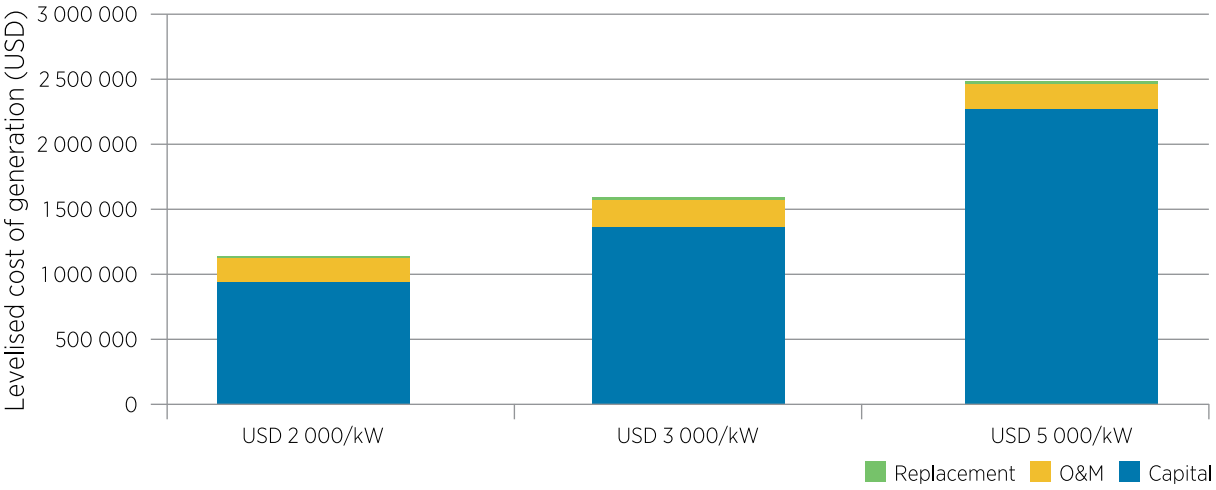
There is some experience of PV systems in Djibouti, but it is restricted to the off-grid PV sector. However, with the help of the Japanese Government, Djibouti has recently installed a 300 kW PV system supplying energy to the CERD campus and feeding the surplus to the grid. Given the specific vulnerabilities of Djibouti's power sector, policy makers are becoming more and more interested in exploring the considerable economies of scale associated with PV grid developments. The grid-connected pilot project offers an excellent demonstration of the opportunities and constraints associated with PV as a possible large-scale option.

A cursory evaluation of the pilot project raises a number of important features of PV-grid systems in the Djibouti context. In the 12 months following its launch in January 2012, the PV power plant generated 508 MWh of electricity. About 158 MWh of the energy produced is consumed by the CERD buildings and the surplus 350 MWh fed to the EdD network. The system's energy balance showed that CERD annual energy consumption amounted to about 438 MWh. This means the PV plant could meet its entire buildings energy demand, except during the peak summer months (June to August) when this exceeds the amount produced by the PV system.

The PV project cost was estimated at about USD 5.9 million (JPY 610 million). This equates to about USD 20 000/kW, which is very expensive. However, the costs may contain other expenses related to official development assistance that may not be clear to outside observers. For this reason, a separate analysis is needed to provide other estimates closer to the market prices. Today, solar PV installed costs in non-OECD regions for utility-scale projects are USD 2 000-7 000 kW. If these figures are applied, PV in Djibouti could be cost-competitive, especially for larger PV systems where the benefits from economies of scale can be significant.

The cost of the above system has been recalculated using market data on PV systems and real economic data from Djibouti.[10] Figure 12 shows the result of this analysis. The levelised cost results showed a wide variation depending on the capital cost of the system. This ranges from about USD 1.1 million to over USD 2.5 million over the system lifetime (figure 12). When viewed in terms of levelised costs

Figure 12: Levelised cost of generation with PV (comparison at different system costs)

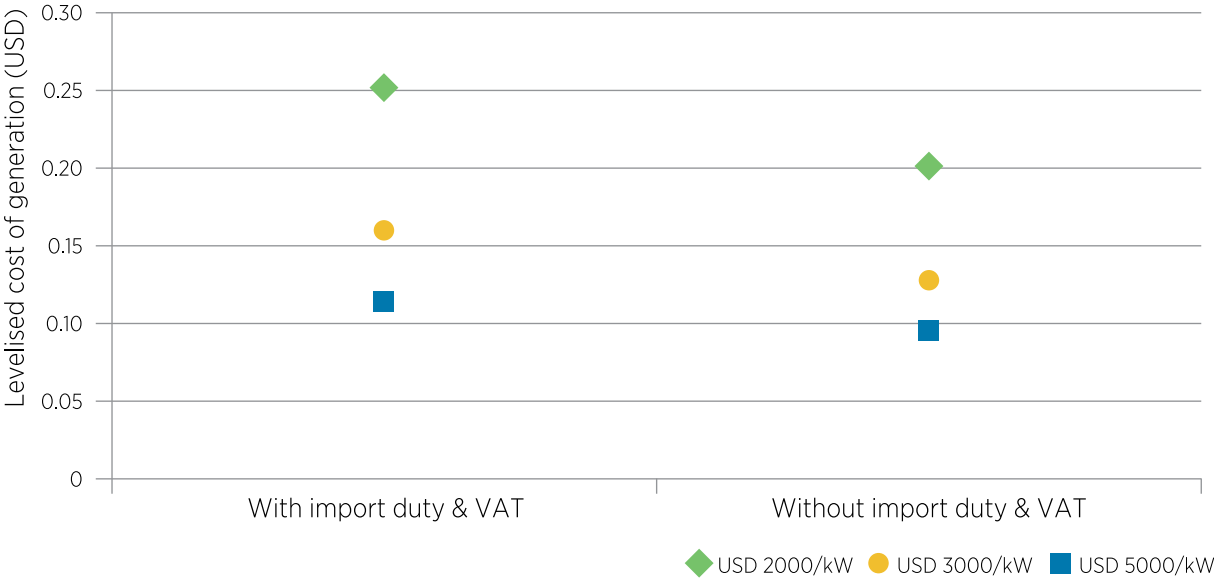


[10] **Assumptions:** capital range = USD 2 000-7 000/kW; annual O&M cost = USD 40/kW (for 300 kW plant); import duty = 26%; VAT = 7%; project time = 20 years; profit margins = 15%; inflation =2%; discount rate =12%. Adapted from IRENA Renewable Power Generation Costs in 2012 where solar PV installed costs in non-OECD regions for utility-scale projects gives an average value of USD 3 000/kW and a range of USD 2 000-7 000 kW

in kWh, a generation cost of USD 0.11-0.25/kWh is obtained (figure 12). This illustrates that larger PV systems can bring economy scale benefits, making them competitive against fossil-based electricity which at present has a generation cost of about USD 0.30/kWh in Djibouti. On the face of it, this makes the PV option attractive from cost and security of fuel supply considerations. Of course, there are other important considerations such as the high initial costs of PV systems whereas fossil-based systems have higher recurrent costs over the system lifetime. However, as the cost of PV systems continues to fall, their value as a reliable and cost-effective option for power generation increases, particularly during daytime peak electricity demand.

There are two other important features that may impact on the viability of PV as part of a long-term energy strategy for Djibouti's power sector. Firstly, the country still has high tariffs on all imports at 26% and VAT at 7%, which also applies to PV systems. As shown in figure 13, the levelised cost of generation of systems charged import tax and VAT on top of the initial cost differs significantly from those that are not. This means the generation cost can rise with more expensive systems. If the provision of affordable electricity is an important goal, then regulation needs to reflect this. A resolution exempting PV-system components from import duties and VAT would go some way to levelling the playing field between market-based PV systems and those benefiting from donor support such as the one discussed above. Reducing import tariffs cuts the costs of grid-connected PV systems and renewables, so it would also make these technologies more affordable to EdD. Of course, such waivers are intended to help end-users in the short term, but may undermine the emergence of a commercially viable local PV manufacturing industry. Although Djibouti may not be quite ready for this leap, the country may consider a research, development and deployment strategy that would consider manufacturing some of the PV components locally. This requires other reforms and policies that link science and technology with industrial development.

Figure 13: Levelised cost of generation of different import duty levels in Djibouti (in USD)



The second important feature affecting the financial viability of grid-based PV relates to the agreed selling price of electricity to the distributor or end-user - in this case EdD. At present, EdD imports power from Ethiopia at a tariff level of USD 0.06-0.07/kWh and sells power to various users at USD 0.153-0.426/kWh depending the user type. Employing these figures and a range of system costs, the payback period of the 300 kW system has been estimated if electricity was delivered to EdD. Table 4 illustrates the extent to which this is a major factor, showing that the selling price of electricity would need to be at least USD 0.15/kWh if the payback period for the system is to be within the project timeframe of 20 years. This indicates that for PV options, the introduction of enabling instruments such as a FiT may be necessary attract investors.

Table 4: Payback years for 300 kW PV system, using different system cost and tariff figures

System Size / Selling Price	USD 2000 /kW (w/o import duty & VAT)	USD 2000 /kW (with import duty & VAT)	USD 3000 /kW (w/o import duty & VAT)	USD 3000 /kW (with import duty & VAT)	USD 5000 /kW (w/o import duty & VAT)	USD 5000 /kW (with import duty & VAT)
USD 0.30/kWh						
USD 0.20/kWh						
USD 0.15/kWh						
USD 0.07/kWh						

Key: yellow:7 years or less; light green: 7-10 years; dark green: 11-15 years; purple: 16-20 years; grey: more than 20 years

The dust deposited on the PV panels is proving challenging. It is estimated that four grammes of dust per square metre can reduce a solar panel's efficiency by 40% (Gastli and Charabi, 2011). While Djibouti enjoys excellent solar radiation, sand and dust movements create problems, requiring regular panel cleaning. This is especially difficult during the Khamsin months of June to August. The CERD plant is wiped with a dry cloth each day except during rainy months, and distilled water is used two months of the year for cleaning. Using distilled water to clean a large solar plant of 5 200 m^2 can be expensive and labour-intensive. In a country like Djibouti with low rainfall, advanced surface coatings and advanced cleaning techniques would go some way to solving this problem. Research and development in this area is currently under way, and most countries in North Africa and the Middle East stand to benefit from innovations in this field.

RRA findings

The RRA process has highlighted a number of technical opportunities and barriers facing the renewable generation and transmission infrastructure in Djibouti. The process also brought to light some of the institutional, financial and capacity issues associated with geothermal, wind and PV power generation to feed the grid. These are discussed below.

Long-term energy plan essential

A long-term energy plan is essential for Djibouti. Such a plan should encourage energy efficiency, and help develop clean, reliable and affordable energy systems that Djibouti will need today and into the future. As Djibouti plans its energy needs for the next 20 years to support its Vision 2035, efficiency will be an important resource to be considered. It is the cleanest and most cost-effective energy resource, and it enables consumers to reduce their energy bills. On the supply side, Djibouti has significant renewable energy resources for a country of its size. Harnessing these resources to meet growing energy needs, both domestically and across the region, should be an important component of a long-term energy plan.

The RRA has revealed that a master plan for the production and transmission of electricity is under preparation in Djibouti. Those preparing the master plan would need to integrate the demand and supply side of the energy picture in Djibouti as well as coming up with short and long-term plans. These should consider multiple technology fronts, and ultimately align the range of options as part of the country's long-term energy pathway. The master plan should stimulate investment interest from the private sector and also strengthen the country's case for support from development partners.

National policy on renewable energy needed

Djibouti has no energy policy. As the energy situation in the country becomes more pressing and opportunities become clearer, a policy addressing energy access, affordability, resources and regional integration is now recognised as an important step. The RRA has underlined that widening energy access is a central national development objective in Djibouti. At present, about half the population benefits from access to electricity. Lack of access is especially acute in rural areas where less than 5% enjoy electricity in their homes. In addition, the RRA also raised concerns over energy security and high electricity tariffs largely caused by the high cost of imported fuel but eased noticeably by electricity from Ethiopia. These multiple challenges have helped provoke an important discussion on electricity from renewables as a significant contribution to closing the supply gap. To this end, Djibouti requires an energy policy that embraces renewable energy as a key component of a longer-term energy vision with a systematic road map for delivery. Djiboutian policy makers and potential investors are engaged in several discussions on grid-based renewable energy. However, the

country needs to rapidly move away from ad hoc projects to well-coordinated programmes, and to encourage investors and entrepreneurs to come forth. Clearly, renewable energy technologies are achieving grid parity in many parts of the world. With the right policy framework supported by strong regulatory instruments and functional institutions, Djibouti stands to benefit significantly from technology innovations and a new appetite for renewables investment.

The RRA has disclosed significant ambition within Djibouti's leadership to extract the country's ample renewable energy resources to meet national development goals. Declarations to achieve energy security through 100% renewable energy supplies are part of the energy narrative at the highest level in government. However, there are neither specific guidelines nor a road map to realise this ambition. The RRA process makes clear that this vision needs to be firmly embedded in the upcoming energy policy for the country. It needs to be supported by specific studies and analysis. These need to demonstrate how the 100% renewable energy ambition can be achieved in reality, what the cost implications are likely to be, and what options need to be considered for financing. The master plan under preparation should consider these demands, which clearly have strong political support, as the discussions during the RRA process have shown. Vision and ambition needs to be complemented by real policies and implementation mechanisms to deliver meaningful results.

Strengthen legal system and regulatory framework

Djibouti has no robust or clear legislative and regulatory framework to govern electricity production. The RRA process has shown the lack of regulation and legal instruments is a major obstacle, especially in constraining the participation of non-state actors such as IPPs and other self-producers in power provision. At present, EdD is the sole distributor of power, and any other entity is not permitted to engage commercially in the supply of electricity. However, it was not possible to locate a legal document that clearly specifies the limits to private sector participation in the power sector. This vagueness in the law still prevents entities other than EdD from entering the energy market.

Given these concerns, the Government of Djibouti is working alongside development partners to reform the legal and regulatory framework to enable private investment without undermining the public interest. With the assistance of EUEI-PDF, a draft Electricity Law is under preparation. It covers tariff setting, licensing, incentives to attract private sector investment, and the roles and responsibilities of various stakeholders. The law will address electricity generation and imports. Other legislative elements could also be introduced to enable renewables to gain traction in the energy market in Djibouti.

Renewables are generally perceived as more expensive when compared to conventional systems, although this perception is changing fast. The technical suitability and economic viability of integrating renewables into the grid go hand in hand. Pricing policies have been designed to improve their competitiveness and drive investment into the renewable energy sector. A FiT scheme is one way to meet this challenge and the preferred option of Djibouti. However, it is not clear whether this is one of the options the EUEI-PDF electricity law and strategy study will consider. The design of the FiT is based on the avoided cost methodology, given the fact that electricity generation is based on imported fossil fuel subject to market fluctuation. Given the high cost of fossil-based generation, an appropriate FiT could act as a major stimulus to the emergence of IPPs in Djibouti's energy market. As shown in the analysis of wind, PV and geothermal systems, two important factors support this proposition. Firstly, Djibouti has considerable renewable resources, and secondly, the cost of renewable technologies has dropped significantly. Provided the legal and regulatory conditions are in place, these two factors play to Djibouti's advantage, allowing it to generate renewable power at a lower cost than fossil-based systems. Appropriately designed and negotiated FiTs would go some way to set rates attractive to both private players and end-users.

Build up research and development institutions

At least in the near term, Djibouti will depend on technologies and to a certain extent expertise from abroad. At the same time, Djibouti will need to work to strengthen and develop its human capacity and upgrade its energy innovation systems to support domestic technology adoption and development. CERD and the University of Djibouti could play important roles in supporting capacity development among practitioners, researchers and policy makers. These knowledge institutions could also support the manufacture of components through training, information sharing, technical seminars and demonstration projects. This would raise the confidence of both development partners and private sector actors who are in a position to provide grants for projects and invest in profit making energy ventures.

The role of institutions like CERD should go beyond research and development in technology development, adoption and dissemination. Data and information on energy consumption in Djibouti are weak at best, and data available in different institutions lack consistency. This makes it notoriously difficult to plan, develop and implement energy efficiency measures. Data also need to extend towards the supply side. Inadequate data on solar and wind energy resources are a major obstacle to attracting investment due to the difficulties in developing rigorous project proposals. An institution like CERD could play a pivotal role as data centre. This would also allow it to build the required human and technical capacity for regular energy demand surveys and renewable energy assessments, both for the government and other clients. Development partners and organisations like IRENA could play a critical role in providing technical support and training to CERD or a relevant institution acting as energy intelligence hub.

Provide business incentives and develop skills

The Government of Djibouti has made considerable efforts to improve the business environment and reduce the high cost of production. 'Doing Business 2014,' a World Bank report (2014), recently ranked Djibouti at 160 out of 185 countries. While this is an improvement from the 2013 report (172), entrepreneurs still face high production costs in addition to the problems of access to energy, water, skilled workforce and telecommunications. It is therefore not surprising that the business environment for renewable energy in Djibouti remains weak. Signs of improvement are visible with the emergence of the master plan and work in progress to improve the regulatory and legal framework governing energy. The state should play a vital role in encouraging the private players, protecting the public interest and introducing transparent processes by taking measures described below.

Adequacy of tax incentives for investors in energy

The country's import tariffs and VAT make renewable technologies expensive and therefore obstruct the domestic private sector from entering the energy market. The government's 26% duty on imported goods and 7% VAT includes renewables and creates barriers to private actors. The RRA process and discussions with Djiboutian entrepreneurs has revealed that removing duties is an important financial incentive. It would encourage serious entrepreneurs to do business in the renewables market.

Djibouti has the added advantage of a stable monetary system with no major currency problems. The Djibouti Franc is 'pegged' to the US Dollar. Anyone is entitled to open an account in Djibouti. Further, there is sufficient liquidity in the banks but there are not enough energy projects coming from the private sector. This is largely to do with uncertainty in the sector and a weak regulatory framework.

Quantify direct and indirect employment

Unemployment is high in Djibouti. This will remain a difficult development issue given that the economy largely relies on service and logistical sectors, which are not labour-intensive. This concern is raised in Vision 2035, within which industrial development and regional integration is seen as an important way to add value to exports and meet the challenge of unemployment. Furthermore, Djibouti's ambition to become the largest logistics hub in Africa using 100% green energy is likely to bring both direct and indirect energy jobs due to energy security. Further research is required to quantify the benefits in terms of local jobs in the energy sector itself under a range of energy expansion scenarios. Econometric studies are also needed relating energy security to the broader economic benefits for Djibouti.

4.2 OFF-GRID RENEWABLE ENERGY OPTIONS

In line with its Vision 2035, the Government of Djibouti places a premium on providing its citizens with access to electricity. Given an electrification rate of about 55% at present and increasing demand for power for social and economic development needs, widening energy access occupies an important policy space in Djibouti. Ambitious targets are currently proposed with a focus on communities that may not be able to obtain grid electrification in the near future.

To this end, an integrated approach will be needed to balance needs, population distribution, costs and resources as well as an understanding of the limits of conventional grid extension. Various small-scale, renewable energy technologies like solar PV and wind are maturing commercially, along with new and innovative service delivery mechanisms. This means off-grid electrification has emerged as a viable alternative for electricity access.

Djibouti has some experience with off-grid PV electrification in clinics, schools, households and water pumping. Each of these is explored below.

Off-grid PV electricity

The main decentralised renewable energy promoted in Djibouti is PV solar, either as a stand-alone or mini-grid system. A recent project supported by the World Bank is worthy of discussion, mainly because it proposes an ambitious and comprehensive plan to widen electrification for rural communities. This study by the World Bank Public Private Infrastructure Advisory Facility (2014) looked at a variety of business plans for a range of income groups and community energy needs. These include mini-grids, stand-alone and battery charging systems (table 5). The first two options are briefly reviewed below.

Mini-grid

The analysis showed that the initial investment required to set up mini-grids in each of the villages is USD 0.3-2 million, depending on size and daily energy requirements. The total cost of this mini-grid programme is estimated at USD 11.5 million. The unit cost for installed capacity is around USD 4-6/kW. This is on the high side but within the margins encountered in other similar programmes.

The analysis also identified O&M as an important cost consideration and critical for the long-term success of mini-grid programmes. It was therefore assumed that over a 20-year period, replacement costs will be incurred for inverters once and batteries twice, as well as labour costs. This will bring the O&M costs to USD 0.20-0.23/kW for systems in large villages.

Stand-alone systems

The regions of Obock and Tadjourah are proposed as the first non-concessional areas to offer stand-alone PV systems. For the first phase of deployment of stand-alone and pico-solar systems, low income sedentary and nomadic communities (representing 65% of the total population considered) were proposed as targets. It is possible that the demand for pico-solar is greater in such areas. However, there may also be high demand from homes and businesses in towns looking to supplement their energy use through pico systems. Pico-solar products are defined by their availability over the counter, requiring little support for installation. They suit semi-nomadic or nomadic lifestyles.

Table 5: Stand-alone and pico systems

Size	Type of system	Average selling price (USD)	Targets (number of units)	% of total
50 Wp*	Solar home systems	600	400	15.0%
100 Wp	Solar home systems	1 050	200	7.5%
250 Wp	Solar systems for enterprises	2 250	60	2.3%
Solar lantern	Portable	50	1 000	37.6%
Micro stand-alone		120	1 000	37.6%
Total number of units			**2 660**	

Source: World Bank Public Private Infrastructure Advisory Facility (2014)
*Watt peak

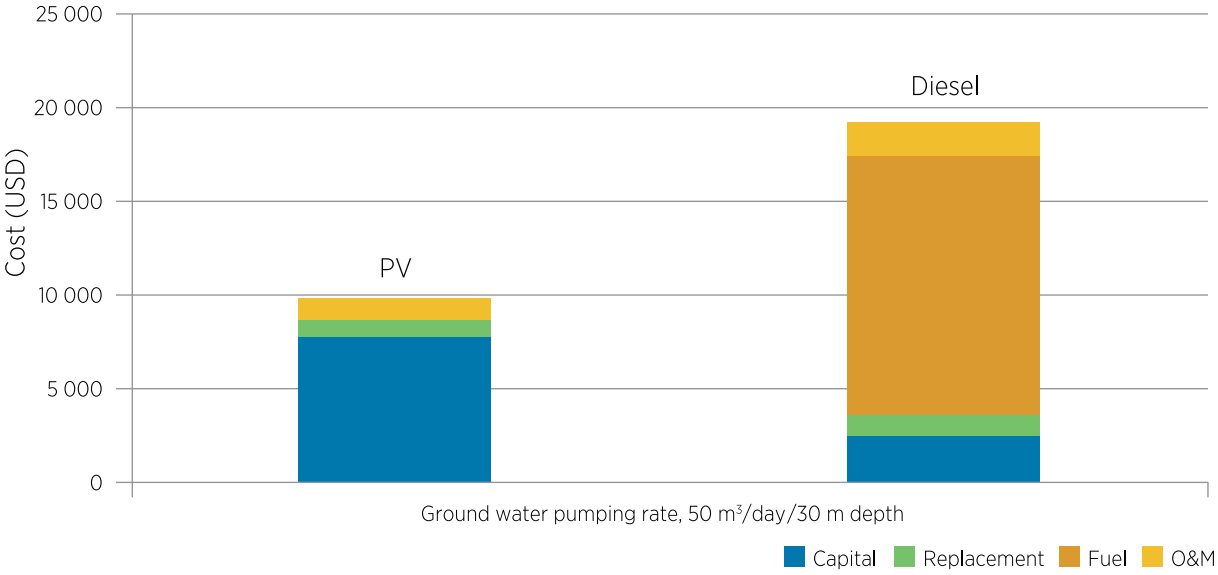
Three matters need to be noted here. Firstly, the off-grid option using renewable energy is cost-competitive with the traditional diesel system. At present, the life cycle cost of operating an off-grid diesel system over a 20-year period is USD 0.55-0.75/kWh, mainly due to the costs associated with fuel imports and transport. A PV option or hybrid (PV/diesel) system would compare favourably with this. Secondly, rural Djiboutians tend to have little cash. This means rural electrification cannot rely on the backing of the private sector alone. Government involvement will remain critical, so the government is working through ADDS to fill this gap. This means cost-saving opportunities are central to this effort. Thirdly, rural areas have little technical capability, which means ADDS will need to double its efforts to bring in private sector entrepreneurs for systems installation and maintenance.

Off-grid PV water pumping

In Djibouti, groundwater sources account for about 95% of the drinking water needs, so energy use for pumping water is a critical input to water access. Diesel generators, PV systems and a few wind pumps are currently in use. The government has also announced its intention of equipping 70 rural boreholes and 100 other wells with solar pumps.

The source of the energy used is critical to the overall cost of waterpumping systems. As PV technologies are coming down in price and the volatility of the fossil fuel market increases globally, PV pumps are rapidly becoming increasingly attractive options. However, further cost analysis of the individual technologies is critical to assess their viability in different parts of Djibouti. In some areas where the wind speed is favourable, mechanical wind turbines could be attractive options. A life cycle cost analysis conducted for Djibouti using country-specific data showed that over the longer term PV performs better than diesel (figure 14) and provides more stable water supply.[11] This illustrates the emerging trends in prices and technology development favouring PV over diesel, and is likely to continue into the future.

Figure 14: life cycle cost for pumping groundwater, comparison between PV and diesel



The need to provide water services is not limited to the household sector, but also extends to commercial and productive sectors. Djibouti is pushing to improve its agricultural sector to boost food security. This means affordable and reliable energy for pumping water for irrigation could play an important role in sustaining agriculture as a meaningful economic activity. Further work will be needed to assess the case for irrigated agriculture for food security as well as for employment generation.

Off-grid wind power

Wind power for rural electrification using stand-alone and mini-grid delivery systems has come a long way. With more data and site assessments taking place in Djibouti, it is becoming increasingly apparent that the country has some of the windiest sites in Africa. This can provide much needed power for rural as well as urban communities on a decentralised scale. However, it is also important to recognise that Djibouti's experience of wind energy is limited to a few wind pumps. A great deal of work awaits the policy makers as they prepare the institutional, regulatory and policy environment for investment in distributed wind energy systems.

RRA findings

The RRA has highlighted the contribution of off-grid renewable systems to raising energy access for rural communities in Djibouti. Given the dispersed character of settlements and the economic activities concerned, decentralised systems are part of the solution to Djibouti's energy access dilemma. Some specific findings from the RRA relevant to decentralised energy in Djibouti are outlined below.

Importance of a clear rural electrification strategy

In Djibouti, as in most countries in the region, electrification initiatives tend to focus on grid-based delivery mechanisms. Grid-based options have limitations as they may not reach remote or dispersed communities, and may even cause

[11] **Assumptions:** PV capital cost = system cost of USD 6 100; pump cost = USD 1 600, replaced every 7 years; annual O&M cost = USD 0.02 of capital cost; genset cost = USD 2 000, replaced every 5 years; fuel cost = USD 1.15 per litre; project time = 20 years; inflation =3%; discount rate =12%.

people to move to electrified areas. The RRA found the recent ADDS village electrification campaign in Djibouti encouraging, and recommended it should be scaled-up. However, this needs to be part of a broader and clearer strategy for rural electrification, which means collaborating with wider government and NGO stakeholders. Almost 80% of the population is urban. A robust rural electrification strategy is therefore necessary laying bare the needs of rural communities and providing clear guidance on how to achieve progress in this sector. This is critical since the broader energy policy can easily marginalise these inhabitants. The strategy would be aligned with local provincial development plans as a way to link rural economic and social development with energy services. It would recognise that rural communities would benefit most from a bottom-up strategy. Such a strategy should define short, medium and long-term access goals supported by technology targets within predefined geographic areas for off-grid and on-grid electrification. One way to do this would be to introduce rural energy service concessions. These would allow an entity such as a private sector, NGO or community organisation to exclusively serve one or more defined areas under a concessionary agreement.

Soft loan schemes or other credit facilities needed for solar PV

Due to their high transaction costs, investments in decentralised renewable options are often not considered appropriate for loans through commercial banks. Rural communities with little disposable income hardly feature as obvious clients to these entities. Soft loans can be attractive, allowing a smaller proportion to be placed as down payment of the total price, and the rest can be spread over a number of years. With the bank interest rate in Djibouti running at 14% for short-term loans and 10% for long-term loans, households and businesses are unlikely to borrow to meet renewable energy costs.

The RRA has emphasised that there is room for private entrepreneurs in installation and O&M in rural energy development. However, the state will continue to play an important role in providing support through direct financing or microfinance schemes. Djibouti has established the Economic Development Fund (Fonds de Développement Économique de Djibouti), a dedicated source of credit supporting small and medium enterprises at concessionary rates. This could be an important support mechanism for social entrepreneurs interested in engaging in energy to support rural livelihoods. However, grants from multilateral agencies or donors could be ring-fenced to get soft loan schemes up and running for household or community electrification purposes.

4.3 OPPORTUNITIES AND CONSTRAINTS FOR SCALING UP RENEWABLE ENERGY DEPLOYMENT

National leaders are exploring opportunities to develop the renewables sector in Djibouti. Some of the critical issues and observations relating to renewable energy development and scale-up in Djibouti are described below.

East African Power Pool effect

East African regional power development work is progressing. A number of transmission and upgrade projects have already been completed, such as the Djibouti-Ethiopia and Kenya-Ethiopia lines. It is expected that in the short term Djibouti will benefit from importing more power than it can produce domestically, and gradually becoming an energy contributor to the power pool in the long run. Renewable energy technologies are likely to play a major role in developing an integrated power pool as new hydropower, wind and geothermal power plants are built. This will increase the share of renewables in the overall balance. This could mean a reduction in the long-term marginal cost of power for smaller countries like Djibouti. This is already evident now that Djibouti has started to import power from Ethiopia through the newly built interconnection. EAPP promises to usher in an era of cheaper and more secure power supply, and this should be welcome. However, Djibouti needs to actively explore ways to develop its own resources to position itself better strategically in the region and improve its energy security. Ambition for energy investment in the region is such that Djibouti can look beyond its regional role to become a transcontinental transmission hub for clean and low emission electricity. The Africa Clean Energy Corridor initiative, launched by IRENA, offers an opportunity for Djibouti to increase energy access. It also offers an opportunity to reduce its dependence on imported fuel and scale up the utilisation of renewable energy systems, hence meeting the development and climate challenge.

Opportunity to become a transcontinental transmission hub

Djibouti is a gateway between Africa and the Arabian Peninsula. Its geographical location creates significant strategic opportunities for the trade of goods and potentially energy. Yemen and Ethiopia have recently embarked on discussions concerning the potential Ethiopian export of 100 MW per year. This would be transferred through a 26 km submarine transmission line along the Red Sea via Djibouti. This is a significant development, and demonstrates the distance energy dialogues have reached as some countries seek cheap electricity

and others new markets. While Ethiopia sees itself as the renewable energy hub of the region, Djibouti can become its transcontinental transmission hub. This brings a number of interesting opportunities to Djibouti. Firstly, it would open up a market for its own surplus power, and provides a major incentive to move ahead with its plans to develop its geothermal and wind energy potential. Secondly, Djibouti can place itself at the heart of the USD 22 billion project backed by the African Union to develop a pan-continental electricity highway by 2020. Thirdly, it would help relieve Djibouti anxiety about its own energy security as it becomes an important strategic player in the region, strengthening its negotiating hand. Finally, Djibouti can become a visible player in global decarbonisation efforts as clean energy from Africa helps emissions reduction and avoidance in the Arabian Peninsula.

Energy efficiency needed on demand side

The Government of Djibouti is extremely concerned about the inefficient use of energy, especially during the hot season when air conditioning is common. Limiting energy losses along the power system chain, *i.e.*, from generation to end-use, is critical. This should form part of Djibouti's future energy strategy. A sustainable energy economy requires major commitments to both energy efficiency and renewable energy development. End-user efficiency gains complement national and regional energy initiatives on supply improvements. To this end, investment in end-use energy efficiency (whether through technology interventions, demand response measures or awareness building) should receive high priority. It could provide energy savings comparable to the electricity generated by power plants. Due to the high capital cost of renewable energy technologies, improvements in demand-side efficiency benefit investments in renewables as they deliver a higher impact for each unit investment. Demand-side measures should be seen as part of Djibouti's energy strategy and given prominence in the energy master plan. The role ADME will play cannot be underestimated. It should be given a greater mandate to ensure that the mission to strengthen demand-side interventions is not subordinated to the country's effort to boost generation and transmission capacity.

Awakening the financial sector

Banks are sitting on significant amounts of liquidity in Djibouti. The energy investment market across Africa is about to take off in a big way, but these resources should not come from international players alone. At present, banks are either unaware of these opportunities or wary of the risks involved. Major efforts are required to improve awareness among the banks and other players in the financial sector of the potential business opportunities in the energy market. This would help on two fronts. Firstly, these entities would have a better appreciation of the commercial potential of energy, and this could change their perception of risk with respect to energy investments. Secondly, banks could play a significant role in advising their clients on emerging energy investments and help prepare appropriate financial products.

Private sector role recognised

Djiboutian authorities acknowledge the important role the private sector can play in financing and deploying renewable energy programmes. Especially notable is the expected role that private investors will play in developing geothermal projects. A great deal of effort is currently invested in creating the enabling conditions for private sector participation in large-scale renewable energy projects. Some effort is also going into incentivising local private sector players to participate in smaller-scale initiatives. However, the incentive structures formed by policies, institutions, finance and regulations are only slowly conceptualised and introduced. For example, high interest rates and the lack of long-term loans at favourable rates create major barriers to financing sustainable energy projects. Moreover, domestic financial institutions are unwilling to provide loans for renewable energy in Djibouti as banks are unfamiliar with the renewable energy market potential in Djibouti.

High risk perception combined with limited technical and management capacity

This major problem is not unique to Djibouti. Most private international finance institutions continue to view Djibouti as risky. Part of the problem is that the country lacks the institutional, policy and governance conditions that attract investors. Moreover, Djibouti has limited technical and management capacity. It will need to build a programme of capacity building at district, city, sectoral and national level to make the most of the enormous energy investment opportunities it clearly possesses.

The RRA disclosed a large number of issues of key significance in effectively deploying renewable energy resources in Djibouti. While some of these are specific to the priority resource-service pairs for scaling up renewables deployment in the short to medium term, others are generic. Section 5 summarises the key actions and steps the RRA identified.

Example of solar water heater in Africa/Shutterstock

V. SUMMARY OF RECOMMENDED ACTIONS

The eight recommended action points from the RRA process are explained below. They apply to all priority resource-service pairs. These actions are not presented in any order of priority, and the list from a rapid assessment is unlikely to be exhaustive. The detailed list of actions can be found in the Annex.

ON-GRID

Action	Steps
Implement long-term energy plan	• Include multiple technology fronts and align range of options as part of the country's long term energy pathway within the electricity master plan under preparation. • Include measures for stimulating private investment within the master plan. • Strengthen the country's case for support from development partners.
Develop national renewable energy policy and action plan	• Make renewable energy a key component of a longer-term energy vision with systematic road map for delivery. • Include the 100% renewables vision in the national energy policy and support it with practical studies on how to achieve this, as well as assessments of the cost implications. • Develop real policies and implementation mechanisms to deliver meaningful results.
Strengthen legal system and regulatory framework	• Prepare an electricity law to establish a legal, economic and institutional basis for renewable energy uptake. • Develop supporting mechanisms such as FiTs, net-metering, competitive bidding and standardised bankable PPAs.
Strengthen research and development institutions	• Build capacities of practitioners, researchers and policy makers at CERD and University of Djibouti. • Support the manufacture of components through training, information sharing, technical seminars and demonstration projects at CERD and University of Djibouti. • Include supply-side data collection for solar and wind in CERD portfolio thereby making it the data centre. • Strengthen CERD human and technical capacity to conduct detailed assessments of wind and solar resources across the country. Undertake regular energy demand surveys and build a robust database.
Improve business environment	• Remove import duties on goods related to renewable energy in order to encourage serious entrepreneurs to do business in the renewables market. • Conduct studies quantifying the benefits in terms of local jobs in the energy sector under a range of energy expansion scenarios. Conduct econometric studies relating energy security to the broader economic benefits for Djibouti.

OFF-GRID

Action	Steps
Develop clear rural electrification strategy	• Develop a solid rural electrification strategy that lays bare the needs of rural communities and provides clear guidance on how to achieve progress. • Define short, medium and long-term access targets supported by technology targets within predefined geographic areas for off-grid and on-grid electrification within that strategy. • Introduce rural energy service concessions that would allow an entity (private sector, NGO, community organisation, etc.) to exclusively serve one or more defined areas under a concessionary agreement.
Provide financial support for small and medium solar PV enterprises	• Provide soft loans supporting small and medium solar PV enterprises. • Provide support through direct financing or microfinance schemes for social entrepreneurs interested in engaging in energy to support rural livelihoods. • Explore the use of grants from multilateral agencies or donors to get soft loan schemes up and running for household or community electrification.

VI. REFERENCES

AEEP (Africa EU Energy Partnership) (2013), "Country Power Market Brief: Djibouti", *www.ruralelec.org/fileadmin/DATA/Documents/06_Publications/Market_intelligence/AEEP_Djibouti_Country_market_brief_EN.pdf*.

AfDB (African Development Bank) (2012), *African Economic Outlook, Djibouti,* AfDB, Tunis.

AfDB (2013), *Projet: Projet d'Exploration Geothermique dans la Region du Lac Assal (Project: Geothermal Exploration Project in the Region of Lake Assal),* AfDB, Tunis.

Ahmed Aye, H. (2009), *Integration des Energies Renouvables pour Unie Politique Energetique Durable: Djibouti (Integration of Renewable Energy for Sustainable Energetics Unie Policy: Djibouti),* Université de Corse (University of Corsica), France.

CERD (Centre d'Etudes et de Recherches de Djibouti) (Center of Studies and Research in Djibouti) (2006), *Wind Energy Data,* CERD, Djibouti.

EAPP (Eastern Africa Power Pool) (2012), *EAPP – Corporate Plan 2012-2014,* EAPP, Addis Ababa.

Eberhard, A., *et al.* (2011), *Africa's Power Infrastructure: Investment, Integration and Efficiency,* World Bank, Washington, D.C.

EIA (Energy Information Administration) (2013), *International Energy Annual, EIA,* Washington, D.C.

EUEI-PDF (European Union Energy Initiative – Partnership Dialogues Facility) (2013), "Development of a Legal Framework and Strategy for the Electricity Sector in Djibouti", *www.euei-pdf.org/country-studies/development-of-a-legal-framework-and-strategy-for-the-electricity-sector-in-djibouti*.

Gastli, A., and Y. Charabi (2011), "Solar Water Heating Initiative in Oman Energy Saving and Carbon Credits," *Renewable and Sustainable Energy Reviews,* Vol. 15, No. 4, pp. 1851-1856.

Government of Djibouti Société Internationale des Hydrocarbures (SIDH) data (2014), *La Seconde Communication Nationale sur le Changement Climatique* (*Djibouti's Second National Communication to the Conference of Parties under the United Nations Framework Convention on Climate Change*), Ministère de l'Habitat, de l'Urbanisme et de l'Environnement (Ministry of Housing, Urban Planning and Environment), Djibouti.

IMF (International Monetary Fund) (2013), "Djibouti: Poverty Reduction Strategy Paper – Annual Progress Report", IMF Country Report No. 12/131, IMF, Washington, D.C., *www.imf.org/external/pubs/ft/scr/2012/cr12131.pdf*.

IRENA (International Renewable Energy Agency) (2012), *Concentrating Solar Power: Renewable Energy Technologies Cost Analysis Series,* IRENA, Abu Dhabi.

IRENA (2013), *Renewable Power Generation Costs in 2012: An Overview,* IRENA, Abu Dhabi.

ISERST (Institut Supérieur d'Etudes et de Recherches Scientifiques et Techniques) (Higher Institute for Studies and Scientific and Technical Research) (1984), *Initiatives Energetiques de Djibouti: Plan Energétique National (Energy Initiatives Djibouti: National Energy Plan),* ISERST, Djibouti.

Pillot, B., *et al.* (2013), "The first disaggregated solar atlas of Djibouti: A decision-making tool for solar systems integration in the energy scheme", *Renewable Energy*, Vol. 57, Issue C, pp. 57-69.

Rutovitz, J., and Harris, S. (2012), *Calculating Global Energy Sector Jobs: 2012 Methodology,* Institute for Sustainable Futures, Sydney.

SNC-Lavalin and Parsons Brinckerhoff (2011), *Regional Power System Master Plan and Grid Code Study,* SNC-Lavalin, Montreal.

Tabors, R. (2009), *Interconnection in the GCC Grid: the Economics of Change,* CRA International, Boston.

UNECA (UN Economic Commission for Africa) (2011), *Progress Report on the Implementation of the Outcomes of the Mid-Term Review Meeting of the Almaty Programme of Action,* UNECA, Addis Ababa.

UNECA (2013), *ICE Paper on Energy Access and Security,* UNECA-EA, Kigali.

UNDP (United Nations Development Programme) (2014), *Human Development Report 2014,* UNDP, New York.

World Bank (2012), *Republic of Djibouti: Geothermal Power Generation Program,* World Bank, Washington, D.C.

World Bank (2013), *Project Appraisal Document – Geothermal, Report No: 68254-DJ,* World Bank, Washington, D.C.

World Bank (2014), "Doing Business 2014: Economy Profile – Djibouti", World Bank, Washington, D.C., *www.doingbusiness.org/data/exploreeconomies/~/media/giawb/doing%20business/documents/profiles/country/DJI.pdf?ver=2*.

World Bank and Parsons Brinckerhoff (2009), *Least Cost Electricity Master Plan, Djibouti,* Project no. 69203, World Bank, Washington, D.C.

World Bank Public Private Infrastructure Advisory Facility (2014), *Djibouti: Etude des Options d'Electrification de 19 Villages par Energie Solaire Rapport Final (Djibouti: Electrification Options Study of 19 Villages Solar Energy Final Report)*, Public Private Infrastructure Advisory Facility at the World Bank, Washington, D.C.

ANNEX

Detailed description of recommended action

ON-GRID

Action	Implement long-term energy plan
Resource-service pair(s)	All renewable energy resources
Description	Djibouti's energy need plans for the next 20 years support its Vision 2035. A master plan for power generation and transmission is under preparation. The ministry will ensure the master plan covers energy efficiency as an important resource due to its cost-effectiveness. Multiple technology fronts should also be considered as well as a range of options aligned with the country's long-term energy pathway. The ministry will ensure the master plan includes measures stimulating private sector investment, and also strengthens the country's case for development partner support.
Actors	MERN, all relevant national stakeholders and development partners
Target date	Mid-2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Develop a national renewable energy policy and action plan
Resource-service pair(s)	All renewable energy resources
Description	Djibouti has no energy policy. As its energy situation becomes more pressing and opportunities become clearer, it is now recognised that a policy addressing energy access, affordability, resources and regional integration is an important step. The electricity access rate is about 50% including 5% for rural areas. Energy security and high electricity tariffs are a major concern for the population. These multiple challenges have helped awaken significant ambition among Djibouti's leaders to harness the country's abundant renewable energy resources to help meet national development goals. However there are no specific guidelines or road map to realise this ambition. To this end, MERN will take the lead in developing an energy policy embedding renewable energy within a systematic road map for delivery. It will be supported by specific practical studies and assessments on how to fulfil the 100% renewable energy ambition, the likely cost implications and finance options. This needs to be complemented by real policies and implementation mechanisms to deliver meaningful results.
Actors	MERN and all relevant stakeholders
Target date	End-2015
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Strengthen legal system and regulatory framework
Resource-service pair(s)	All renewable energy resources
Description	Djibouti does not have a solid or clear legislative and regulatory framework governing electricity production. This lack of regulation and legal instruments is a major obstacle, especially constraining the participation of non-state actors like IPPs and other self-producers in power provision. The Government of Djibouti is working alongside development partners on a draft Electricity Law targeted at electricity generation and imports. It covers tariff setting, licensing, incentives attracting private sector investment and the roles and responsibilities of various stakeholders. MERN will ensure the law includes legislative elements to enable renewables deployment in the energy market in Djibouti. A FiT scheme is one of the best options for Djibouti given the high cost of fossil-based generation. An appropriate FiT would act as a major stimulus drawing IPPs to Djibouti's energy sector. Appropriately designed and negotiated FiTs would go some way to setting tariffs attractive to the private players as well as end-users.
Actors	MERN, Ministry of Finance, private sector, EdD, all other relevant stakeholders
Target date	End-2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Strengthen research and development institutions
Resource-service pair(s)	All renewable energy resources
Description	Djibouti will depend on technologies and to a certain extent expertise from abroad in the short term at least. However it will need to work to strengthen and develop its human capacity and upgrade its energy innovation systems to support domestic technology adoption and development. At the same time, data and information on energy consumption in Djibouti are weak and inconsistent. This makes it notoriously difficult to plan, develop and implement energy efficiency measures. CERD and the University of Djibouti will play important roles in supporting capacity development among practitioners, researchers and policy makers. These knowledge institutions will also support the manufacture of components through training, information sharing, technical seminars and demonstration projects. This would both raise the confidence of development partners and private sector actors in a position to provide grants for projects and invest in profit-making energy ventures. Moreover, an institution such as CERD will play a pivotal role serving as the data centre. This also allows CERD to build the required human and technical capacity to undertake regular energy demand surveys and renewable energy assessments, both for the government and other clients. Development partners and organisations like IRENA could play a critical role in providing technical support and training to CERD or a relevant institution that can act as energy intelligence
Actors	CERD, Université de Djibouti, MERN, private sector, development partners and international organisations, all relevant stakeholders
Target date	End-2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Improve business environment
Resource-service pair(s)	All renewable energy resources
Description	The Government of Djibouti has made considerable efforts to improve the business environment and reduce the high cost of production. Despite the improvement recorded in doing business in 2014 compared to 2013, the business environment in the country remains weak in general and especially so for renewable energy. MERN, the Ministry of Economy and Finance, Ministry of Commerce will play a vital role in encouraging private players, protecting the public interest and introducing transparent processes. They will do this by introducing adequate tax incentives for investors (removal/reduction of duties on imported goods) and raising awareness of the opportunities for direct and indirect employment creation.
Actors	MERN, Ministry of Economy and Finance, private sector, all relevant stakeholders
Target date	End-2017
Keys to success	Broad consultation and engagement of all relevant stakeholders

OFF-GRID

Action	Develop clear rural electrification strategy
Resource-service pair(s)	All renewable energy resources
Description	As with most countries in the region, Djibouti electrification initiatives tend to focus on grid-based delivery mechanisms. Although almost 80% of the population lives in urban areas, the grid-based options have limitations as they may not reach remote or dispersed communities. The recent ADDS village electrification campaign in Djibouti is encouraging and should be scaled up. MERN will work with ADDS and relevant stakeholders to develop a robust rural electrification strategy that lays bare the needs of rural communities. This will provide clear guidance on how to achieve progress in this sector since the broader energy policy can easily marginalise these inhabitants. The strategy would be aligned with local provincial development plans to include short, medium and long-term access goals supported by technology targets within predefined geographic areas for off-grid and on-grid electrification.
Actors	MERN, ADDS, local communities, all relevant stakeholders
Target date	End-2017
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Provide financial support for small and medium solar PV Enterprises
Resource-service pair(s)	Off-grid PV
Description	Due to high transaction costs, loans through commercial banks are often not considered appropriate for investments in decentralised renewables. Rural communities with little disposable income hardly feature as clients to these organisations. Soft loans can be attractive, allowing a smaller proportion to be placed as down payment for the total price and the rest to be spread over a number of years. With bank interest rates for short and long-term loans at 14% and 10% respectively, households and businesses are unlikely to borrow to meet renewable energy costs. The Government of Djibouti will continue to play an important role in providing support through direct financing or microfinance schemes supporting private solar PV entrepreneurs in rural energy developments. The Economic Development Fund, a dedicated source of credit for small and medium enterprises, could to this at concessionary rates or grants from multilateral agencies or donors.
Actors	Ministry of Economy and Finance, MERN, partners and all other relevant stakeholders
Target date	End-2017
Keys to success	Broad consultation and engagement of all relevant stakeholders

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