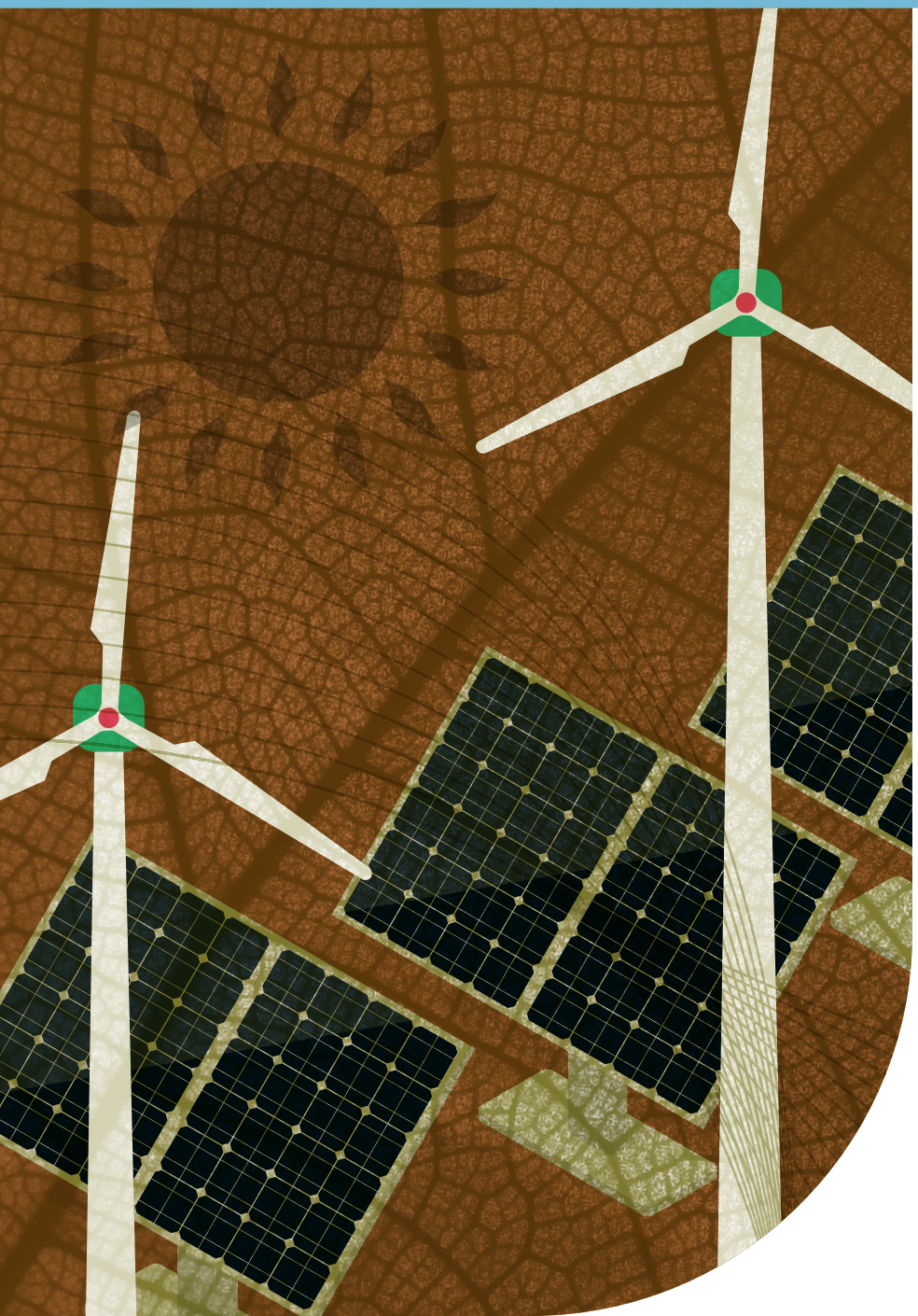
IRENA
International Renewable Energy Agency

RENEWABLES READINESS ASSESSMENT

BOTSWANA



August 2021

About IRENA

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

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About the RRA

A Renewables Readiness Assessment (RRA) is a holistic evaluation of a country's conditions that helps to identify the actions needed to overcome barriers to renewable energy deployment. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders. While the RRA helps to shape appropriate policy and regulatory choices, each country determines the best mix of renewable energy sources and technologies to achieve national priorities. The RRA is a dynamic process that can be adapted to each country's circumstances and needs. IRENA has continually refined its methodology for the RRA process based on experience in a growing range of countries and regions.

For more information: **www.irena.org/rra**

Acknowledgement

This report was prepared by IRENA in close collaboration with the Government of Botswana, represented by the Ministry of Mineral Resources, Green Technology and Energy Security. Special thanks are due to the numerous officials who contributed to its realisation, and in particular those from the Botswana Power Corporation (BPC) and the Botswana Energy Regulatory Authority (BERA). The report has benefited from the input of expert reviewers, including Kudakwashe Ndhlukula (SACREEE), Lauren Culver, Celine Ramstein and Yuri Handem (World Bank), James Jakoba Molenga, Lesego Molapisi, Mareledi Gina Maswabi and Tebogo Thakadu (Botswana). From IRENA, Paul Komor, Asami Miketa, Gayathri Nair, Francisco Boshell, Seung Kang, Mohammed Nababa, Costanza Strinati and Carlos Guadarrama provided valuable inputs.

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For further information or to provide feedback: **publications@irena.org**

Contributing authors

This report was developed under the guidance of Gürbüz Gönül and Binu Parthan (IRENA) and authored by Nopenyo Dabla, Benson Zeyi and Elizabeth Njoki Wanjiru from IRENA, as well as consultants Nicolas Fichaux and Boiki Mabowe.

Disclaimer

RENEWABLES
READINESS ASSESSMENT

Botswana

FOREWORD

by the Minister of Mineral Resources, Green Technology and Energy Security

The Ministry of Mineral Resources, Green Technology and Energy Security (MMGE) is delighted to have benefitted from the technical support provided by the International Renewable Energy Agency (IRENA) that has resulted in the development of this Renewable Readiness Assessment (RRA) for Botswana, despite the uncertainties caused by the COVID-19 pandemic.

The release of this report coincides with the recent adoption by Parliament of the Botswana National Energy Policy – a key, strategic instrument for the successful and economic development of the local energy sector. A prominent objective of the Policy is to achieve a substantive penetration of new and renewable energy sources in the country's energy mix; the goal is to attain adequate economic energy self-sufficiency and security, as well as positioning Botswana to fulfil its vision in becoming a regional net exporter, especially in the electricity sector. The Policy also recognises and supports increased energy efficiency and the use of renewable energy as key drivers for an inclusive transition to a clean energy future.

Botswana has also issued an Integrated Resource Plan (IRP) for electricity generation over the next 20 years, covering renewable energy technologies such as solar photovoltaic, wind, concentrated solar thermal, and batteries for energy storage. Other related initiatives include the Biogas Pilot Project – currently in the implementation stage – that ultimately will be rolled out nation-wide; the Off Grid Solar Programme, also its early stages of development and implementation; and the Rooftop Solar Photovoltaic Programme, for which implementation is underway following the launch of the programme in November 2020.

The RRA is expected to augment government initiatives and programmes designed to improve energy supply availability, reliability and access. The Government seeks to ensure renewables make up 15% of the national energy mix by 2030, and to reduce greenhouse gas emissions as part of its commitments to the United Nations Framework Convention on Climate Change (UNFCCC).

This RRA study provides an in-depth assessment, evaluation and analysis of the readiness of Botswana's energy sector for the integration of renewable energy and recommends various actions to address the challenges and limitations to renewable energy uptake in the country. Key objectives for the government of Botswana include improvements in energy sector regulation; capacity building; and the development of effective implementation frameworks for energy projects and programmes such as the IRP, off-grid solar solutions and the on-going National Electrification Programme.

The implementation of these recommendations is key to ensuring an inclusive energy transition that balances environmental concerns with the socio-economic needs of communities and industries. I would like to thank IRENA for its continued support and am hopeful that this collaboration will continue until we have attained both energy self-sufficiency and exports based on the deployment of renewable energy and energy efficiency technologies.

Hon. Lefoko Maxwell Moagi
Minister for Mineral Resources, Green Technology and Energy Security

FOREWORD

from the IRENA Director-General

The Government of Botswana has adopted an Economic Stimulus Programme to boost growth and promote economic diversification and job creation. ESP aims to deliver universal access to electricity in urban and rural areas, and achieve a national energy surplus, with a view to accessing regional electricity markets within the Southern African Power Pool.

Botswana possesses considerable potential for renewable energy development. This Renewables Readiness Assessment (RRA) presents clear and practical steps to maximise the country's use of renewables in driving sustainable economic growth. It identifies the need to adopt a broader range of renewable energy technologies to diversify Botswana's power generation away from coal, generate socio-economic value and fulfil the country's environmental and climate commitments.

The report recommends various short-to-medium term actions for developing the basis for a transition to renewable energy, including in the areas of policy, regulation, risk, investment, skills development, electrification and generation, and end-use applications. These actions can contribute to creating a more conducive investment environment for renewable energy by addressing key challenges to the energy transition.

Since 2011, nearly 40 countries from Africa, the Middle East, Latin America and the Caribbean, Asia, the Pacific and South East Europe have undertaken Renewable Readiness Assessments, exchanging knowledge and fostering co-operation among national and international partners to accelerate the deployment of renewables. Each of these assessments has been country-led, with IRENA providing technical expertise, sharing regional and global insights, and facilitating consultations among national stakeholders.

IRENA is grateful to the Botswanan authorities – and particularly the Ministry of Mineral Resources, Green Technology and Energy Security – for their commitment to this study, as well as to the many other stakeholders whose positive engagements and valuable inputs contributed to its completion. I am confident that the recommendations in this report will strengthen efforts towards energy transition in Botswana and across the wider region.

Francesco La Camera
Director-General
International Renewable Energy Agency

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ABBREVIATIONS

ACEC	Africa Clean Energy Corridor
AEP	Annual energy production
AfDB	African Development Bank
BCCN	Botswana Climate Change Network
BERA	Botswana Energy Regulatory Authority
BEST	Biomass Energy Strategy
BITC	Botswana Investment and Trade Centre
BITRI	Botswana Institute for Technology Research and Innovation
BIUST	Botswana International University of Science and Technology
BoB	Bank of Botswana
BOCOBONET	Botswana Community-Based Organisations Network
BOOT	Build–own–operate–transfer
BOSA	Botswana–South Africa (interconnector)
BPC	Botswana Power Corporation
BWP	Botswana pula
CBM	Coal Bed Methane
CDM	Clean Development Mechanism
CEM	Clean Energy Ministerial
CERC	Clean Energy Research Centre
CFL	Compact Fluorescent Lamp
CIP	Climate Investment Platform
CO_2	Carbon Dioxide
CSP	Concentrated Solar Power
DAR	Department of Agricultural Research
DMS	Department of Meteorological Services
DNI	Direct Normal Irradiance
DOE	Department of Energy
DTU	Danish Technology Institute
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EEP	Energy and Environment Partnership Trust Fund
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPC	Engineering, Procurement and Construction
ESMAP	Energy Sector Management Assistance Program
ESP	Economic Stimulus Programme
EU-TAF	European Union Technical Assistance Facility
FIT	Feed-in Tariff
GCF	Green Climate Fund
GESA	Green Energy and Sustainability Association
GEF	Global Environment Facility
GDP	Gross Domestic Product
GHG	GreenHouse Gas
GHI	Global Horizonal Irradiance
GIS	Geographic Information System
GJ	Gigajoule
GoB	Government of Botswana
HDI	Human Development Index
HVAC	Heating, Ventilation and Air conditioning
HVDC	High Voltage, Direct Current
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IMF	International Monetary Fund
INDC	Individual Nationally Determined Contribution
IPP	Independent power producer
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan
JACSES	Japan Centre for Sustainable Environment and Society
JICA	Japan International Cooperation Agency
KEPCO	Korea Electric Power Corporation
KTH	Royal Institute of Technology (Sweden)
LBNL	Lawrence Berkeley National Laboratory (US)
LCOE	Levelised Cost of Electricity
LPG	Liquified Petroleum Gas
MENRCT	Ministry of Environment, Natural Resources, Conservation and Tourism

ABBREVIATIONS

MEPS	Minimum Energy Performance Standards
MEPS	Minimum Energy Performance Standards
MMEWR	Ministry of Minerals, Energy and Water Resources
MMGE	Ministry of Mineral Resources, Green Technology and Energy Security
MoLG	Ministry of Local Government
MSW	Municipal Solid Waste
MW	Megawatt
NDC	Nationally Determined Contribution
NDP	National Development Plan
NEED	Network of Excellence in Renewable Energy Technologies for Development
NEES	National Energy Efficiency Strategy
NEF	National Electrification Fund
NESC	National Electricity Standard Connection
NGO	Non-Governmental Organisation
NREL	National Renewable Energy Laboratory
NWTGC	North–West Transmission Grid Connection
OSAP	Off-grid Solar Action Plan
PJ	Petajoule
PPA	Power Purchase Agreement
PPAD	Public Procurement and Asset Disposal Act
PPP	Purchasing Power Parity
PV	Photovoltaic
REFIT	Renewable Energy Feed-in Tariff
REAB	Renewable Energy Association of Botswana
REP	Rural Electrification Program
RERA	Regional Electricity Regulators Association of Southern Africa
RERE	Renewable Energy Rural Electrification programme
RRA	Renewables Readiness Assessment
RSP	Rooftop Solar Programme
RIIC	Rural Industries Innovation Centre
SACREEE	Southern African Development Community Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SAPP	Southern African Power Pool
SAPP-MTP	SAPP Market Trading Platform
SEA	Strategy Environmental Assessment
SEIA	Strategic Environmental Impact Assessment
SHP	Small Hydropower Potential
SHS	Solar Home System
SIAB	Solar Industries Association of Botswana
SIEEP	SADC Industrial Energy Efficiency Program
SMW	Solid Municipal Waste
SOLTRAIN	Southern African Solar Thermal
TCF	Trillion Cubic Feet
TFEC	Total Final Energy Consumption
TOE	Tonnes of Oil Equivalent
TPES	Total Primary Energy Supply
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USD	US dollar
VAT	Value-Added Tax
VRE	Variable Renewable Energy
ZIACD	Zambezi Integrated Agro-Commercial Development

Photograph: Shutterstock

EXECUTIVE SUMMARY

Botswana is an arid to semi-arid country of 582,000 square kilometres located in Southern Africa. It is a landlocked developing and upper-middle-income country with a population of 2.3 million inhabitants, of which 30% live in rural areas. Access to electricity stands at 65% (81% in urban areas and 28% in rural areas). The country's total energy supply of 2.9 Mtoe in 2017 consists of oil products (35%), coal (44%), (traditional) biofuels and waste (19%) and imported electricity (2%). Electricity is mainly produced from coal, or from petroleum products imported mainly from South Africa.

Botswana's gross domestic product (GDP) has almost tripled since 2000, whilst its total final energy consumption (TFEC) has increased by 45%. Botswana is gradually recovering from an economic downturn in 2015, during which the country suffered from a negative growth owing to a decline in diamond exports, severe drought and energy shortages. Subsequently, the Government of Botswana adopted an Economic Stimulus Programme in order to boost growth and promote both economic diversification and job creation. The recovery has been supported by the development of non-mining sectors such as communications, trade, transport and tourism. Although diamond mining remains the primary source of wealth and development, in recent years the tourism sector has expanded thanks to the country's wildlife preservation practices and large game refuges (prior to the onset of the COVID-19 pandemic in 2020).

As is the case in most countries of the region, Botswana's power system is characterised by unreliable power supply, lack of investment, poor maintenance and high service costs. To meet its peak power demand, Botswana imports power from the Southern Africa Power Pool (SAPP) – mainly from South Africa – and when imports are not available, resorts to the use of costly backup diesel power plants.

Botswana's total primary energy supply (TPES) is fossil-based and largely reliant on oil products and coal, complemented by biomass and waste energy. A large proportion of TFEC comes from biomass energy in the form of traditional wood fuel (27.8%). Botswana relies heavily on fossil fuels for its electricity generation, depending on two major coal-fired power plants (Morupule A and B) and a number of diesel plants. Until recently, Botswana relied on electricity imports to meet up to 94% of its demand. With the ongoing recovery of the Morupule B plant, the share of electricity imports in total supply has decreased to about 15%.

The country possesses considerable renewable energy potential, most notably solar, wind and bioenergy; however, these remain largely unexploited, despite the country's ambitious plans for integrating renewable energy into its energy system. In the Integrated Resource Plan (IRP) launched in December 2020, it was announced that renewable energy should account for at least 15% of the energy mix by 2030, whilst the country's Vision 2036 calls for a 50% renewable energy contribution to the energy mix by March 2036.

With a view to supporting progress toward these targets, and more generally to assist Botswana on its path towards the integration of a higher, more diversified share of renewable energy in its national energy mix, this Renewables Readiness Assessment (RRA) identifies the following critical actions that could significantly impact the energy transition in Botswana:

1. **Promote and facilitate implementation of a clear long-term vision for renewable energy development**

   Steady renewable energy capacity increases require a clear vision, embodied in appropriate and implementable planning. In this regard, Botswana can succeed in its uptake of renewable energy by transforming vision and roadmaps into binding commitments that contain specific renewable energy technology targets. It is also important that the targets outlined across different policy and strategy documents are aligned to provide a consistent, long-term signal to potential investors.

2. **Operationalise the regulatory authority**

   Botswana has embarked on the path to regulatory reform, embodied by the establishment of the Botswana Energy Regulatory Authority (BERA) in 2017; however, the Authority remains largely non-operational. Operationalising BERA will require a guaranteed, sustainable and independent budget, as well as sufficient political independence and capacity to hold utilities to account for their financial and operational performance.

3. **Establish a grid code that is conducive to variable renewable power**

   Under the authority of the BERA, grid codes prioritising access to the grid for electricity generated from renewables, as well as its dispatch based on marginal cost, should be developed to govern all current and future electricity generators. These codes should replace the BPC operational manual that currently governs transmission and will serve to provide transparency concerning grid access by independent power producers (IPPs). The BPC is currently a vertically integrated utility, potentially transitioning towards a single buyer model.

4. **Revise the tariff-setting structure**

   The process of defining tariffs now falls under the supervision of BERA; they will be set based on a transparent methodology applied by its Electricity Committee that will include some level of performance management. The current price setting mechanism is apparently based on 'rate of return' rather than 'incentive-based' regulation, raising concerns regarding the pass-through of inefficiencies to end-consumers in Botswana. Now that the Botswana Power Corporation (BPC) has achieved full cost recovery, some incentives for performance management should be introduced to the methodology, reflecting aspects such as quality of service and new policy paths (concerning electrification, GHG emissions, security of supply, etc.). There is also scope for customising tariffs to match the spatial or temporal profile of consumption.

5. **Define a clear regulatory framework to manage risks involved in private sector participation**

   Although improving, the recourse to BPC for the procurement and off-take relating to the national renewable energy strategy has limitations. In theory, IPPs could participate in adding new generation capacity; but in practice, power purchase agreements (PPAs) have yet to materialise. A key issue associated with IPP contracts is the need to balance risks against off-take, the absence of which may lead to windfall profits from unaffordable tariffs at one end of the spectrum, or the inability of the private sector to engage into the programme – and the stalling of the private sector development of renewable energy – at the other. A regulatory framework that balances the risks and rewards between the IPP and BPC therefore must be defined and developed.

6. **Perform a location-specific (pre-feasibility) study for renewable energy generation and streamline permitting processes**

   Experience has demonstrated that efficient investments will build on an integrated spatial master plan. Investments in renewable energy generation require the collection of 1–2 years of bankable resource data, and potentially investments in distribution or transmission assets. Timely investments therefore require careful strategic planning in future project locations to avoid uncertainties, and subsequent delays and higher costs in the procurement phase. The first step is to perform a detailed geospatial analysis (pre-feasibility), as proposed by IRENA and the World Bank.

   Also, the permitting process in Botswana must be made more transparent; for example, by establishing frameworks for environmental impact studies, grid connection studies and cost provisions for grid connections.

7. **Conduct a study on the capability of the grid to absorb power from VRE sources**

   In addition to location-specific pre-feasibility studies, a comprehensive dynamic grid impact study is required, based on dynamic (time-dependent) simulations with detailed cost assumptions that consider new technologies and advanced dispatch strategies. A means to regularly update the IRP based on these findings is also needed, building on grid stability studies of the power system and realistic assessments of the penetration potential of renewable energy – including grid reinforcement and storage on a cost-efficiency basis. Potentially, the study could also help BERA develop grid codes and regulations for merit-order dispatch, accounting for the specific characteristics of variable renewable energy (VRE) sources.

8. **Integrate rural electrification strategies into a single, comprehensive document and consolidate rural electrification activities**

   The need to add both small-scale distributed generation at scale, and a rural electrification programme to the IRP has also been suggested. During stakeholder consultations, the mini-grids, smart grids, waste-to-energy and solar home systems market segments were seen as potentially large, untapped market segments able to drive investment, jobs, entrepreneurship and gender equity. Limited private sector engagement and competition exists in this sector in Botswana, which sets it apart from current practices across sub-Saharan Africa.

9. **Support the growth of solar rooftop and home systems through strong incentives and policy instruments**

   Guidelines for rooftop solar installation are undergoing development and will provide an alternative mechanism to increase the uptake of solar energy as well as facilitate private sector participation. Attractive incentives should be put in place to support the adoption of this technology. Policy instruments such as net-metering and feed-in tariffs for roof-top solar projects would help facilitate market access for investors. The government also needs to finalise the feed-in tariffs.

   The growth in demand for solar home systems was highlighted during stakeholder workshops. Dedicated planning, business models and implementation mechanisms supporting private sector engagement should be developed to promote this market segment. Furthermore, the government should establish national quality standards aligned with international standards, enhance local certification capabilities, facilitate affordable payment schemes and consider gender equity in the energy sector.

10. Develop a strategy for renewable energy and agriculture

The agriculture sector in Botswana is predominantly subsistence based, mainly due to traditional farming methods, regular droughts and limited infrastructure. In this sector, solar water pumping, biogas for cooking and lighting, and bioenergy (biodiesel) for transport were identified as relevant areas to explore. To improve uptake of these energy services, financial resources should be mobilised; affordable, locally available technologies should be developed; and regulations and incentives established.

11. Develop a strategy for renewable energy in the transport sector

No incentives currently exist to encourage bioenergy in transport, despite the existence of biodiesel standards, given the absence of specific legislation to trigger enforcement. The local market is considered to be small and unable to achieve economies of scale due to limited use in the transport sector. The Department of Energy (DOE), with technical support from the University of Botswana (UB) and the Department of Agricultural Research (DAR) of the Ministry of Agricultural Development and Food Security, are engaged in a research project that seeks to stimulate the development of the local Biofuel industry.

In this sector, solar electric navigation was also mentioned in consultations, as a demonstration is ongoing for solar tourist boats. However, the potential for market scale-up is limited. Currently, no plans for electric road transportation have been identified, nor has an electric vehicle strategy been defined. Considering the strong dynamics of this market worldwide, it is suggested that Botswana develop an e-mobility strategy.

12. Promote the role of renewable energy for heating, cooling and cooking

The need for increased uptake of renewable based heating, cooling and cooking was highlighted in the RRA stakeholder workshops. This can be achieved by raising awareness of the technologies among residents, building local manufacturing and installation capacities, and introducing the skills needed to develop bankable proposals to increase access to finance by renewable energy companies. Local financial institutions should also be encouraged to provide finance to support private investments in renewable energy solutions. This can be facilitated by providing training to financial institutions on renewable energy project appraisals. Financial incentives can also be provided by government to ensure that citizens can afford renewable energy services.

13. Develop local human capacities along the project value chain

There are also opportunities to develop competencies in the maintenance and repair of renewable energy equipment, particularly given the severe lack of training and availability of trained personnel in remote areas. Private sector engagement in the management of training facilities can be enabled through public–private partnerships (PPPs) for off-grid supply and mini-grids.

Also, building local capacity within BPC and BERA is important and will provide Botswana with the technical capacity to operate a power system with high shares of renewables. Capacity building should include capabilities in power system modelling, simulation studies, reserve sizing, flexibility analysis, economic dispatch and VRE forecasting, etc., so that Botswana can identify and address future challenges to the system.

Photograph: Shutterstock

Photograph: Shutterstock

1. COUNTRY OVERVIEW

Botswana is a landlocked country located in central–southern Africa, with a mean altitude above sea level of 1 000 metres and a total area of 582 000 square kilometres (km^2).

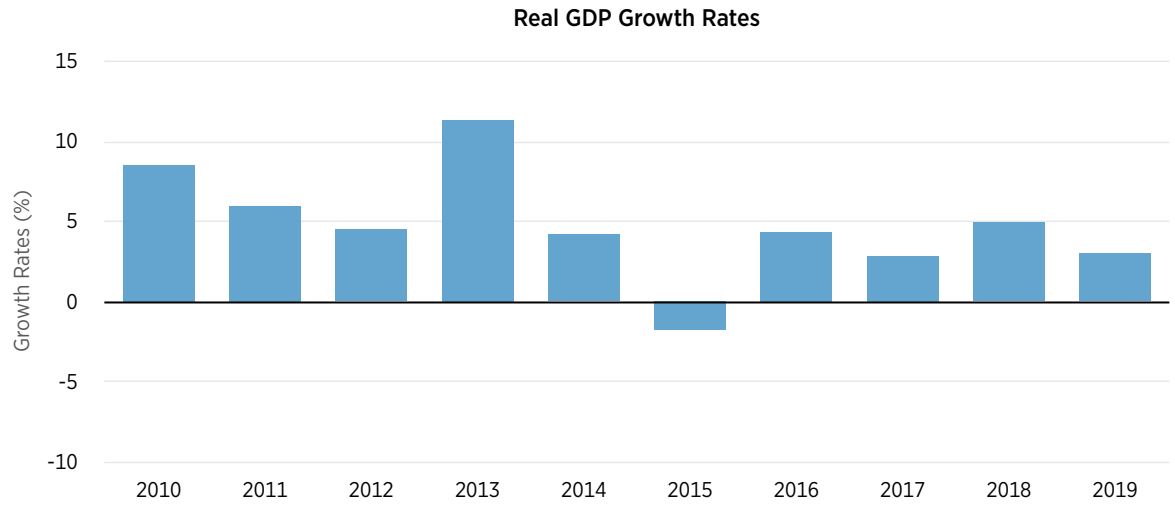
The official languages are English and Setswana, which are widely spoken in the country, and the pula (BWP) is the nation's official currency. The country is divided into nine districts and five town councils. Botswana's climate is arid to semi-arid and rainfall is highly erratic. Botswana has not been spared by climate change and continues to incur considerable environmental and economic costs in addressing the challenges of negative climatic impacts. Severe rainfall deficiencies occur periodically, and most parts of the country are affected by droughts. Since the early 1980s, extreme weather events – including droughts, storms and floods – have increased in frequency. In terms of greenhouse gas (GHG) emissions, the World Bank's latest data indicate that Botswana's emissions per capita stand at 3.367 metric tonnes of carbon dioxide (CO_2) per year – its highest rate ever recorded. This emissions value is about half of the average figure (6.154 tCO_2) for upper middle-income countries in 2014 (World Bank, 2019 b).

When it gained political independence in 1966, Botswana was one of the world's poorest countries. However, it swiftly became one of the world's development success stories. Mineral wealth, fiscal discipline, uninterrupted civilian leadership, prudent economic management, progressive social policies, peace and tranquillity and a comparatively small population of a little more than two million, have helped to position Botswana as an upper middle-income country (Statistics Botswana, 2014).

The economy is dominated by extractive industries – predominantly diamond mining; nonetheless, tourism is an expanding sector due to the country's nature preservation practices and large game reserves. Diamond mining has been an important source of wealth and development and accounted for 20% of Gross Domestic Product (GDP) in 2017. Other key sectors are wholesale and retail trade; finance, real estate and business services; and agriculture, accounting for 21.6%, 15.3% and 2.2% of GDP, respectively, in 2018. The water and electricity sector accounts for 0.8% of GDP (AfDB, 2018). Although total energy consumption increased by 86% between 1994 and 2013, this was accompanied by an almost three-fold increase in GDP (at constant prices, see Figure 1).

Real GDP grew by 5.1% in the year leading to September 2018, compared to around 2.5% in 2017 and 2019. GDP growth was buoyed by sustained improvement in the non-mining sector and the recovery in mining output growth, giving Botswana the best sovereign credit risk rating (A2) in Africa from S&P and Moody's (BoB, 2019); GDP in 2019 corresponded to USD 18.34 billion. Figure 1 gives a summary of real GDP growth between 2010 and 2019.

Figure 1 Evolution of real GDP growth for Botswana, 2010–2019



Source: Statistics Botswana (https://www.statsbots.org.bw/national-accounts).

The Government of Botswana has adopted an Economic Stimulus Programme (ESP) in order to boost economic growth, promote economic diversification and job creation. Launched in 2015, the ESP aims to expand the economy through a development agenda that includes energy (Government of Botswana, 2015 a). Specifically, the ESP seeks to accelerate the electrification of urban and rural areas, and intends for the country to become an energy surplus nation. Moreover, after a decade of efforts to diversify the economy the share of mining sector in the GDP has decreased from 25% to 20% (Ministry of Finance, 2018). Yet, despite a reduction in GDP share, diamonds alone are accounted for 90% of exports (BoB, 2019).

With respect to human development, the United Nations Development Programme (UNDP) reported a Human Development Index (HDI) score of 0.735 for Botswana in 2020, placing the country in the high human development category and positioning it at 100 out of 189. Between 1990 and 2020, Botswana's HDI has registered a 26% increase, rising from 0.581 to 0.735 (UNDP, 2020).

The latest census (in 2011) estimated a population of 2.024 million inhabitants, representing a growth rate of 1.86% in a decade (Statistics Botswana, 2014). More recent estimates suggest that Botswana was home to 2.303 million inhabitants in 2019 (World Bank, 2019a). In line with the 10-year interval pattern for national population censuses, another such exercise is planned for 2021 (Statistics Botswana, 2018 b). A large share of the population is concentrated in areas with natural water resources and arable land, mainly in the east. 70.1% of the population is settled in urban areas. The census reveals steady growth in the working population, now estimated at 64.9% compared to 58.2% in 2001 (Statistics Botswana, 2014). According to estimates for 2018, unemployment affects 18.3% of this group (UN, 2018).

The wholesale sector employs the largest proportion of the population, followed by manufacturing and construction. The agriculture, and electricity and water sectors account for 3% and 3.81%, respectively (Statistics Botswana, 2018 a). Overall social indicators have shown constant improvement, and as unemployment falls, the proportion of people living in poverty also declines.

Botswana is gradually recovering from its latest economic downturn; in 2015 the country suffered a negative growth rate of -1.7% (in real GDP), (World Bank, 2019 b) owing to the decline in diamond exports, severe drought and severe energy and water shortfalls.

The recovery has been boosted by the development of non-mining sectors such as trade, tourism, transport and communications. The agricultural sector, which remains modest and subsistence-oriented, is mainly driven by beef exports (AfDB, 2018). The contribution to GDP of the electricity and water sector has improved in recent years, with a sector-specific growth of 79.7% in 2016–2017 and 27.3% in 2017–2018 (BoB, 2019).

Despite the recovery being felt, economic growth remains unequally distributed (Botswana ranks 100 out of 189 according to the Gini coefficient) and 17.2% of the population suffers from poverty (UNDP, 2020). Economic growth is precarious, as risks persist in key development sectors, and is currently being undermined by the COVID-19 crisis. Therefore, overall economic recovery – and the specific recovery of the diamond market – remains uncertain.

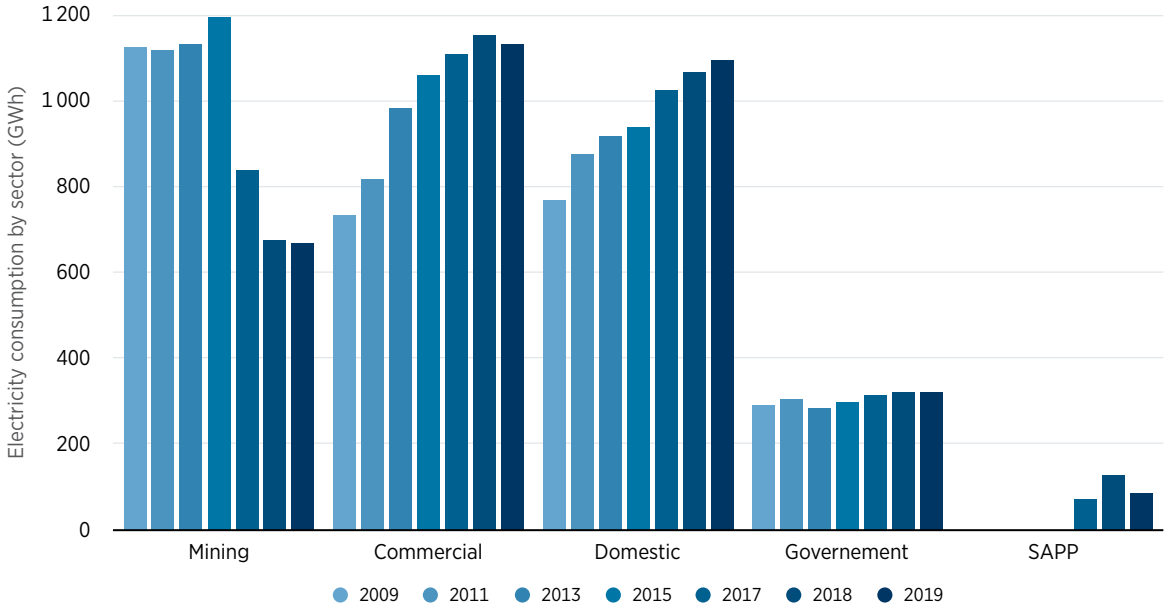
Botswana ranks 87 out of 190 countries in the World Bank's *ease of doing business* index (World Bank, 2020) with sub-rankings of 139 in 'getting electricity' (due to low scoring on the *reliability of supply and transparency of tariff index*); 137 in 'enforcing contracts'; and 159 in 'starting a business'.

Delays and cancellations of projects in the electricity and water sector should be closely monitored, as they will have a direct impact on Botswana's ability to achieve the desired level of economic development through the ESP. Agriculture and water availability are also at risk, as climatic conditions are likely to worsen with climate change.

1.1 The role of electricity in development in Botswana

An overview of national electricity consumption by customer type is presented in Figure 2. Consumption by the commercial and domestic sectors have been steadily increasing since 2009 (Figure 2), and government usage remained steady, while mining consumption peaked in 2015 and fell rapidly following the closure of operations at the BCL and Tati nickel mines in 2016.

Figure 2 Evolution of electricity consumption by customer category (including exports to SAPP)



Source: Adapted from BPC (2019).

The peak demand stands at 596 MW (BPC, 2019). Botswana imported 70 GWh, 127 GWh and 200 GWh of electricity from the Southern African Power Pool in 2017, 2018 and 2019, respectively.

Energy is recognised globally as essential to the economic development of any country and is considered a key driver for economic growth in the most important sectors of the economy.

- **Energy for services**: in 2019, Botswana ranked 139 in the *Ease of Doing Business Index* on the indicator 'getting electricity'; costs and reliability are of concern (World Bank, n.d). The current account balance of Botswana for 2019 shows a service sector at deficit of – 0.7% of the national GDP. Although the situation has slightly improved since 2014 (-1.5% GDP), the sector is only expected to reach a net balance in 2022. Renewable energies have a significant role to play in the development of the services sector by providing reliable and sustainable energy supply.

  The communications sector has been growing steadily and has relied on solar PV for many decades. Today, Botswana has one of the highest cell phone penetration rates in Africa. Other social services in remote areas – such as health, water access and education – already depend on solar PV. According to the participants of the validation workshop undertaken for this study, the main challenge that has been reported for many years is the inability to maintain or repair this solar PV equipment in case of failures, as in remote areas there is a severe lack of training and availability of trained personnel.

- **Energy for tourism:** according to the IMF (2019), disruptions caused by the coronavirus could depress growth in tourism activity. A major issue for a sector that represents more than 13% of national GDP. Botswana may develop eco-tourism, supported by reliable, affordable energy. The tourism sector has already invested in renewable energy – in particular solar in eco-lodges and camps. Solar thermal and PV systems are usually seen as the best solutions compared to the traditional stand-alone diesel systems. Among the benefits of solar systems are the absence of noise, a reduction in maintenance and operation costs, and a positive image in the context of sustainable tourism.

- **Energy for agriculture**: with 2% of its GDP derived from agriculture, this sector in Botswana is underdeveloped and is predominantly subsistence-based. This is mainly due to traditional farming methods, repeated droughts and limited infrastructure (AfDB, 2018), as well as the sector's vulnerability to climate events. Water pumping with renewable energy could help to limit dependence on rainfall and contribute to increased production yields. Increased use of biofuels could also have a positive impact on farming.

- **Energy for industry**: in recent years, the industrial basis of the economy has gradually diversified away from mining. Diversification has taken place through the development of the trade sector, which is vulnerable to recurrent power outages. In 2010, during a survey carried out by the World Bank more than 90% of the companies surveyed in Botswana suffered from power cuts for an average of three hours per day (World Bank, 2010). Estimated losses due to these interruptions amounted to nearly 4% of annual sales. Similarly, more than a third of companies perceived power cuts as a major constraint. Despite the fact that the surveys are from 2010 and following the major shortfalls of 2015, the situation for enterprises has not considerably improved.

- **Regional energy integration**: Botswana is interconnected with its neighbours and is a member of the Southern African Power Pool (SAPP). Several projects are ongoing to reinforce these (SAPP, 2018), including the Botswana–South Africa interconnector (BOSA) and the Zimbabwe–Zambia–Botswana–Namibia Interconnector (ZIZABONA). These projects are aligned with the ESP, which aims for Botswana to become an energy surplus nation. The fulfilment of this ambition will require the establishment of a SAPP electricity market in which trade will allow Botswana to leverage national synergies.


Photograph: Shutterstock

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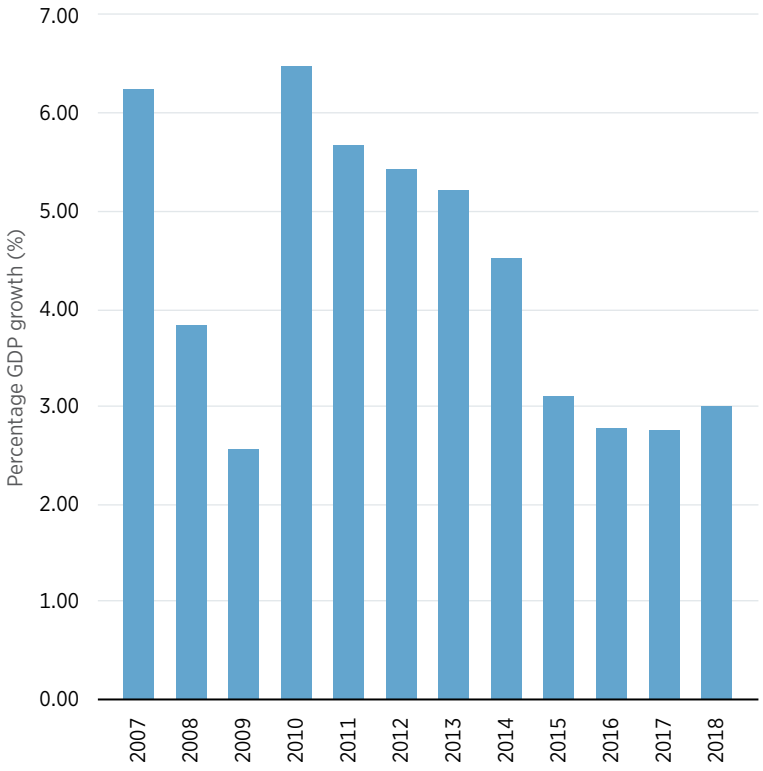
2. ENERGY CONTEXT

2.1. Regional energy context

The southern Africa region[1] presents great disparities in terms of economic development – both between countries and over time (Figure 3). For instance, South Africa's per capita GDP in 2019 was USD 13 034 compared to Lesotho's USD 2 824. Despite these great inequalities, the regional trend is towards economic growth, with an average annual GDP growth rate of 4.31% between 2007 and 2018 as depicted in Figure 3 below.

Yearly per capita electricity consumption is also very uneven in the region (Figure 4). For example, per capita consumption for South Africa in 2018 stood at 4 002 kWh/cap., compared to the Seychelles (4 434 kWh/cap.), Mauritius (2 475 kWh/cap.) and Botswana (1 554 kWh/cap.), all of which demonstrate an electricity consumption 20 to 30 times higher than Comoros, Madagascar, Malawi, the Democratic Republic of Congo or the United Republic of Tanzania, which range between 60 and 150 kWh per capita.

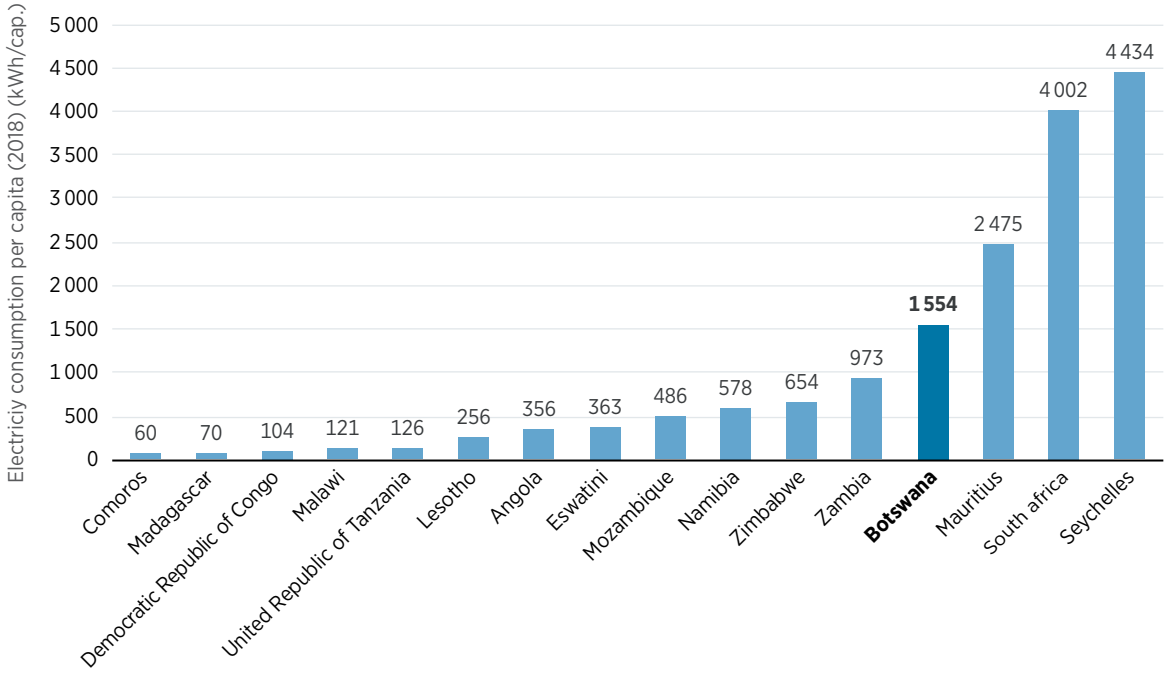
Figure 3 Average GDP growth rate in the SADC region



Source: World Bank, n.d

1 Defined here as the Southern African Development Community (SADC): Angola, Botswana, Comoros, Democratic Republic of the Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, United Republic of Tanzania, Zambia, Zimbabwe.

Figure 4 Yearly electricity consumption per capita for the SADC countries, 2018



Based on IRENA Statistics and World Bank data compiled from UN and national sources.

The lowest rates of access to electricity are found in Malawi, where just 18% of the population has access to electricity (leaving 15.7 million people without access) and the Democratic Republic of Congo with 19% access (where 67.7 million people lack access). Nine out of the sixteen Southern African Development Community (SADC) countries have access rates lower than 50% (*e.g.*, up to 37.1 million people lack access to electricity in the United Republic of Tanzania [Figure 5]). Mauritius, Seychelles, Eswatini, South Africa and Comoros have the highest rates of access to electricity in the region. On average, almost 50% of the population does not have access to electricity across the SADC as a whole, which corresponds to a total of 210 million persons (World Bank, 2019 a).

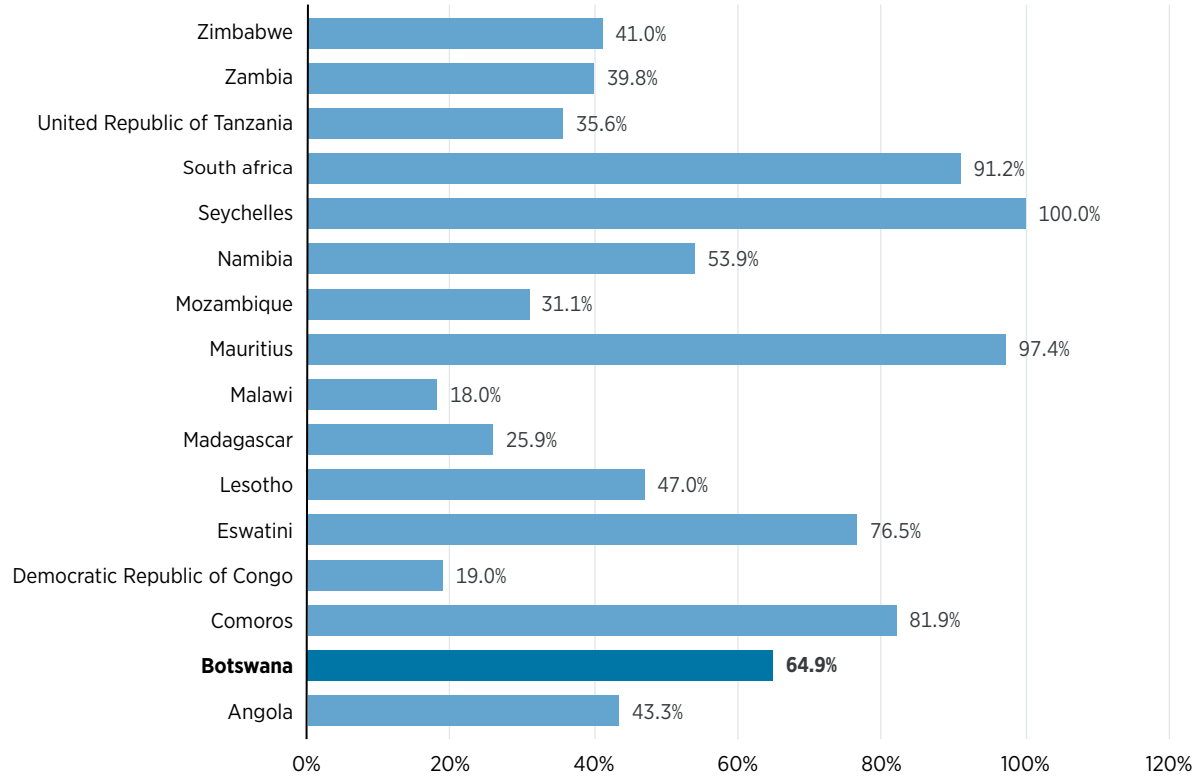
As highlighted by SADC (2018), the region began to witness a structural energy deficit in 2007. Pressured by strong economic growth, the region faced power outages and rolling blackouts across the SADC Member States. The supply gap was estimated at 8 GW in 2014, due to insufficient generation capacity, and high transmission and distributions losses estimated at 19% in 2015 (SADC, 2019).

UNECA (2018) lists the multiple drivers of the SADC electricity system, which comprise a mix of challenges and opportunities, including:

- An over dependence on coal, combined with coal supply challenges;
- Water challenges affecting the performance of thermal power plants;
- A need for further grid extensions;
- Strong GDP growth, including new mining developments causing further constraints to the grid; and
- Ageing equipment, with the bulk of baseload generation coming from equipment reaching 40 years old, and ageing transmission and distribution assets.

The impact of this energy crisis is significant, with effects on the manufacturing industry, company closures, cost of doing business, reduction in government revenues and an overall slowdown in economic growth and development (UNECA, 2018).

Figure 5 Electricity access rates in Southern Africa, 2018



Source: adapted from the World Bank (n.d.)

The Southern African Development Community (SADC)

The Southern African Development Community (SADC), established in 1992, includes sixteen countries covering the southern part of Africa. The partnership promotes economic development, growth, peace and security, poverty alleviation, and improving quality of life based on democratic principles, fairness and sustainable development. SADC addresses various regional integration themes related to energy via different subsidiaries, such as the Southern African Development Community Centre for Renewable Energy and Efficiency (SACREEE), Southern African Power Pool (SAPP), Regional Petroleum and Gas Association (REPGA), Coal Association and Regional Electricity Regulators Association (RERA) (SACREEE, 2019).

SADC (2016) published the first Regional Strategy and Action Plan for Renewable Energy and Energy Efficiency (REEESAP) in 2016. The strategy emphasises the added value of a regional approach to leveraging economies of scale and synergies amongst SADC members. The Energy Division under the SADC Secretariat, with the support of SACREEE, is responsible for facilitating the adoption of REEESAP through the establishment of national action plans.

Botswana commits to achieve 15% GHG emission reduction by 2030

SADC Centre for Renewable Energy and Energy Efficiency (SACREEE)

Officially launched in October 2018, the Southern African Development Community Centre for Renewable Energy and Energy Efficiency (SACREEE) aims to promote access to modern energy services and improve energy security through the promotion of renewable energy and energy efficiency. SACREEE, mandated by SADC members, seeks to participate in the region by developing and executing programmes related to sustainable energy policy, capacity building, knowledge management, and the promotion of investment, innovation and entrepreneurship.

SACREEE has ongoing programmes and projects with multiple international partners, including: IRENA for the Africa Clean Energy Corridor and SADC Renewable Energy Entrepreneurship Support Facility; the European Union Technical Assistance Facility (EU-TAF) for the SADC Industrial Energy Efficiency Program (SIEEP); and the National Renewable Energy Laboratory (NREL) for the Gender Mainstreaming and Women in Sustainable Energy program and the SACREEE SADC Energy Efficiency Program (World Bank, n.d.).

Box: The Renewable Energy Entrepreneurship Support Facility

In partnership with the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and the International Institute for Water and Environmental Engineering (2ie), IRENA established the ECOWAS Renewable Energy Entrepreneurship Support Facility in 2015. The Facility aims to enhance and strengthen the capacity of small- to medium-sized entrepreneurs in the renewables sector.

Through capacity building, technical advisory and mentorship support, more than 80 enterprises from all 15 ECOWAS member countries have so far been assisted over three annual cohorts. Approximately USD 1 million in debt financing has been accessed through the project proposals submitted to local funding institutions. The Facility also contributed to the creation of the Regional Solar PV Professionals Association.

In conjunction with the SADC Centre for Renewable Energy and Energy Efficiency (SACREEE), IRENA replicated the initiative in southern Africa. Established in 2017, the Facility has attracted nine partners comprising funding institutions, business incubation centres and technical training centres. With a focus on gender and youth development, the first call for applications from entrepreneurs was issued in 2019 and received 70 applications, of which 32 were selected for participation in the entrepreneurship programme.

The Facility conducted commercial and technical training in November 2020 and February 2021, respectively, for its first cohort of 32 entrepreneurs. The mentorship programme, which provides guidance to entrepreneurs on business development and growth, and refines their proposals to reach bankable levels, commenced in April 2021 for the 1st cohort.

A virtual workshop on renewable energy finance was jointly organised by IRENA and the SADC Centre for Renewable Energy and Energy Efficiency form 3rd to 28th May 2021 to increase the confidence of financial institutions in sustainable energy systems and ensure that SMEs obtain project funding on affordable terms.

The Facility conducted a virtual advisory board meeting workshop on 10 May 2021, in which the advisory board members provided advice and recommendations to support the sustainability of the Facility.

Thereafter, the Facility launched the second round of applications for training and mentorship at the beginning of 2021 and selected 33 applicants for support in April 2021.

Source: IRENA

The Southern African Power Pool (SAPP)

The Southern African Power Pool (SAPP) was established in 1995 through a Memorandum of Understanding. The current membership comprises twelve national utilities from SADC, two independent transmission companies and three independent power producers (IPPs). SAPP's mission is to increase energy accessibility to rural communities seeking least cost, environmentally friendly solutions.

Since 1999, SAPP has faced the challenge of power demand that is increasing faster than generation capacity. As an energy-deficient region, load-shedding and unmet demand are common in most SADC countries; in 2015, the equivalent of 8 000 MW was not supplied (SADC, 2016).

As reported by the SAPP (2018), the main ongoing activities are:

- Generation and transmission projects to strengthen the transmission network among the countries of the SAPP. Transmission priority projects are defined as:
  - interconnecting the outstanding members, namely, Angola, Malawi and the United Republic of Tanzania, which are still not interconnected to the SAPP grid;
  - strengthening transmission corridors such as the Central Corridors; and
  - evacuating power from new generation projects, as listed below.
- As per the recently adopted 2017 SAPP Pool Plan (SAPP, 2017), SAPP has identified a list of committed generation projects expected between 2018 to 2039 and priority interconnection investments.
- Key generation projects in the SAPP Pool Plan include:
  - Batoka, Zambia and Zimbabwe – 2 400 MW in 2023;
  - Mphanda Nkuwa, Mozambique – 1 500 MW in 2028;
  - Devil's Gorge, Zambia and Zimbabwe – 1 200 MW in 2032;
  - Inga 3 and 4, Democratic Republic of Congo – 4 800 in 2030; 9 426 MW in 2032, rising yearly to 11 654 MW in 2034; and
  - Stiegler's Gorge, United Republic of Tanzania – 1 048 MW in 2036; 2 096 MW in 2039.
- Key transmission projects in the SAPP Pool Plan include:
  - Inga-Angola, 3 x 400 kV HVAC – 1 100 MW in 2020 (2 lines); 1 600 MW in 2034 (with a third line);
  - Inga-Luano (Zambia) 500 kV HVDC – 2 000 MW in 2029;
  - Inga-Limpopo (Gauteng) (SA), 600 kV HVDC – 3 000 MW in 2032; and
  - STE (Mozambique), 2 x 400 kV HVAC 500 kV HVDC – phased development over 2023–2028.

2.2. Energy supply and demand in Botswana

Figures 6 and 7 present the energy balance in Botswana for 2018, describing the flows from production and imports (Figure 6) to total final energy consumption (Figure 7). Botswana's total primary energy supply (TPES) primarily comprises oil products (34.7%), coal (47.7%) as well as (traditional) biofuels and waste (19.1%), (Figure 6). A large fraction of total final energy consumption (TFEC) (Figure 7) comes from biomass energy in the form of wood fuel (27.8%).

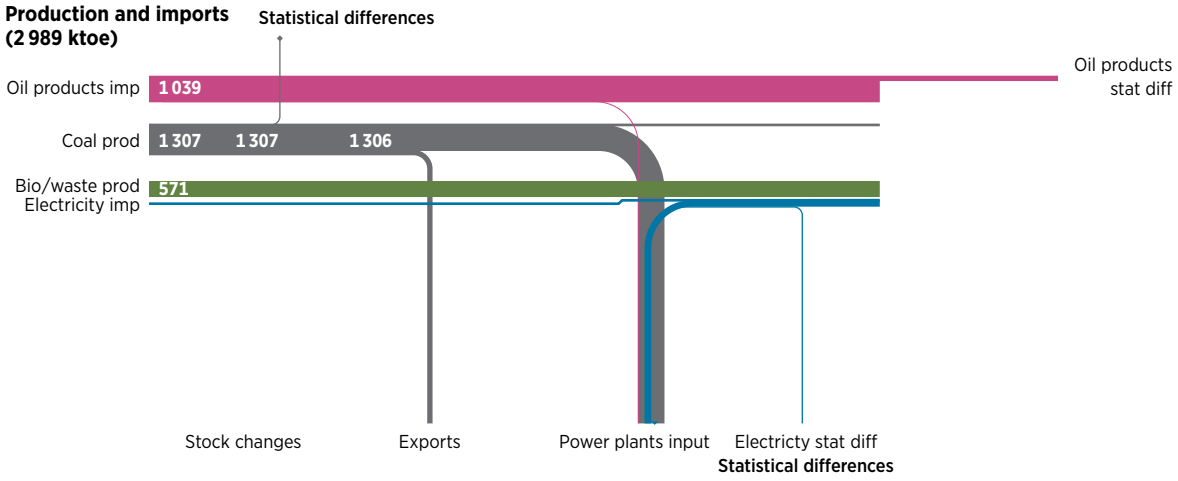
Oil products are primarily used for transport and marginally in the industrial sector. Traditional biomass represents a significant share of primary energy supply (20%). Electricity is mainly produced from coal, with a large proportion of the flow representing power losses (centre). Botswana has high energy dependency, as the largest proportion of overall energy consumption is imported, and oil-based products are mainly imported from South Africa (ICA, 2017).

As represented in Figure 6, the biofuels and waste category (traditional biomass) is directed towards the residential sector. Electricity is marginal, relative to the transport and residential sectors. The largest electricity consumers are the commerce and public services, residential and mining sectors.

According to the IEA's Clean Coal Centre, Botswana has estimated coal resources of 40 Gt (IEA , 2013). In 2014, the only two measured coal reserves were Morupule and Mmamabula basins, with a capacity of 7.2 Gt (MMEWR, 2017b). This abundant resource is underexploited as only a single coal mine, Morupule, is currently operating.

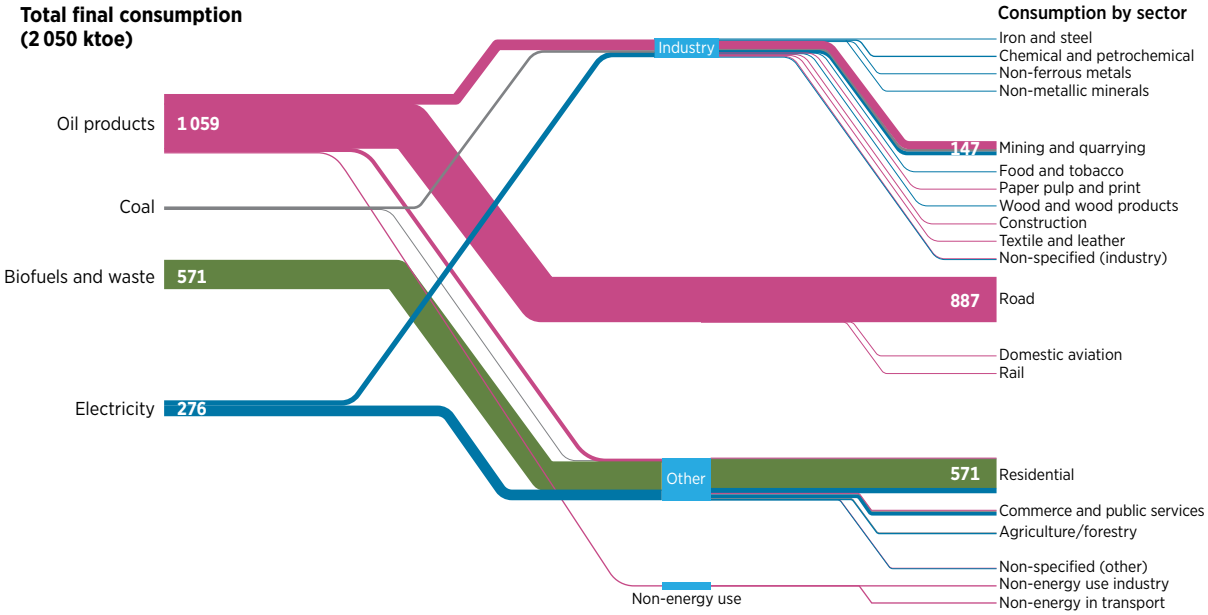
Abundant coal bed methane (CBM) resources have been estimated at 196 trillion cubic feet (tcf), of which 60 tcf is located in the Kalahari Karoo Basin and 136 tcf in associated carboniferous shales (MMEWR, 2017b). Some companies are currently in the initial development planning stage for its extraction.

Figure 6 Total final energy consumption in Botswana, 2018



Source: IEA (2018).

Figure 7 Total final energy consumption in Botswana by sector, 2018

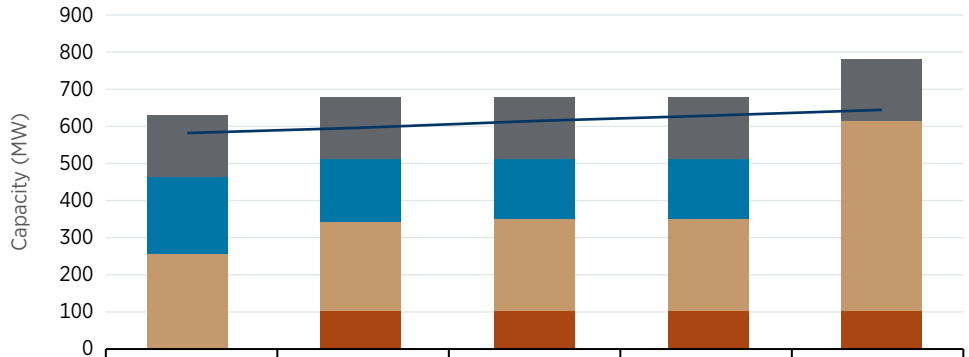


Source: IEA (2018).

Demand forecast

The Botswana Power Corporation (BPC) 2019 annual report provides power demand projections, showing peak demand increasing from 596 MW in 2018 to 633 MW in 2023 (Table 1). BPC's plans are to supply the demand primarily from coal, with diesel as backup power, and a zero-net balance of trade. Compared to earlier plans (BPC, 2017 a) this version does not include planned solar capacities presented later in this report.

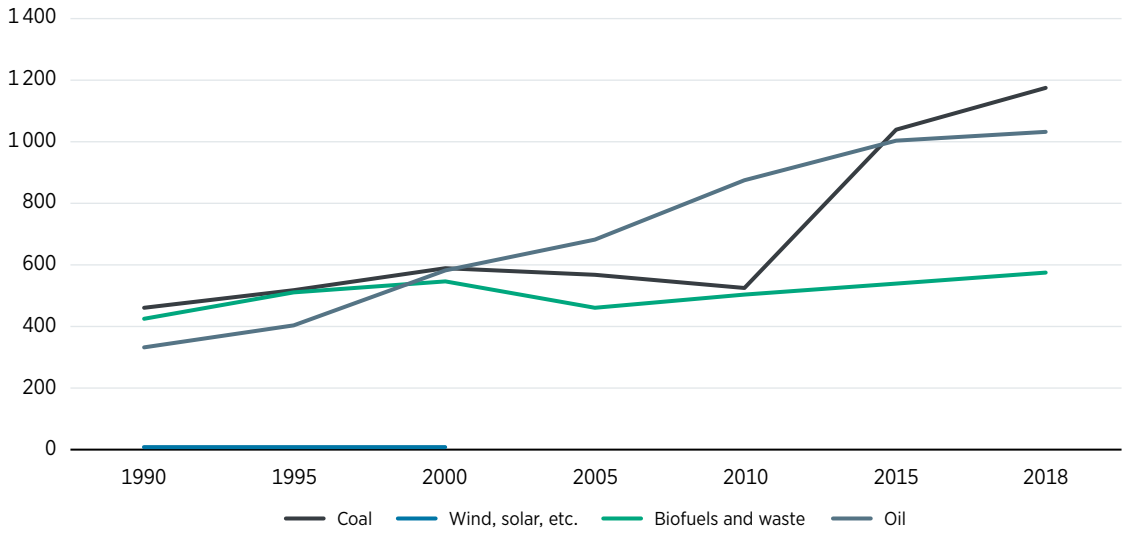
Table 1 Forecast supply–demand balance, 2019–2023



	2019	2020	2021	2022	2023
Emergency (Diesel)	160	160	160	160	160
Imports	200	150	150	150	0
Morupule B	260	260	260	260	520
Morupule A	0	100	100	100	100
Peak Demand	596	605	614	623	633

Source: BPC (2019).

Figure 8 Evolution of the total primary energy supply in Botswana, 2006-2016.



Source: adapted from IEA (2016)

Energy intensity

According to the latest available data presented by the World Bank data portal, the increase in energy consumption has been accompanied by an increase in GDP. Over nearly two decades, GDP almost tripled (in current international PPP, from USD 14.4 billion in 2000 to USD 42.7 billion in 2018) and TFEC increased by 45%, from 1 408 toe in 2000 to 2 050 toe in 2018. The GDP created by a unit of energy (in PPP, million per toe of TFEC) increased from 10.22 to 20.8 over the same the period.

The World Bank (2017) plea, in its detailed examination of the causes of reduced energy intensity in the economy, notes that a large portion of this is attributable to increased economic output and only a marginal amount to energy efficiency improvements.

The statistics indicate a sharp increase in CO_2 emissions (2 780 kilotons in 2000 to 6 340 kilotons in 2016), but a slight decrease in CO_2 emissions per GDP (from 0.201 kg in 2000 to 0.171 kg in 2017 per PPP$ of GDP), potentially related to the slowing down of mining activities and progressive diversification of the economy.[2]


Photograph: Shutterstock

2 For reference, figures in 2016 for South Africa were 0.668 kg per 2017 PPP$ of GDP and 476 643 kt CO2.

2.3 Electricity sector

The Ministry of Mineral Resources, Green Technology and Energy Security (MMGE) leads the electricity sector through the Department of Energy, while the Botswana Energy Regulatory Authority (BERA) is tasked with regulating the sector by guaranteeing a competitive environment.

Established in 1970, Botswana Power Corporation (BPC) is the state-owned utility company. BPC is responsible for electricity generation, transmission, distribution and retail. South African utility provider, ESKOM, has exported to Botswana since 2017 to complement national production, especially during peak periods. A number of renewable energy projects have been initiated, with the private sector involved in bidding. However, no projects in the form of IPPs have materialised in Botswana.

Electricity supply

Botswana relies heavily on fossil fuels for its electricity generation. As shown in Table 2, the country's installed generating capacity stands at 893.3 MW, comprising 600 MW from Morupule B (coal-fired), 132 MW from Morupule A (coal-fired), 90 MW from Orapa power plant (diesel peaking plant), 70 MW from Matshelagabedi power plant (diesel peaking plant), (MMEWR, 2017b) and 1.3 MW from Phakalane solar photovoltaic power plant. Although the installed capacity can cover peak demand – which is estimated at 610 MW – BPC's interconnected system faces several challenges:

- In 2017, Morupule A did not produce electricity and was closed down for refurbishment. It produced 25 GWh in 2018 but had to be shut down again to remedy defects identified during commissioning (BPC, 2019).
- Morupule B has been running under capacity since its commissioning in 2013 due to plant breakdown and system failures. BPC is currently undertaking remediation, which is expected to be completed in 2023/24, with all units running at 100% production.
- The diesel power plants of Orapa (90MW) and Matshelagabedi (70MW, rented to Alstom) were conceived to support peak load but are being used for regular electricity supply (BPC, 2017a). The Corporation's two diesel power stations were not used during 2018 and remained on standby, as it is cheaper to import power than it is to generate from a diesel-fuelled facility.

Table 2 Centralised generation outlook in Botswana for the year 2018 (updated 2019)

POWER GENERATION	TECHNOLOGY	INSTALLED CAPACITY (MW)	CAPACITY CONTRIBUTION (MW) 2019	GENERATION (GWH) 2018
Morupule A	Coal	132	0	25
Morupule B	Coal	600	260	2 974
Orapa	Diesel	90	160	0
Matshelagabedi	Diesel	70		0
Phakalane	Solar	1.3		N/C
Imports	SAPP	N/A	200	594

Source: adapted from BPC (2019 & 2020).

The lack of capacity to satisfy electricity demand requires regular imports from surrounding countries. Until recently, Botswana relied on electricity imports to cover up to 94% of its demand. With the progressive recovery of the Morupule B plant, the share of electricity imports in total supply decreased to about 17%, or 594 GWh in 2018 (from 1 297 GWh in 2017 due to lower demand from the mining sector). The regularity of imports led, in 2017, to an agreement between ESKOM and BPC for the firm sale of electricity for a three-year period (BPC, 2017b).[3]

In addition to installed capacity, there are many potential power generation projects in the pipeline. Other private initiatives for coal bed methane or underground coal gasification generation are at different stages of development through the Mamba, Lesedi and Lethlakeng projects.[4] On the renewable energy side, numerous projects have been initiated over the past decade, including:

- 2006: a 200 MW concentrated solar power (CSP) project billed for the mining town of Jwaneng was discussed. Due to high tariffs and recommendations from other studies, the CSP technology project was discontinued. It was replaced by 100 MW solar PV project, broken into to two 50 MW projects, one to be constructed in Jwaneng and the one in Selibe-Phikwe.

- 2017: BPC issued an expression of interest for a joint venture covering the two 50 MW solar power plants. Although procurement was cancelled in May 2019, BPC received 166 bids from local and international power producers. The decision to cancel the projects was later re-visited and bidders were re-invited to tender for the project. A bidders' conference was held at the end of August 2020. The two 50 MW projects have since been delayed, because of changes to the project structure by the Ministry of Minerals, Green Technology and Energy Security (MMGE). The new tender will be 100% IPP as BPC and MMGE are trying to liberalise the market. Currently the 100 MW (2 x 50 MW) project is still under evaluation and is expected to be awarded in April/May 2021.

- In May 2017, BPC issued an expression of interest for a joint venture regarding the deployment of hybrid networks in 20 rural areas of Botswana and 12 on-grid solar photovoltaic projects to be connected on the distribution grid (1–4 MW projects with a total of 35 MW) at end of 2018. At the closure of the tender in June 2017, 111 offers were submitted (BPC, 2017 c), illustrating the appetite of the private sector to engage in the rural electrification programme with BPC. Two projects have been awarded and 10 were marked for re-tendering. The two awarded in February 2020 are in Shakawe and Bobonong. They were exempted from the need to undertake full environmental impact assessments (EIAs) and are currently undergoing environmental management plan (EMP) development. The EMPs are expected to be completed in December 2020 with the commencement of construction in January 2021 and an expected completion date of June 2022. With regards to the 10 projects that were re-tendered, adjudication is still ongoing, and is expected to be completed in the first half of 2021; the award is expected in late-2021.

- A pilot on-grid solar project, for the Phakalane 1.3 MW plant, was commissioned in 2012. This project, developed with the support of the Japanese government, aimed to prove feasibility and encourage new foreign investment in the sector.

- A project initiated by the private sector identified a potential zone to implement 100 MW of wind with a capacity factor of 24%, which will generate over 210 GWh per year. This project at a very early stage has been proposed to be designed on a build–own–operate–transfer (BOOT) basis after 20 years of service (CD4CDM, 2013). The project is not moving forward.

3 Additional information on this bilateral agreement will be sought through interviews.

4 Off-grid systems are an exception in Botswana. Examples are listed in this section, please see the off-grid section for further references.

- The University of Botswana installed a 20 kW experimental solar plant in Mokolodi village (Gaborone) with net metering and resell of excess power to the BPC grid.

- Other examples can be found (with limited details) of stand-alone applications, such as the 20 kW installed at Multi-waste building at Commerce Park in Gaborone; 200 kW installed at Botho University in Gaborone; and more than 32 kW installed at different residences in Gaborone.

Ongoing and short-term developments

- The development of twelve grid-tied solar power plants by IPPs in pre-selected rural villages is being pursued by BPC and plans to for IPPs to establish 100 MW in grid-connected solar capacity (2 x 50 MW) (BPC, 2018 a, p. 12) in Jwaneng and Selebi Phikwe are ongoing. A review of renewable energy feed-in tariffs (REFIT) is also ongoing, based on those developed in 2011, to encourage greater and more effective private sector participation in power generation in Botswana.

- A 20-village extension project for solar mini grids is underway, entailing rapid load assessments in villages where solar PV plants have been installed to power primary schools as well as associated teachers' accommodation. The objective of the exercise is to consider extending the currently installed primary school solar PV systems to cover other government facilities within the same villages.

- A proposal to install 7 000 Solar Street Lights in 20 villages is being considered, supported by a Chinese grant that is already available.

- A national feasibility study is underway for the implementation of waste-to-energy projects and to advise on an associated road map.

- Through the Rooftop Solar Deployment Programme, policy, regulation, standards and administrative processes were developed and completed in 2020 with the support of Power Africa.

- Through its Biofuels Project, the Department of Energy (DOE) – with technical support from the University of Botswana (UB) and the Department of Agricultural Research (DAR) under the Ministry of Agricultural Development and Food Security – is engaged in a research project that seeks to stimulate the development of the local Biofuel industry. An extension of the Jatropha project completed in 2017, this research project focuses on indigenous plants for oil potential and aims to produce biofuel guidelines and blending ratios.

Grid infrastructure

In the context of reducing energy dependence on neighbouring countries and enhancing the reliability of the national power system, BPC is pursuing a number of grid improvement projects, such as the North-West Transmission Grid Connection (NWTGC) and Rakola Grid Extension projects. The NWTGC aims to extend the transmission grid to the North-West, Chobe and Ghanzi districts to meet the demand from upcoming mining operations and the Zambezi Integrated Agro-Commercial Development (ZIACD) project (BPC, 2017a). The project began in January 2019 and was scheduled for completion in December of 2020; however, due to COVID-19 constraints it was completed and officially launched by the President of the Republic of Botswana in April 2021. The construction of the Rakola substation, a new 220 kV bulk supply point, was completed and commissioned in 2017 (BPC, 2017 a; BPC, 2018 a). According to BPC's annual report, power losses were estimated at 15.3% in 2018.

Figure 9 The power system of Botswana

Source: Botswana Power Company

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

Costs and tariffs

BPC has been in a precarious financial state for many years due to high import costs, operational difficulties and inoperative assets, and has been kept afloat by government subsidies. The cash flow difficulties experienced by BPC were reflected by its net margin ratio of -5.1% in 2017. In 2018, for the first time since 2009, BPC posted an operating profit in excess of USD 27.4 million, before receiving a government grant of USD 133.4 million.

As reported by BPC (BPC, 2017a), the Government of Botswana has committed to provide fiscal support to the Corporation to: achieve cost-reflective tariffs; subsidise operations (through a medium-term plan of tariff subsidies to compensate for the unrealistic cost of electricity to consumers and operational subsidies to meet loan obligations and other operating costs); and provide an equity injection for infrastructure development.

To improve its financial position, BPC has launched its internal MASA 2020 strategy, through which the Corporation seeks to achieve profitability, efficiency and cost-reflective tariffs by 2020, as presented in Table 3.

BPC's cost recovery ratio rose from 64.1% in 2010 to 98.2% in 2019. The gap is compensated for by the government grant, which brought BPC to full capital cost recovery in 2019. The situation is beneficial to the electricity sector, as the financial position of BPC continues to improve over time.

The tariff structure (Table 4) shows that the first 200 kWh are incentivised for domestic consumers. Medium and large businesses benefit from preferential electricity prices, whilst the highest tariffs apply to government, water pumping and small businesses. This tariff setting could correspond to cross-subsidies between consumer categories.

The journey to cost recovery has been driven by sharp increases in electricity tariffs and revenue collection, increasing revenue per customer, and it is difficult to assess progress on operational performance. For instance, system losses have increased by five percentage points over the last decade.

According to IRENA's internal analysis, the cost recovery ratio is based on net operating expenses. The current price setting mechanism appears to be based on 'rate of return' more than 'incentive-based' regulation. The concerns associated with 'rate of return' regulation include the possibility for a pass-through of inefficiencies to end-consumers – which is potentially the case for Botswana at the moment.

The definition of tariffs has been transferred to the Botswana Energy Regulation Agency (BERA), following its creation in September 2017. BERA will ensure that tariffs are fixed on the basis of a transparent tariff methodology – including some level of performance management – through its Electricity Committee. The tariff settings, power purchase agreements (PPA) and tariff definition benefits are also overseen by its Electricity Department, and tariff definition benefits from the advice of the Finance and Procurement Department.

Table 3 BPC cost recovery ratio and performance.

		2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
(A)	Total sales (GWh)	3 294	3 326	3 349	3 479	3 495	3 449	3 310	3 198	3 118	3 109
(B)	Total revenues ('000 USD)	302 683	270 860	249 196	257 144	228 022	203 418	178 578	163 404	136 101	102 193
(C) = (B) / (A)	Average effective electricity tariff (US cents/kWh)	9.2	8.1	7.4	7.4	6.5	5.9	5.4	5.1	4.4	3.3
(D)	Average cost / unit (2020 US cents/kWh)	9.4	8.9	11.6	12.5	11.6	9.4	9.8	7.7	6.1	5.1
(E) = (C) / (D)	**Cost recovery ratio**	**98.2%**	**91.4%**	**64.1%**	**59.1%**	**56.2%**	**63.0%**	**55.0%**	**66.8%**	**71.3%**	**64.1%**
(F)	Revenue grant from the government of Botswana ('000 USD)	72 000	131 130	150 075	208 922	209 412	133 920	78 390	45 720	40 860	0
(G) = (F) / (A)	Grant contribution per kWh sold (US cents/kWh)	0.2	0.4	0.4	0.6	0.6	0.4	0.2	0.1	0.1	0.0
(H) = (G) / (D)	**Grant contribution to cost recovery**	**2.3%**	**4.4%**	**3.9%**	**4.8%**	**5.2%**	**4.1%**	**2.4%**	**1.9%**	**2.1%**	**0.0%**
(I) = (H) + (E)	**Overall cost recovery on net operating expenses**	**100.5%**	**95.8%**	**68.0%**	**63.9%**	**61.4%**	**67.2%**	**57.4%**	**68.7%**	**73.5%**	**64.1%**
(J)	Total consumers	463 250	434 795	409 925	376 003	367 003	343 050	315 669	291 338	251 773	214 170
(K) = (B) / (F)	**Revenue / consumer (USD / consumer)**	**653**	**623**	**608**	**684**	**621**	**593**	**566**	**561**	**541**	**477**
(L)	**System losses**	**14.0%**	**15.3%**	**14.9%**	**15.1%**	**14.6%**	**7.5%**	**10.3%**	**12.3%**	**13.9%**	**10.7%**

Table 4 Botswana electricity tariffs, 2020

SECTOR	FIXED CHARGE (PER MONTH)		ENERGY CHARGE (P/KWH)		DEMAND CHARGE (P/KW)	
	Pula	USD/kWh	Pula/kWh	USD/kWh	Pula/kW	USD/kW
Domestic (up to 200 kWh)	32.45	2.99	0.938	0.0867	-	-
Domestic (above 200 kWh)	32.45	2.99	1.303	0.1199	-	-
Small Business (up to 500 kWh)	100.89	9.31	1.136	0.1052	-	-
Small Business (above 200 kWh)	100.89	9.31	1.684	0.1550	-	-
Medium Business	100.89	9.31	0.858	0.7937	240.618	22.2094
Large Business	100.89	9.31	0.773	0.7107	226.491	20.9052
Government	100.89	9.31	2.412	0.2224	-	-
Water Pumping	100.89	9.31	1.732	0.1596	-	-

Source: BPC, Tariffs, www.bpc.bw/customer-service/tariffs

Rural electrification

According to the World Bank's data portal (World Bank, 2017 a), the electrification rate in Botswana in 2017 was 62.8%, of which urban areas accounted for 80.4% and rural areas 24.2%. Rural electrification in Botswana has been ongoing through various programmes since the 1980's, and the Government of Botswana has set a national electricity access target of 100% by 2030, under the SEforAll Initiative.

Grid expansion and mini-grids

Two programmes are currently dedicated to facilitating the population's access to electricity: The Rural Electrification Program (REP), under the Revised National Policy for Rural Development, and the National Electricity Standard Connection (NESC) program.

The National Electricity Standard Connection (NESC) entails a uniform household electricity connection charge of BWP 5 000 (USD 461.504) in all recognised electrified settlements, villages, towns and cities. In order to effectively implement these connections, the Government approved the establishment of a National Electrification Fund (NEF), which generates revenue through a levy of 5 thebe (USD 0.0046) per kilowatt-hour on electricity sold by the Botswana Power Corporation. The NEF finances the difference between the actual market household electricity connection cost and the NESC cost.

As of 2017, more than 107,000 households have been connected under this scheme (SAPP, 2018); in 2019, 11 759 households were connected to the electricity network through the NESC scheme (BPC, 2019).

In 2018, the Government of Botswana issued an off-grid solar action plan, supported by funding from the World Bank's Energy Sector Management Assistance Programme (GoB, 2018a, 2018b), that proposes the development of rural electrification projects. In terms of households' access, however, the study notes that 126 out of 493 villages might not be connected due to their remoteness from the grid. Considering the high costs of grid connection incurred by consumers, the estimated consumption of 175 kWh/month at BWP 70 (USD 6.46) might bring isolated PV systems close to grid parity in such remote areas, considering the falling costs of PV and storage.

- The action plan estimates that 60% of unelectrified households could be connected, increasing the access rate by 19% to 84% overall. This would require 200 000 households to be electrified through 145 000 installations.

- For public facilities, the action plan foresees the electrification of 43 schools, one clinic, 12 health centres and government facilities in 52 villages.

The action plan calls for further geospatial analysis to determine the final location of the installations that considers BPC's network expansion plans. Provided there is limited risk for investors – *i.e.*, that that the location would eventually be grid-connected – and if demand estimates and 'willingness to pay' assumptions can be validated, the implementation of the off-grid action plan could offer attractive investment opportunities for the private sector.

Box: Togo Case Study

The Togolese Renewable Energy and Energy Efficiency Agency (AT2ER), supported by the European Union and the IFC, commissioned a full assessment of the viability of mini-grid business plans for 318 villages across the country. Based on ground-collected socio-economic data (household surveys), the study established the load profile, capacity and willingness to pay for each village, as well as productive uses. The study then performed a technical dimensioning and financial analysis of each potential system, based on the most recent investment cost estimates. This study, and the data collected, including GIS-based mini-grid designs, are shared with potential bidders, thus improving the chances of success of the national rural electrification programme. In the case of Botswana, such background information is not available to support the rural electrification scheme. This creates uncertainty on the dimensioning and risk pricing for these investments.

Source: TogoFirst (2019).

BPC actively participates in efforts to achieve the objectives set out by the initiative, and the 2019 budget speech declared that, by the end of 2018, the Rural Electrification Program had electrified around 402 villages out of the 493 villages targeted by the Government.

According to BPC (2018), fifteen more villages were electrified during the year and network extensions were completed in another 45 villages that had outgrown their coverage, reducing the number of un-electrified villages from 107 to 92. In the coming financial year, 41 villages will be electrified and network extensions will be carried out in 72 villages. The target is to electrify all villages in the next five years, with all households being connected to the national grid.

To achieve this, BPC will work with the Government to address the costs of connection (currently subsidised through the NESC scheme) with internal household wiring. A consolidation of assets is ongoing, with the transfer of mini-grid projects to the Energy Ministry. This involves 20 systems from a previous donation (50 kW) that currently power local schools and neighbouring facilities. The plants are operated by the local authorities, and electricity is supplied for free, including to the teachers' facilities.

In May 2017, BPC issued an expression of interest for a joint venture regarding the deployment of hybrid networks in 20 rural areas of Botswana. At the closure of the tender in June 2017, 111 offers had been submitted (BPC, 2017c) , demonstrating the appetite of the private sector to engage in the rural electrification programme with BPC.

Today, the overall installed PV capacity in solar homes and small-scale systems is formally unknown, as no agency or institution keeps track of the deployment of such systems. A solar thermal and PV market exists, as numerous private companies provide sales and installation of solar home systems, and the creation of the Solar Industries Association of Botswana (SIAB) and the Renewable Energy Association of Botswana (REAB) has contributed to the expansion of this market.

Box: The BPC renewable energy roadmap

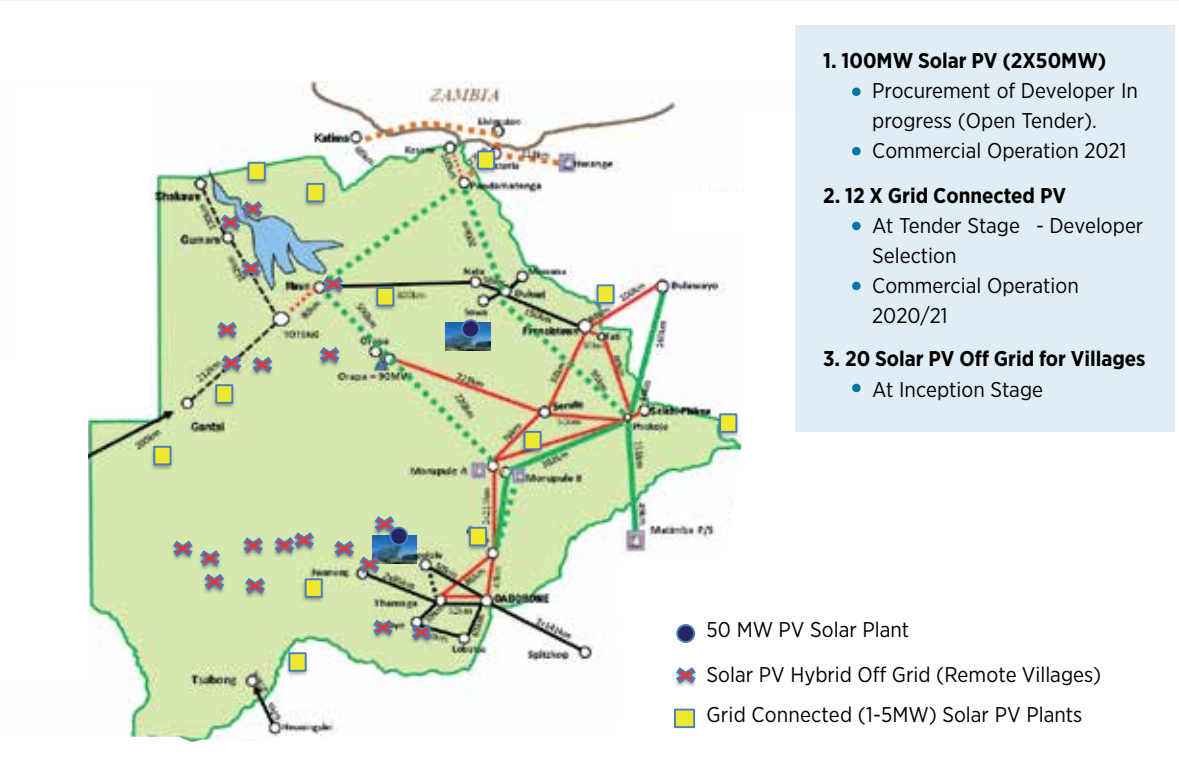
A company presentation from BPC (BPC, 2018b) asummarises its renewable energy strategy to diversify the company's energy mix. The strategic document focuses on solar PV development, including the following:

- 100 MW of solar PV (2 x 50 MW): in 2017, BPC issued an expression of interest for a joint venture with BPC for a 100 MW solar power plan. The procurement was cancelled in May 2019, but BPC had received 166 bids from local and international power producers. According to the BPC 2018 Annual Report, financial, legal and engineering advisers have been appointed to assist during the procurement phase of the project and to ensure that BPC achieves its goal of realising the design, procurement, construction, ownership and operation of a 100 MW solar power plant by 2021.

- 12 grid-connected PV plants (Figure 10): in May 2018, BPC initiated procurement for 12 solar plants with a total capacity of 35.4 MW (BPC, 2018c), and with BPC as the off-taker. Two projects have been awarded the tender, while 10 were disqualified. The re-tendering process is now underway (BPC, 2018a).

- 20 solar PV off-grid villages (Figure 10).

Figure 10 BPC's renewable energy plan



Source: BPC (2018b).

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries

The market has also been developed by NGOs promoting solar-powered pumps and lighting. One example is the Renewable Energy Rural Electrification Programme (RERE), launched by UNDP and GEF (UNDP, 2005; UNDP GEF, 2011), with the then Ministry of Minerals, Energy and Water Resources. The Department of Energy was the executing agency for the project, while the public–private partnership, BPC Lesedi, was the implementing agency.

The RERE estimated 25–35% of the 140 000 to 160 000 of households could meet their basic electricity needs with small PV systems. By replacing fossil fuels, such as petrol and diesel, wood, paraffin and coal, with PV and LPG, the project sought to power rural homes and communities whilst also reducing national energy-related CO_2 emissions. The objectives were ambitious:

- Implement PV lantern/LPG systems for 5 152 households in 88 selected villages.
- Install solar home systems (SHS) for 1 373 households in 88 selected villages (through cash sales, lay-by and credit models).
- Install, operate and monitor a mobile PV mini-grid (one village).
- Provide basic, PV-based electricity services to 6 500 households in five years, and a total of 45 000 households within 20 years.

However, the RERE reached a fraction of this potential before being liquidated (UNDP, 2011).

While several solar systems have been installed in recent years, many systems are no longer working. Most often, lack of maintenance and follow-up, combined with panel degradation, reduces the life expectancy of the systems to only 3–5 years. Deficiencies in user training and the unavailability of technical support are the main causes of these failures (Mooiman & Matlotse, 2016).

The results of the programme were inconclusive and potentially even created a negative precedent for this market segment. The RERE final evaluation report (UNDP, 2011) concluded that the conditions for implementation, rather than market scale, was the main concern. It identified learnings from the programme and formulated recommendations moving forward. In particular, consistent with the outcomes of stakeholder workshops, it noted:

- The need for an *Electrification Master Plan*. Such a plan, featuring both grid- and non-grid electrification, should include clear timeframes and connection rates. The absence of such a plan was identified as a bottleneck for private sector participation owing to the increased costs and perceived risk. The report recommended that the plan should feature strategies for grid expansion and mini grids (captured by the Integrated Resource Plan);
- The need for technical standards, such as those endorsed by Lightning Global; and
- The need to clearly define the role of the private sector, available funding mechanisms, financing sources and effective procurement procedures, with appropriate timelines.

Currently, the Botswana Power Corporation (BPC) implements the Rural Electrification Programme, which had electrified 82% of 493 selected villages by 2018.[5] This electrification programme is complemented by the NESC programme, which offers a flat cost for connection to the grid in selected villages. For locations outside the scope of the NESC, since 2018, the government has also been implementing an Off-grid Solar Action Plan (OSAP) for public facilities. The plan provides clear objectives in terms of solar electrification:

5 As mentioned in the 2019 budget speech, by the end of 2018, the Rural Electrification Program had electrified around 402 villages out of the 492 villages targeted by the Government.

- To provide access to 43 remaining primary schools, most of which have existing non-functional PV systems;

- To provide access to one remaining unelectrified clinic with maternity facilities, and provide access to the 12 health posts with defunct PV systems that will not receive improved access under the Ministry of Local Government (MoLG) programme; and

- To provide access to government facilities in 52 additional villages, most of which do not have existing PV systems.

Through a consolidation of assets that will see the transfer of mini-grid projects to the Energy Department, including 20 system mini-grids of various capacities totalling 2 280 kW that currently power local schools and staff housing.

Discussions are ongoing to expand these systems into a village mini-grid to electrify zones that did not benefit from the initial grant. This potential is sizeable but would require a deeper evaluation and a rural electrification plan.

For the 20 villages currently within the scope of the expansion, these projects would involve investing in systems and grid expansion as well as addressing connection costs. This stage of the discussions foresees investment in the form of a government grant to BPC (pending) and the potential for connection costs to be subsidised through expanding the NESC programme to rural areas.[6]

Although little is known about the potential demand, willingness and capacity to pay, or adoption rates, grid-connected tariffs are foreseen for these rural areas, with the view that the systems would operate at a loss and put an additional burden on BPC's balance sheet.[7]

Rooftop Solar Programme (RTS)

The Government of Botswana is implementing its Rooftop Solar Programme to create an environment in which end-users can generate their own electricity and sell any excess to BPC. The Programme is a suitable alternative mechanism to increase the uptake of solar energy and facilitate private sector participation. It entails the development of rooftop solar guidelines, applicable rules, regulations, standards, tariffs and a review of processes.[8] The guidelines define the framework and administrative process for the implementation of small-scale grid-tied solar photovoltaic (PV) systems, either roof or ground mounted. The system-wide aggregate capacity of the Programme in the first 12 months is capped at 10 MW. At the time of writing this report, applications are still being received by BPC.

The RTS program will provide access for domestic commercial and Industrial (C&I) consumers to produce solar-generated electricity for their own use, on a first-come-first-served basis; it will allow net-metering for domestic customers with grid-tied ground or rooftop-mounted solar systems generating up to 35 kW and up to 1 MW for C&I customers. It will also track and credit excess kWh generated towards the next billing cycle; allow net-metering customers to sell excess generation back to BPC annually; and be capped at 10 MW for the first 12 months, with annual re-evaluations.

6 Stakeholder workshop.

7 Ibid.

8 Currently only the guidelines have been developed and approved.

Non-power uses

Owing to Botswana's semi-arid climate, low soil fertility and erratic rainfall, only 0.65% of land is suitable for arable agriculture. Therefore, the agricultural sector (mainly comprising production of sorghum, maize, millet and cowpeas) accounts for only 3% of GDP. Wind energy has rarely been used in Botswana; few local farmers have adopted it for water pumping. Other than the aforementioned, no additional initiatives have been identified.

Under the patronage of the Ministry of Mineral Resources, Green Technology and Energy Security, a feasibility study is ongoing regarding the development of waste-to-energy in Botswana. Current findings indicate gaps related to the absence of Integrated Waste Management Plans and challenges related to revenues and costs.

The Government of Botswana, in partnership with UNDP, is implementing a GEF-financed biogas and agro-waste project in South-eastern Botswana, with a view to encouraging low-carbon investments and public–private partnerships. The ultimate goals are to establish a sustainable biogas industry and a sustainable means of managing agricultural waste (primarily organic waste). The programme, which is expected to be completed in 2022, has trained masons for the construction of small-scale digesters and, so far, 34 units have been deployed.

2.4 Climate action

GHG emissions for Botswana are projected to increase from 26 386.6 Gg CO_2 equivalent (eq.) in 2012 to 48 973.5 Gg CO_2 by 2030 (Government of Botswana, 2019). The energy sector is the main emitter; in 2015, it contributed 87% of total emissions excluding the land-use, land-use change and forestry sector (MENRCT, 2019). According to its first National Determined Contribution (NDC) under the Paris Agreement, Botswana aims to reduce overall emissions by 15% between 2010 and 2030 – mainly through energy sector initiatives involving stationary and mobile sources (Government of Botswana, 2015b). Botswana launched the National Energy Policy (Government of Botswana, 2020b) and is preparing draft policies on, climate change, waste management and integrated transport that set out measures to combat climate change and achieve the pledges articulated in the NDC document (Government of Botswana, 2019).

According to Botswana's NDC, approximately USD 18.4 billion is required to achieve the set target of a 15% GHG emission reduction by 2030. According to the initial NDC, Botswana must:

- Identify funding sources for mitigation measures;
- Channel more contributions from government and international sources to support these measures;
- Assess related impacts on economic growth; and
- Develop a legal framework capable of supporting a 15% emissions reduction.

According to the country's Third National Communication to UNFCCC, the Government of Botswana has been intensifying its efforts to reduce GHG emissions, with an emphasis on adopting renewable energy. The mitigation projects currently under implementation in the country include:

- Biogas plants: there are a number of potential biogas projects in the pipeline for implementation; mainly the Botswana Meat Commission biogas plant (2.5 MW), Mmamashia Biogas plant (1 MW), Mabesekwa Bio plant (50 kW) and household biogas plants (6 m^3 x 1500). The combined, estimated avoided GHG emissions from these projects is approximately 190 Gg CO_2 eq. by 2030.

- Solar power stations: there are various mini on-grid to off-grid solar power stations, some of which are in operation and others that are undergoing feasibility studies. The capacities of these solar power stations range from 32 kW to 50 MW. Operational PV plants include Phakalane (1.3 MW), 60 kW mini plants installed in 21 primary schools and 32 kW mini power stations powering camp sites in the delta. At full operation, the solar power stations have the potential to reduce GHG emissions by 261 Gg CO_2 eq. by the year 2030.

- Street lighting: a solar street lighting project is currently underway, being implemented by government through the Botswana Institute for Technology Research and Innovation (BITRI) to reduce reliance on coal-based electricity generation. So far, 850 streetlights have been installed throughout the country, leading to an estimated GHG emissions reduction of 0.24 Gg CO_2 eq. Under a planning scenario to install 1000 streetlights per year, they have the potential to reduce national GHG emissions by 3.87 Gg CO_2 eq. by 2030.

- An efficient lighting programme was implemented by BPC in 2012 to improve electricity saving by giving households CFL bulbs for free and replacing their incandescent light bulbs. It is estimated that CFL can save up to 60% of electricity relative to incandescent light bulbs. This mitigation action contributed to a GHG emissions reduction of about 145 Gg CO_2 eq. in 2012 and is projected to achieve 300 Gg CO_2 eq. by 2030. Retrofitting CFLs with LEDs increases the mitigation potential.

- Solar-powered boreholes: farmers in the country are also voluntarily switching from diesel powered pumps to solar powered boreholes, influenced mainly by their cost-effectiveness. Similar to other solar appliances, solar-powered boreholes remove the need to use fossil fuel and petroleum products and thus reduce GHG emissions. Currently, it is estimated that there are about 537 solar-powered boreholes, with a combined emission reduction potential of 0.55 Gg CO_2 eq., rising to 169 Gg of CO_2 eq. by 2030.

- Solar geysers: although solar geysers have been in existence for over 50 years in the country, their adoption is extremely low. According to a household survey, only 0.2% of households were using solar power for heating in 2015/16 (BPC, 2018 a), while BPC estimated that only 3% of high-income households were using solar geysers. At 0.14%, it is estimated that only around 750 households use solar energy for heating. This translates into 0.07 Gg CO_2 emission reduction, which is projected to increase to 8 Gg CO_2emissions reduction by 2030.

  One example of an active solar geyser initiative is SOLTRAIN, the Southern African Solar Thermal project, running from 2019 to 2023**.** The aim of the project is to provide framework development to support uptake of solar thermal technologies to meet national Energy Efficiency targets through policy engagement, capacity building, grant for demonstration of technologies. It includes activities such as quality training, cooperation support with the GoB, dissemination of information and awareness raising; and

- Methane capture and usage as an energy source: this is another mitigation project that is currently being undertaken at the Glen Valley wastewater treatment plant, where methane is captured and flared to heat up oxidation ponds. Methane as an energy gas can be captured and used for generating electricity, heating up the ponds to speed up anaerobic processes, or as cooking gas. Capturing methane reduces GHG emissions by 53 Gg CO_2 eq. and is projected to increase to 400 Gg CO_2 eq. by 2030.

The National Climate Change Strategy and Action Plan (UNDP, 2018b) envisions a society that is "climate-resilient, and whose development follows a low carbon development pathway, in pursuit of prosperity for all". The strategy is designed to provide stimulus for Botswana making significant progress on adaptation and mitigation, whilst meeting its socio-economic development goals, realising Vision 2036, and achieving the UN Sustainable Development Goals (SDGs). As the strategy foresees an emission reduction target, mitigation strategies suggest a sustainable energy component. Both the strategy and action plan build on seven identical strategic interventions:

- Develop a comprehensive financial and tax incentives programme for energy efficiency, energy conservation, and clean energy use in micro, small, medium-sized and rural community enterprises.
- Develop a Low Carbon Pathways Methodology and Guidance Toolkit for Botswana and conduct training workshops for relevant officials in all ministries (in their own language) overseeing carbon-intensive sectors to adopt the low carbon pathway approach into their planning cycles.
- Adopt and fully implement the Botswana Renewable Energy Strategy, finalised in 2017.
- Adopt and fully implement the draft net metering guidelines finalised in 2018 to incentivise growth in domestic and commercial solar power generation and usage.
- Increase the levels of incentives for renewable energy and conservation-related technologies and equipment under Botswana's Manufacturing Investment Incentive and Import Duty Exemption.
- Increase the incentives for renewable energy and energy efficiency related technologies and equipment such as solar power to households and businesses.
- Design, establish and operationalise a multi-sectoral greenhouse gas emissions monitoring, reporting, and verification system in compliance with United Nations Framework Convention on Climate Change (UNFCCC) standards, to annually measure progress against the NDC target of 15% GHG reduction in absolute terms over the 2010 baseline.


Photograph: Shutterstock

Box: Climate Investment Platform (CIP)

The CIP is a global initiative supported by IRENA, the United Nations Development Programme (UNDP) and Sustainable Energy for All (SEforAll), in co-operation with the Green Climate Fund (GCF). The CIP's objective is to step up climate action and translate ambitious national climate targets into concrete investments on the ground (IRENA, n.d. a). Whilst initially focused on energy transition, the ultimate goal of the initiative is to accelerate investments in renewable energy and enable the success of the Nationally Determined Contributions (NDCs).

The platform offers an avenue to strengthen existing collaboration and presents an opportunity to consider ways to more effectively bring together stakeholders to catalyse action, all within existing institutional structures and in line with the respective mandates of the partner organisations.

In this context, investment forums, a key element of IRENA's strategy to facilitate investments in renewable energy, offer an effective organising framework for the implementation of the CIP through a sub-regional approach.

The sub-regional forums have two main aims: to strengthen the ability of decision-makers to build a strong enabling environment for renewable energy investments; and to support developers in preparing bankable projects and accessing finance. Post-forum project support is also provided.

In operationalising the CIP, IRENA intends to work closely with multilateral, bilateral and local financial institutions, development partners and other institutions that are prepared to provide financial and/or technical resources, and/or support the realisation of projects, as well as private companies and private investors.

In Southern Africa, IRENA aims to implement a sub-regional investment forum to scale up renewable energy investments in the region, support project development and implementation, and contribute to the creation of policy and regulatory frameworks conducive to renewable energy investments. Key forum activities will include matchmaking between project developers, potential financiers and investors. Renewable energy projects, along with renewable-based electricity grid and energy efficiency projects, may be considered for support.

Source: IRENA, (n.d.a).

Photograph: Shutterstock

2.5 Energy efficiency

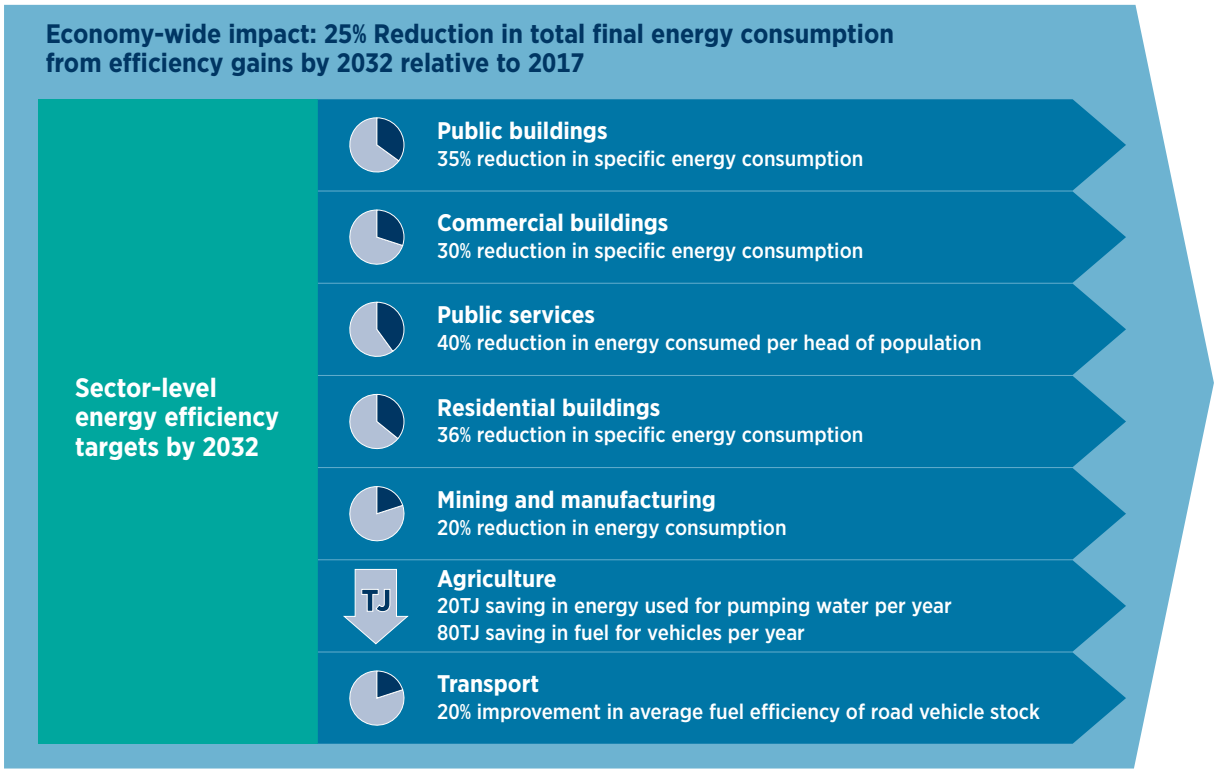
In 2017, the World Bank-funded National Energy Efficiency Strategy of Botswana (World Bank 2017b) identified efficiency sources, some of which involved the deployment of renewable energy. According to the Strategy, 100 000 households are using electric water heaters[9], a figure that will rise to 200 000 by 2032. Switching to solar water heating could free up as much as 2 PJ of electricity by 2032.

The World Bank (2017) notes that 100 000 smart meters were installed in households located in two cities and five major towns. The meters allow BPC to manage the load remotely during supply shortages by giving users an hour to comply with a temporary 10 A (amperes) limit on maximum demand. Failure to do so results in a four-hour disconnection. The meters provide additional benefits, such as remote meter reading, disconnections and reconnections. BPC estimates that the programme has yielded 20–30 MW in demand savings.

The following additional savings from energy efficiency have been noted in the generation sector (World Bank, 2017b):

- **Ensuring the continuous and problem-free operation of power plants could generate energy savings that are comparatively larger than the efficiency savings that can be achieved in most end-use sectors.** According to the World Bank report, the 4.2% reduction in thermal efficiency in 2014/15 relative to the level achieved during 2012/13 represented an energy loss of about 3.2 PJ for that year (2014/15). If the plants were operating at maximum capacity and an 80% load factor, every percentage point reduction in thermal efficiency would represent an energy loss of about 1.2 PJ.

Figure 11 National Energy Efficiency Strategy of Botswana



Source: World Bank (2017b).

9 The country counted approx. 400 000 households in 2011 according to the 2011 census.

- **Reducing the level of own-use at Morupule B**, which currently stands at about 14%. In South Africa, ESKOM pursued a programme of "internal energy efficiency" to reduce the amount of auxiliary power consumption within their own facilities, achieving savings of up to 18%. A more modest reduction of 10% in the own-use of power at Morupule B would yield annual savings of about 0.2 PJ once the plant is operating at full capacity.

National policies currently in place that promote energy efficiency in Botswana include the:

a. National Energy Efficiency Strategy (2017);

b. General Energy Efficiency Standards for Buildings;

c. Draft Botswana Building Control Regulation; and

d. The Meteorological Service Act and the Ozone Depletion Substance Regulation.

The Botswana Energy Regulatory Authority (BERA) was also formed partly to regulate energy efficient appliances in Botswana.

Although Botswana has made an effort in terms of EE policy frameworks, the country currently does not have minimum energy performance standards (MEPS) or energy efficiency labelling for appliances. However, at the regional level, there is an expectation from SACREEE that MEPS will be introduced for lighting (when they are finalised and launched later in 2021).

Botswana is also on the path to develop technical services and a national framework for leapfrogging to energy efficient refrigerators and distribution transformers through a project that is expected to be completed in June 2022.

2.6 Renewable energy potential and use

With regard to renewable energy, Botswana presents considerable opportunities, particularly for solar energy but also from biomass sources. If utilised to their full capacity, these untapped renewable resources have the potential to reduce the country's dependency on fossil-based energy tremendously, enhancing energy security, addressing issues of climate change, increasing access to modern energy services and local economic development.

The development of renewable energies can enable Botswana to meet rising power demand, reduce dependency on power imports, diversify generation and energy supply portfolios, mitigate climate change and increase access to reliable, clean energy to alleviate poverty as well as stimulate and drive economic development.

Solar

Botswana has a very high rate of solar irradiation, making solar energy a promising renewable energy source in the country.

The Ministry of Minerals, Energy and Water Resources renewable energy resource assessment study (MMEWR, 2016a) produced a solar Atlas of Botswana. The results are derived from satellite observations and simulations with the HelioCLim 2 methodology. These simulations do not provide bankable information but are relevant for high-level energy planning. Since the release of this study, the World Bank Group (ESMAP) and IRENA have published more recent solar atlases covering Botswana (Figure 12).

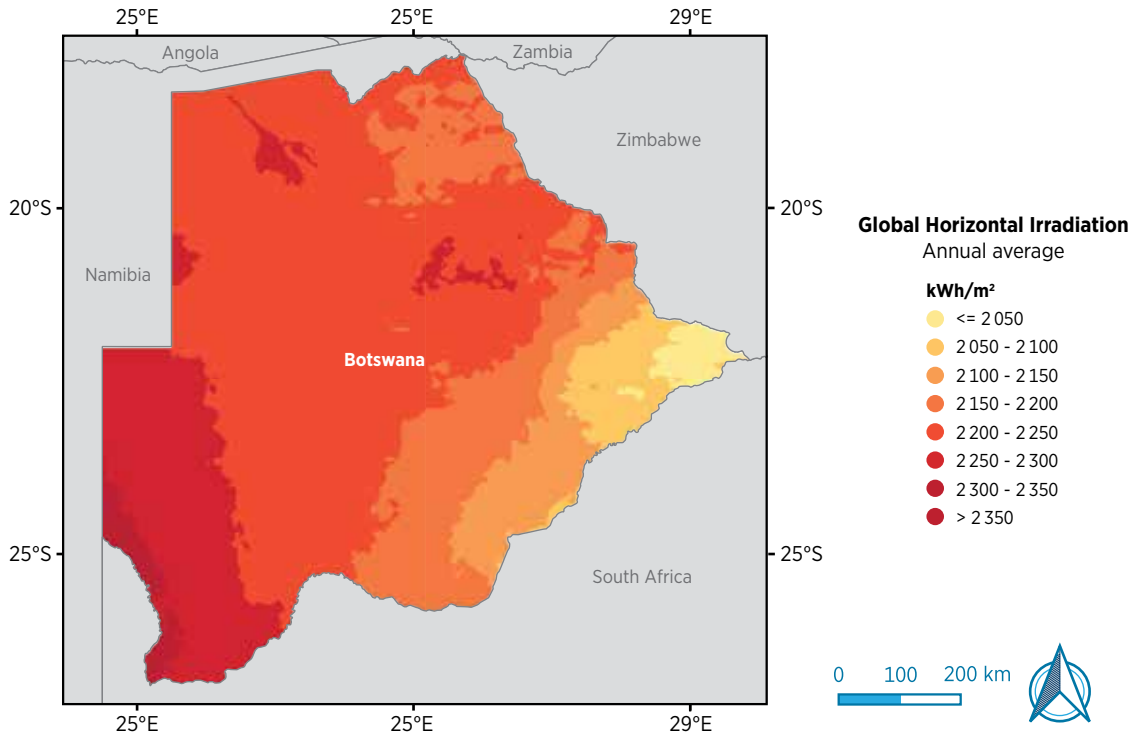
Botswana has a very high rate of solar irradiation, making solar energy a very promising source

According to the MMEWR study, the yearly solar resources from global horizontal irradiation (GHI) range from 2 050 to 2 920 kWh/m^2. For comparison, these irradiation levels are similar to those in California, which is amongst the most competitive solar market today.

The highest values of insolation appear in the southwestern parts of the country, in the Kgalagadi and Ghanzi districts, where values reach 6.2 kWh/m^2/day. Few other zones in the North-West and Central districts present similar GHI rates. The lowest values are observed between the eastern Central district and southern Northeast district, but still reach 5.5 kWh/m^2/day. In terms of direct normal irradiance (DNI), the highest values have been estimated in the southernmost zone of the country, in the Kgalagadi district bordering South Africa, with values above 7 kWh/m^2/day.

From this theoretical potential, technical constraints need to be factored in to assess the technical potential. The economic potential varies depending on the cost of electricity and hence the power mix. The detailed economic potential analysis was performed for Africa (IRENA and KTH, 2014).

Figure 12 Global horizontal irradiation for Botswana



Source: IRENA Global Atlas for Renewable Energy.
Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

Box: IRENA Global Atlas geospatial and site assessment services

Resource mapping is the first phase in planning a cost-effective renewable energy project for subsequent development.

IRENA's geospatial assessment service identifies areas and zones (and attributes) in a country that are appropriate for deploying utility-scale wind and solar PV power projects. The methodology combines resource maps and ancillary data, such as transmission lines and road networks, protected areas, land cover, topography and population growth. These factors are assessed in order to identify areas and zones that have good resource availability, are within reasonable proximity to the necessary infrastructure, and have low environmental and social impacts, based on local conditions. Furthermore, the assessment calculates the maximum installable capacity, identifies the energy generation potential and suggests possible storage opportunities in each zone. Such information supports adequate generation and transmission expansion planning, reduces the risk of investing in unsuitable areas, supports countries in making strategic decisions on energy security and increases the share of sustainable sources of electricity generation.

IRENA's site assessment service aims to evaluate the technical and financial viability of sites for solar PV and wind project development. The methodology uses high resolution site-specific time series resource data, site characteristics and technological parameters to calculate annual energy production (AEP) at different exceedance probabilities for each site. It further simulates the levelised costs and tariffs at which the sites would become viable for further investment in in-situ measurements and subsequent development. This information is of critical value to local authorities, which can screen these sites by comparing the pro-forma tariffs or levelised costs to a benchmark, ensuring resources are invested only in appropriate locations.

Source: Global Atlas (2021).

Bioenergy

Botswana is endowed with a range of bioenergy resources which could be used for energy production. Wood fuel remains the dominant cooking fuel for rural households, as 42% of the population relies on it (IEA, 2016). In 2009, a usage rate of 53% in rural and 13.1% in urban households was reported (SEforALL, 2012).

The MMEWR renewable energy resource assessment study (MMEWR, 2016a) sought to determine Botswana's bioenergy potential through an analysis that addressed crop residues, livestock residues, forest harvesting residues, municipal solid waste and energy crops for biofuel production.

It estimated a total energy potential from biomass residues in excess of 19 million tonnes per year, potentially corresponding to more than 32 million GJ/year (Table 5). The biodiesel and bioethanol potential is even more substantial at 24 million tons per year for biodiesel, and 17 billion litres of bioethanol.

For the considered energy crops (jatropha and sweet sorghum), the theoretical potential may be substantially reviewed if the sustainability indicators of the Global Bioenergy Partnership were to be applied; for example, the competitive use of agricultural space could be factored into the analysis.

Total energy potential from biomass residues is estimated to be in excess of 19 million tonnes annually or 32 million GJ/year

Biomass

In the context of Botswana, the following biomass sources are considered:

- Crop residues from sorghum, maize, millet, bean/pulse, sunflower, groundnuts and watermelon.
- Manure or livestock residues mainly from cattle, goats, sheep, poultry, pigs and horses. The major producers of this type of biomass are located in the Central and North-West districts (MMEWR, 2016a). According to the MMEWR study, this type of residue has potential that should be further evaluated.
- Agro-industrial residues in maize, sunflower and groundnut. Districts with the most important potential in this regard are Central and North-East for crops, and Kweneng, Southern, Central and North-East districts for agro-industrial residues.
- According to the same study, the highest yields from forest harvesting residues are found in the Central district, in Tutume and Serowe sub-districts.
- Wood processing residues are also available in the country, but no quantitative data is available to estimate production. The study further observed that forest harvesting residues represent more than 50% of the total energy potential (Table 5). The other residues only offer a limited energy potential that may be tapped by rural communities.
- Regarding municipal solid waste (MSW), an estimation of the production in the country has been conducted based on the census of 2011. As expected, 80.6% of its production is concentrated in the largest cities of the country, with Gaborone and Francistown leading the production of MSW at more than 337 000 tonnes per year.
- The National Energy Policy indicates that approximately 20 known biogas plants (small-scale biogas digesters) are installed across the country. Another (larger) GEF-funded project includes, *inter alia*, the development of 1 000 small-scale biogas digesters and three medium-scale digesters to be commissioned (UNDP, 2020).

One of the main existing challenges is to avoid an irreversible decline in wood fuel species – a situation that has been already observed in some parts of the country. The study mentioned theoretical potentials that should be further defined, taking into consideration the sourcing distance, distance to power lines, water supply and road network (MMEWR, 2016a).

Table 5 Estimated biomass production and energy potential

POWER GENERATION	CAPACITY CONTRIBUTION (MW)	STATUS
1. Crop biomass residues	54 764	642 063
2. Agro-industrial biomass residues	995	14 120
3. Livestock residues (manure)	17 756 735	12 504 115
4. Forest harvesting residues	1 354 566	15 306 596
5. Wood processing residues	N/A	N/A
6. MSW incineration	422 034	3 798 304
Subtotal	**19 589 094**	**32 251 078**
7. Biofuels		
• Biodiesel	24 011 569	864 656 585
• Bioethanol ('000 litres/year)	17 248 517	341 520 635

Source: MMEWR (2016a).

Biofuels

The 2016 World Bank study is based on a government study from 2007 to assess the potential for biofuel production and use in Botswana. This study revealed the potential for the production of biodiesel from *Jatropha curcas* and bioethanol from sweet sorghum and sugarcane (Donald & Kelebogile, 2009). Table 6 presents the estimated potential of the most significant crops.

Table 6 Biofuels production potential

	Production (tonnes/year)	BIOFUEL	ENERGY POTENTIAL (GJ/YEAR)
Jatropha	80 038 652	24 011 569 (tonnes/year)	864 656 585
Sweet sorghum	431 212 914	17 248 517 ('000 litres/year)	341 520 635

Source: MMEWR (2016a).

The Central district presents the highest biodiesel potential from Jatropha production, while bioethanol potential from sweet sorghum is mainly located in the North-West district, in the Ngami sub-district.

Another study coordinated by IRENA evaluates and indicates very different potentialities for Jatropha, sugarcane and soybean, as depicted in Table 7 (IRENA and KTH, 2014). The main conclusions of the study are:

- Jatropha is not suitable to cultivate in Botswana, as 100% of the land is restricted due to: protected areas, wetlands, existing agricultural lands or urban areas, as well as additional exclusion areas; and other restrictions in terms of market access, water availability and distances to urban areas and existing grid lines.
- Sugarcane crops are only viable if irrigated, the extent of production could reach 9% of the land. This could represent from 1 200–3 000 million litres of bioethanol.
- Soybean is identified as a potential crop for biodiesel production; production of this crop could reach 3% of the land in a rain-fed condition – after applying land restrictions.

Even if the conclusions of the studies vary in terms of biofuels potential, they collectively suggest substantial potential in Botswana.

Table 7 Available land areas and potential yields (dry mass).

	FIXED CHARGE (PER MONTH)				ENERGY CHARGE (P/KWH)			
	rain-fed		irrigated		rain-fed		irrigated	
	restricted land	% land areas yield (> 1 t/ha)	restricted land	% land areas yield (> 1 t/ha)	restricted land	% land areas yield (> 1 t/ha)	restricted land	% land areas yield (> 1 t/ha)
Sugarcane	100%	0%	77%	8%	100%	0%	91%	3%
Jatropha	100%	0%			100%	0%		
Soybean	61%	0%			80%	3%		

Source: adapted from IRENA and KTH (2014).

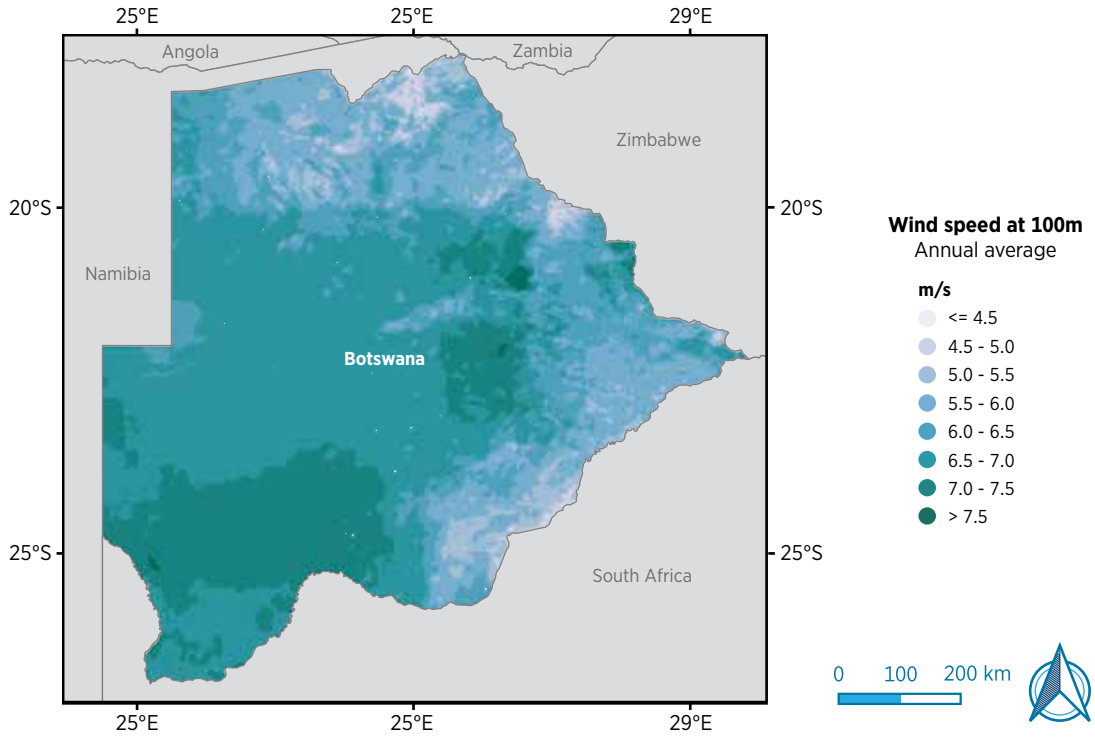
Wind

The renewable energy resource assessment study (MMEWR, 2016a) produced the Wind Atlas of Botswana, calculated from mesoscale atmospheric model outcomes and downscaling models. These simulations do not provide bankable information but are relevant for high-level energy planning. Since the release of this study, the World Bank Group (ESMAP) and IRENA have published more recent solar atlases covering Botswana. These atlases have been created using similar algorithms as the 2016 resource assessment study.

According to these studies, it appears some areas may present limited wind potential. Some regions present wind speeds reaching 7 m/s at 50 m, such as Kgalagadi, Kweneng, South-West and Central districts. A long-term meso-scale simulation (5 km resolution) at 100 m has yielded average wind speeds above 7 m/s and wind power densities above 200 W/m^2. These results must be validated with ground-based data for at least one year in the zones of interest (MMEWR, 2016a).

Even if these speeds could be sufficient for the implementation of wind power plants, when taking into account the different constraints and profitability criteria, areas of feasibility are further reduced. The analysis conducted by IRENA and LBNL for the Africa Clean Energy Corridor depicts some suitable zones for wind turbine power deployment, which are mainly located in the southern part of Kgalagadi district near Tsabong and the Southern district, with a technical potential of up to 1.5 GW (Figure 13).

Figure 13 Wind Speed Map for Botswana



Source: IRENA Global Atlas for Renewable Energy, based on data from the Danish Technology Institute (DTU).
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Small hydropower

Botswana has a limited hydrology suitable for power generation, and regularly suffers from severe droughts and floods which make continuous use of large water resources difficult. Today, no hydropower resource has been used in Botswana and small hydropower potential (SHP) is currently estimated at 1 MW (UNIDO, 2016). Because of its limited potential, the development of this form of energy remains marginal and not a priority for energy stakeholders. To tap into this resource, more precise assessments are needed.

2.7 Other relevant strategic renewable energy plans

The Africa Clean Energy Corridor

In 2013 and 2014, IRENA conducted two major strategic analyses for the SADC region.[10] The first (IRENA, 2013) was a least-cost analysis for the Southern Africa Power Pool (SAPP) and the second a GIS analysis of energy potential performed at continent-scale (IRENA and KTH, 2014).

The least-cost analysis was developed with a view to optimising power trading on the SAPP. The level of precision is low for individual countries. Figures are therefore illustrative. For Botswana, the following technical potentials were identified:

- Solar thermal – 130.7 TWh;
- Solar PV – 137.6 TWh;
- Biomass – 10 MW; and
- Wind (high capacity factor) – 1152 MW.

The least-cost analysis estimated a potential of 199 MW from renewable energy, 139 MW of which in utility-scale projects and 60 MW off-grid. The firm reserve margin would reach 23% in 2030, with zero net imports.

Subsequently, IRENA reviewed the 2014 analysis of renewable energy potentials using a more advanced analytical framework in partnership with the Lawrence Berkeley National Laboratory (IRENA and LBNL, 2015). The study for the Africa Clean Energy Corridor (ACEC) included a multi-criteria approach including population density, water bodies, land use, etc. Rather than a firm capacity in MW, the study delivered maps of areas ranked by levelised cost of electricity (LCOE).

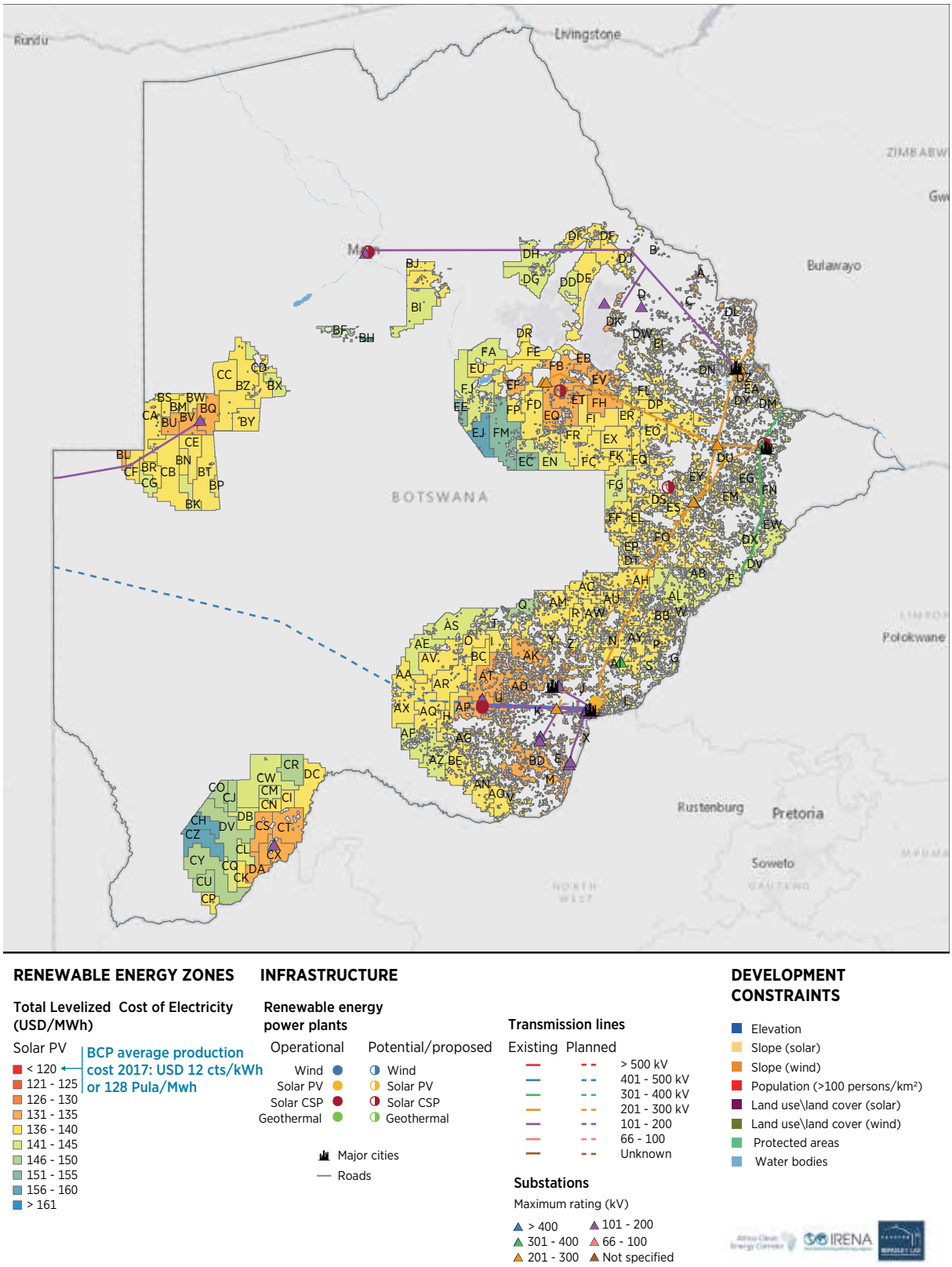
For Botswana, the outcomes are presented in Figures 14, 15, and 16. The BPC 2017 production cost is indicated in each figure in order to compare the LCOE values to actual production costs. Noticeably, there is a good correlation between the 12 sites currently tendered by BPC and the IRENA analysis.

Based on its 2015 analysis, IRENA is in process of updating the ACEC study, also taking into account the 2017 SAPP masterplan. At the regional level, the study foresees an increase in power trade through the interconnectors.

For Botswana, by 2040 the transmission capacity is projected to increase as follows: with South Africa, from 549 MW (2019) to 1349 MW; and with Zimbabwe, from 1630 MW to 2 030 MW.

10 An update by IRENA is forthcoming in 2021.

Figure 14 Photovoltaic solar power zones in Botswana.



Source: IRENA and LBNL (2015).

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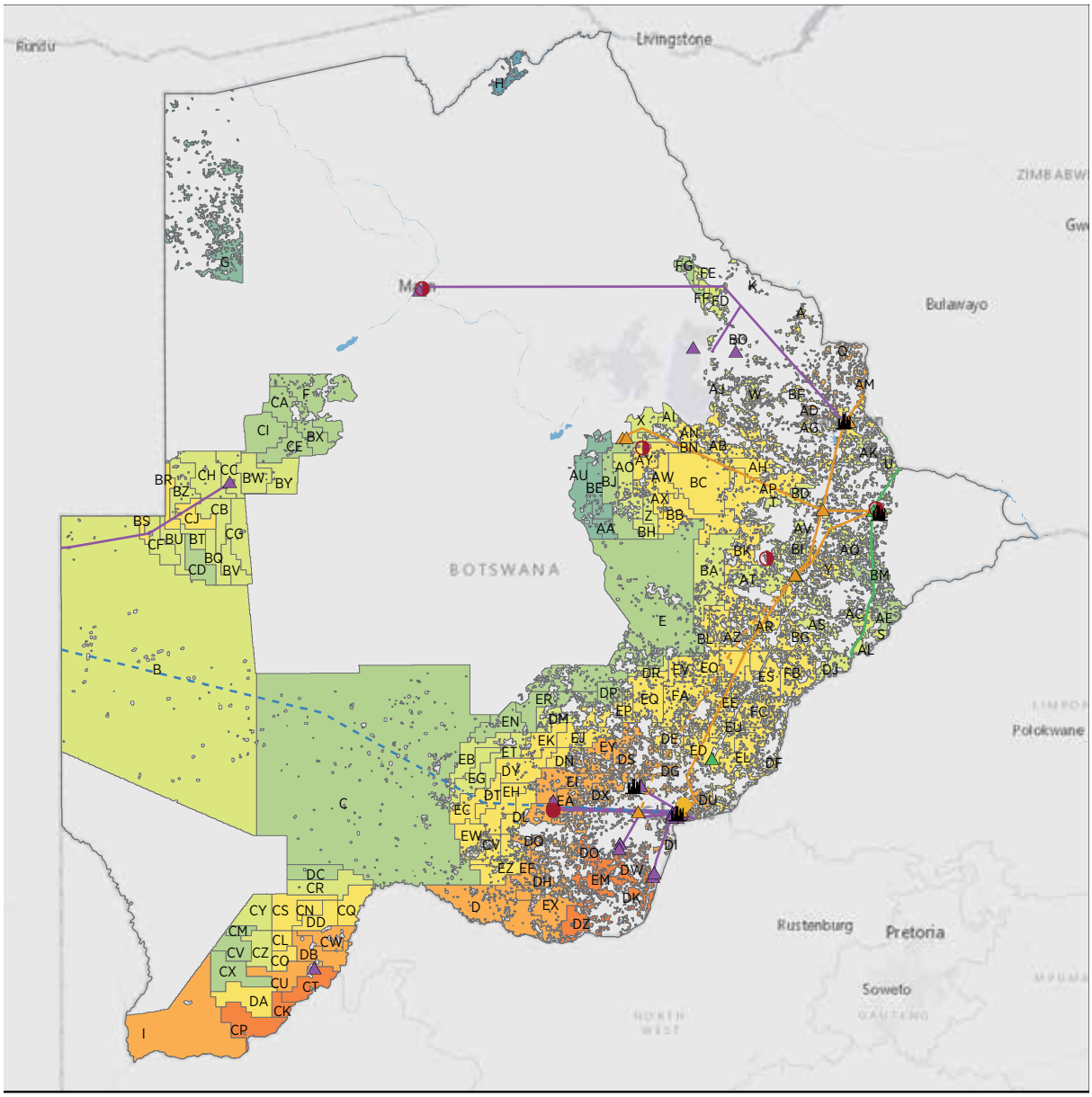
Figure 15 Concentrated solar power zones in Botswana



Source: IRENA and LBNL (2015).

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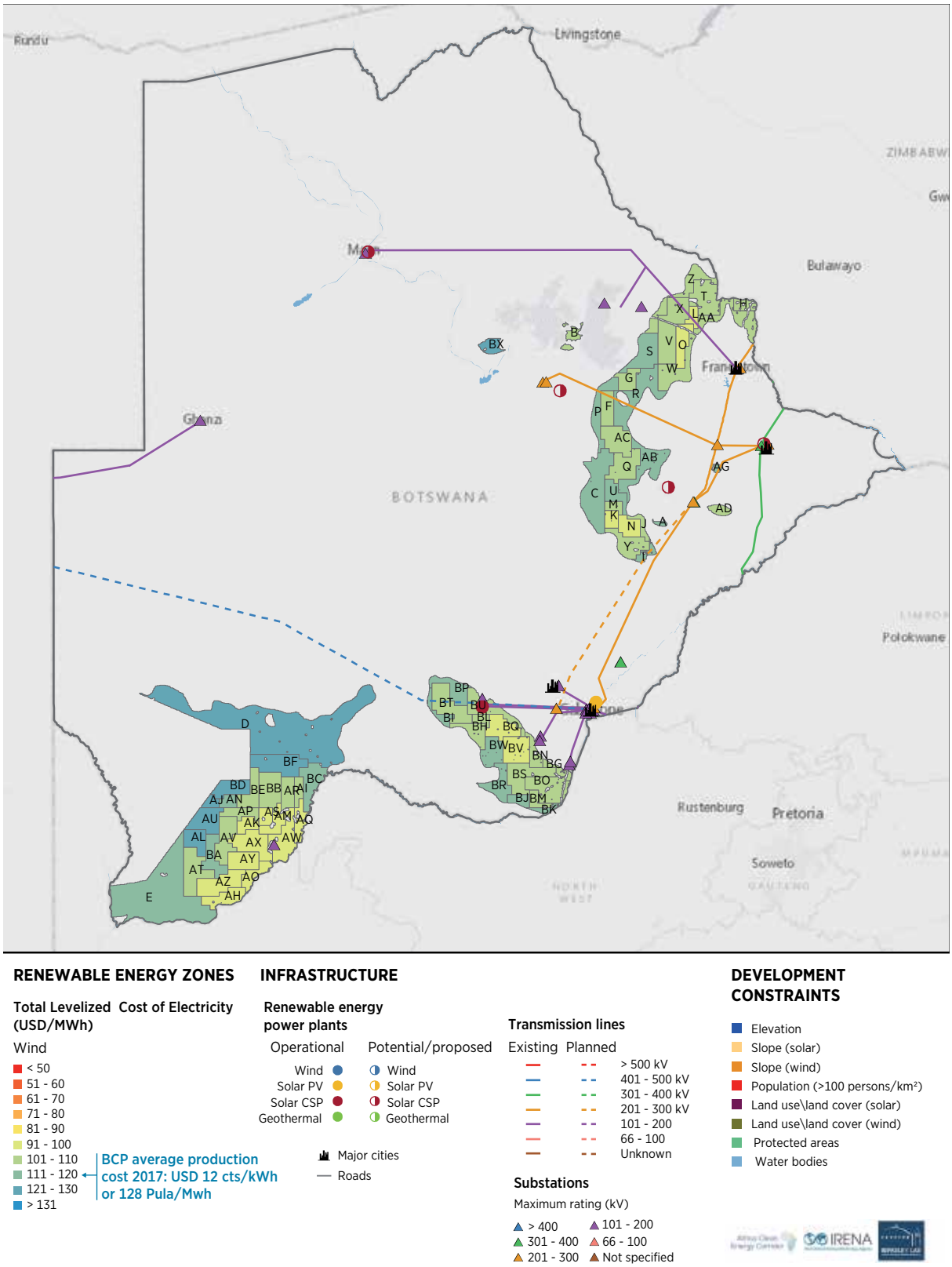
Figure 16 Wind power zones in Botswana



Source: IRENA and LBNL (2015).

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In this newly designed Clean Energy Corridor, the capacity of variable renewable energy increases substantially to benefit from economies of scale and capacity credit at system level. In terms of capacity, the simulated results demonstrate that very significant solar PV capacities can be achieved.

Renewable Energy Strategy for Botswana

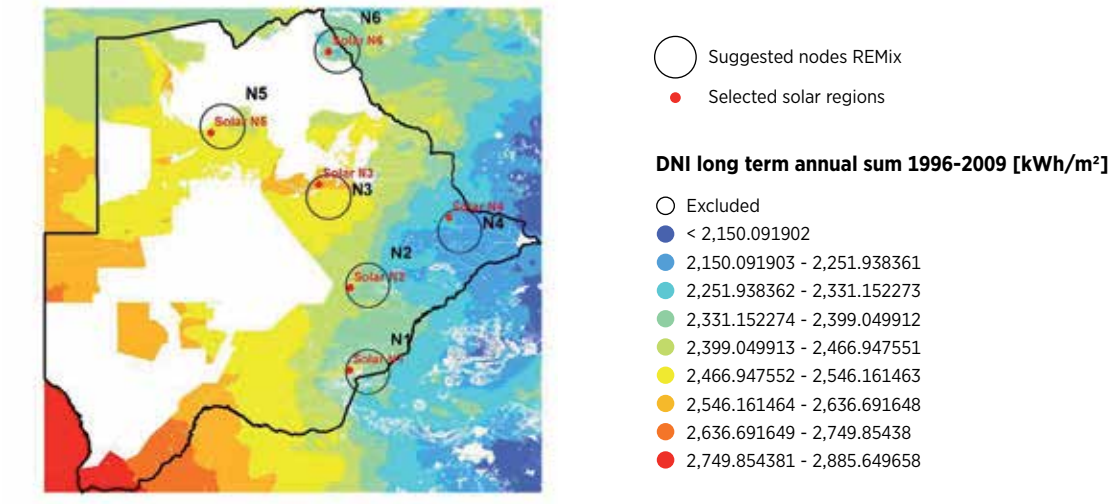
In 2017, the World Bank supported the development of Botswana's Renewable Energy Strategy.[11] The strategy is based on a least-cost analysis (MMEWR, 2017c), which follows the high-level resource assessment (MMEWR, 2016a) described in previous sections.

The least-cost analysis considers seven potential wind sites of 50 MW capacity each, and six representative sites for solar energy of 25 MW for solar PV and 100 MW for solar CSP (Figures 17 and 18).

A visual inspection of the data shows the sites proposed by the World Bank study overlap with the IRENA study, although some large clusters are outside the zones identified by the IRENA study. However, there is limited correlation with the solar sites selected by BPC in their renewable energy strategy (BPC, 2018b).

From the latest study, a least-cost supply curve is presented in Figure 19; the lowest cost renewable energy development would favour the development of PV sites, followed by subsequent wind energy development. Solar CSP is improving in terms of cost priority. The report highlights the value of storage from CSP to manage the system, despite the higher costs.

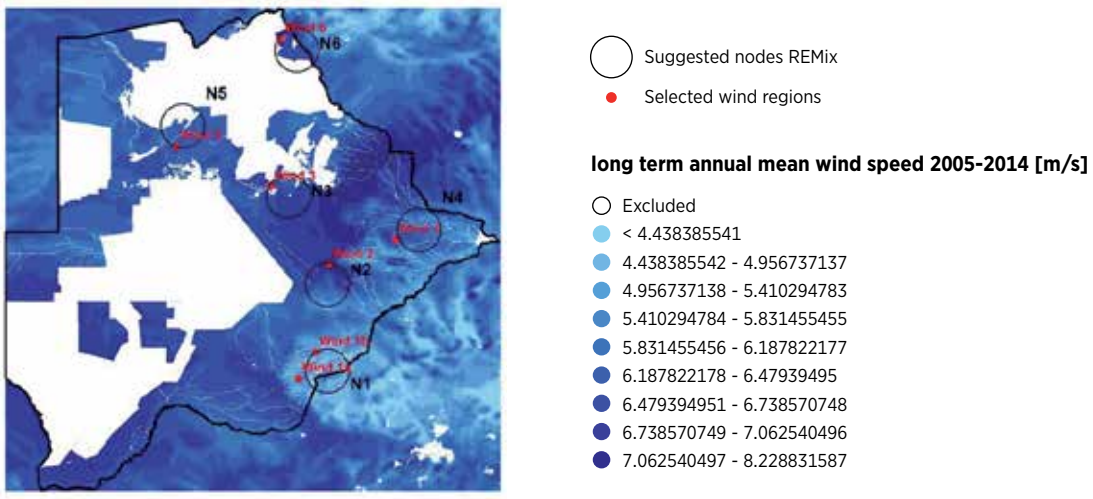
Figure 17 Least-cost analysis, selected solar power (PV and CSP) sites



Source: MMEWR (2017c).
Notes: in the final RES roadmap, sites N1, N3 and N4 are selected as final recommendations.
Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

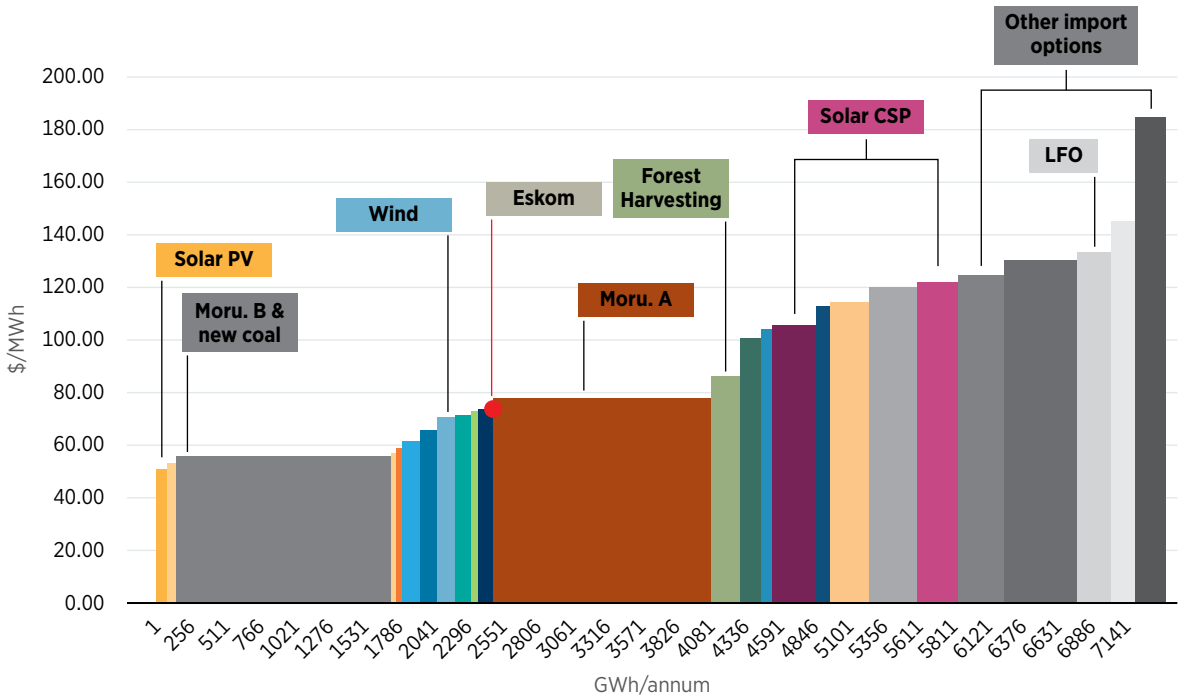
11 Further discussions with the World Bank will allow this contribution to be positioned with regards to the development of renewable energy regulatory frameworks.

Figure 18 Least-cost analysis, selected wind power sites



Source: MMEWR (2017c).
Notes: in the final RES roadmap, sites N1, N2 and N4 are selected as final recommendations.
Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

Figure 19 Least-cost supply curve for Botswana in 2020



Source: MMEWWR (2017c).

In 2017, based on the MMEWR study (MMEWR, 2017c) and a high-level resource assessment (MMEWR, 2016a) supported by the World Bank, the Ministry of Minerals, Energy and Water Resources published the Renewable Energy Strategy for Botswana. The Renewable Energy Roadmap, a document accompanying the Strategy (MMEWR, 2017a) foresees the development of large-scale grid-connected renewable energy that may meet 20% of total electricity consumption by 2030. The final roadmap recommends the addition of 300 MW of CSP and 350 MW of PV by end-2030.

The study emphasises reducing imports, and the least-cost analysis therefore favours baseload capacity, such as coal and CSP; this aspect may explain the strategy recommendation to deploy 100 MW CSP as a priority.

The various zoning studies and least cost analysis results showed that more ambitious renewable energy scenarios could be adopted, provided constraints on the management of the system could be relaxed, including efficient import/export strategies to and from the SAPP.

In this case, the drivers for energy policy would not only be energy independence, but also internalised socio-economic benefits and increased diversification of the national economy.

2.8 Drivers for renewable energy deployment in Botswana

Given the energy context described in the previous chapters, many drivers exist to stimulate support for the deployment of renewable energy technologies in Botswana. These include enhanced energy self-sufficiency, access to modern energy services, climate change mitigation and adaptation and local economic value creation.

Enhanced energy self-sufficiency

To meet its electricity peak demand, Botswana imports power from the Southern Africa Power Pool – mainly from South Africa – and when imports are not available, resorts to the use of backup diesel power plants which are costly to run due to the need for imported fuel. Tapping its vast endogenous renewable energy potential will enable Botswana to reach adequate and economically feasible energy self-sufficiency and security. This is in line with the ambition to become a net exporter in the region, especially in the electricity sub-sector.

Improved access to modern energy services

In Botswana as a whole, about a third of the population has no access to electricity and in rural areas the figure is less than 30%. Access to energy is widely recognised as essential to improving economic well-being. Access to reliable, cost-effective and environmentally sustainable energy through renewable energy technologies can have multiplier effects on development, such as reduced health impacts, improved livelihoods, poverty reduction, job creation, greater gender equality and improved access to water, sanitation, healthcare and food. These cross-cutting impacts of renewable energy are also at the heart of efforts to fulfil Sustainable Development Goals.

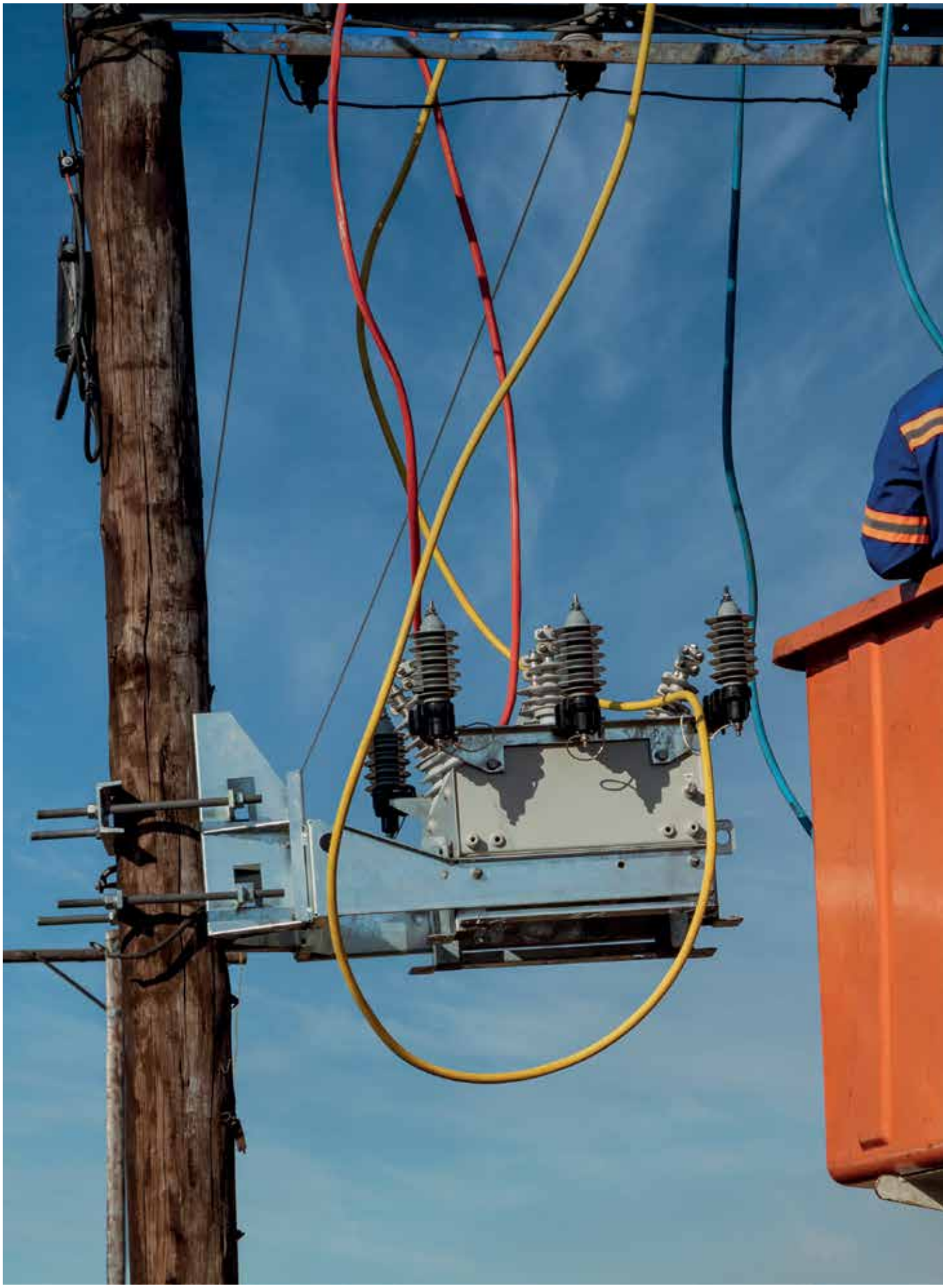
Socio-economic development

With 11.5 million jobs created worldwide to date, renewable energy is a catalyst for new employment opportunities. This is especially true in a country traditionally dominated by conventional energy sources. It offers new avenues for technological innovation and the development of new sectors for economic value creation as anticipated in the Economic Stimulus Programme (ESP). According to the National Energy Policy, sustainable utilisation of available energy will facilitate the transformation of Botswana from an upper middle-income country to a high-income country by 2036.

Low-carbon development

In its first Nationally Determined Contribution (NDC) to combatting climate change, Botswana mentioned its vulnerability to the impacts of rainfall deficits and variability, as well as droughts, which are projected to increase in frequency and severity. This comes with corollaries such as constrained agricultural production, increasing food insecurity and growing water stress. As described above, Botswana's power generation infrastructure, which is heavily reliant on fossil fuels and notably coal, is a major source of CO_2 emissions as well as local air pollution, with sulphur dioxide, nitrogen oxide and micro-particulates among the main pollutants. In its first NDC under the Paris Agreement, the country committed to reduce its GHG emissions by 15% from a 2010 baseline by 2030. The NDC already emphasises the infrastructural development in the energy and transport sectors required to achieve this goal.

Photograph: Shutterstock



Photograph: Shutterstock

3. ENABLING FRAMEWORKS FOR RENEWABLE ENERGY DEPLOYMENT

3.1 Policy and regulatory frameworks

The **Botswana Energy Master Plan** (MMEWR, 2004) presents the country's socio-economic and environmental goals and highlights the nexus between energy and the achievement of these goals. It also details existing achievements and outstanding goals since its last review in 1996.

The following renewable energy-based rural electrification goals are outlined by the Botswana Energy Master Plan:

1. Promote solar energy (government);
2. Grid and non-grid technology integration;
3. Encourage renewable energy-related R&D;
4. Develop an institutional framework to support renewable-based rural electrification;
5. Define strategies to remove barriers to renewable energy uptake; and
6. Use PV power generation – mainly for lighting – to promote child and female welfare.

The **Botswana Biomass Energy Strategy** (MMEWR, 2009) seeks to address the needs of biomass energy end-users and associated problems encountered in Botswana, focussing on domestic, industrial and institutional thermal applications of biomass, such as cooking and heating.

The **Renewable Energy Strategy and (Road Map)** of 2018 encompasses an Investment Programme which is derived from the Capacity Expansion Plan and guides the Strategy's structure. The objective of the Strategy is to lay out the enabling environment requirements for the implementation of the investment plan. The enabling environment embraces the policy, regulatory, commercial, legal and procurement frameworks required for renewable energy to rapidly assume its warranted role in Botswana's energy supply mix. In conforming to the National Energy Policy, the Strategy has a particular focus on private sector participation in the provision of renewable energy, including independent power producers (IPPs) for larger RE generation projects.

The adoption of a **National Energy Efficiency Strategy** (NEES) is ongoing, which is a necessary requirement for Botswana to achieve several of the priorities identified in its National Development Plan 10 (2009–2017). The strategy supports and promotes national energy security. Other national priorities supported by the strategy are climate change, economic development, and universal and affordable access to energy. This demonstrates the government's commitment to enabling the achievement of these goals, providing a strong and clear mandate to address energy efficiency.

The **Botswana 2017–2023 National Development Plan** (Government of Botswana, 2017) aims to reduce the country's reliance on energy imports, including by increasing energy saving in all sectors. The Plan foresees the increasing participation of IPPs in the energy mix and the increased use of indigenous sources of energy (including fossil resources). Having pointed out the declining technology costs, a renewable energy programme is envisaged, with solar identified as a niche market with a target of 100 MW by 2017.

Under the Plan, the government has begun developing a comprehensive renewable energy strategy, with the support of the World Bank, that will provide a sound basis to spur investments in this sector.

Government studies to promote renewable energy include a solar water heating survey; a biofuels production and use feasibility report; a feasibility study for a 200 MW CSP Universiplant; and a study supporting renewable energy feed-in tariffs (Government of Botswana, 2017).

In 2011, the Government of Botswana, through the Department of Energy (DOE), commissioned a **Renewable Energy Feed-in Tariff (REFIT)** study. The aim of the study was to encourage greater and effective private sector participation in power generation in Botswana – in particular for renewable energy technologies (RETs) – through the establishment of regulatory mechanisms that reduce risk for investors and developers. The REFIT was also developed to create an enabling environment for achieving renewable energy targets and goals. However, the REFIT was not implemented due to high proposed tariffs and additional funding required.

The government, in collaboration with UNDP, has secured the services of a consultant to review and update the REFIT. The objective of the review is to advise the government on up-to-date, practical and effective ways of implementing and monitoring the Feed-In Tariff (FIT) Programme, considering global trends, cost implications and technical limitations. The consultant will develop relevant REFIT strategies to international standards; generate appropriate guidelines for key stakeholders through workshops and tailor-made training programmes; and support programme management staff, where applicable, on REFIT related issues. The project is expected to be completed by the end of 2021.

An **Integrated Resource Plan (IRP)** was launched in December 2020 to amend and replace previous plans. It announces an electricity generation mix comprising at least 15% renewable electricity by 2030, as compared to the current 2%. It outlines a least-cost development plan for a period of 20 years (2020–2040). The Plan considers various scenarios for energy demand and supply strategies and identifies least-cost development paths by simultaneously examining (1) demand-side measures, (2) energy efficiency improvements and (3) electricity supply options from domestic and regional sources.

The optimal capacity expansion path proposed in the IRP maintains prescribed standards for reliable electricity generation systems and a high level of social equity, and also considers environmental protection. The main approach of the IRP is based on a detailed techno-economic analysis of potential demand and supply strategies through various scenarios. However, the IRP does not capture the full extent of the potential for renewable energy development. The IRP is discussed further in the next section.

The latest **National Energy Policy** (Government of Botswana, 2020a) foresees the provision of reliable, affordable energy for sustainable development, and improved access to efficient and effective uses of energy resources. Some of the strategies that the National Energy Policy aims to implement relate to:

1. The government's role in investigating Botswana's supply security challenges and investing in an appropriate reserve margin.
2. The government's role in facilitating the participation of IPPs to meet national power demand peaks and regional exports.
3. Ensuring appropriate regulation of the electricity industry to assure equitable access to transmission infrastructure.
4. Ensuring that electricity tariff policies provide a basis for sustainable power supplies over long term.
5. Setting cost-reflective tariffs.
6. Reforming institutional arrangements to promote increased access to petroleum products.
7. The government's role in ensuring security of supply and maintenance of strategic petroleum oil reserves, through Botswana Oil.
8. Facilitating the optimal country-wide distribution of petroleum products.
9. Ensuring the availability of enabling legislature to facilitate private sector participation in the coal sub-sector.
10. Promoting the use of bio-energy resources as a feedstock in the generation of energy services.
11. Facilitating the development and use of CSP and PV electricity generation.

Key regulatory and legislative documents

The main regulatory documents identified by this review are:

1. The Botswana Power Corporation Act, 1970 (rev. 2002);
2. The Electricity Supply Act 1973 (amended 2007);
3. The Botswana Energy Regulatory Authority Act, 1973 (rev. 2016);
4. The Environmental Impact Assessment Act, 2005; and
5. The Revised National Policy for Rural Development, 2002.

The Botswana Power Corporation Act (Government of Botswana, 1970) establishes the national utility of Botswana. BPC is mandated to manage electricity generation, transmission, supply and distribution in areas approved by the Minister, and to trade electricity, purchase and sell in bulk.

Aside from appointing the BPC chairman, the Minister may also provide BPC with advice in support of the implementation of public policies, provided these do not conflict with other legal obligations.

Through this Act, BPC is mandated to prescribe tariffs and methods of charging for different customer categories. The tariffs should enable operation in a commercially sound manner. The revenue requirements are set according to the fair value of assets and reasonable returns in accordance with the Ministry.

The **Electricity Supply Act** (Government of Botswana, 2007) was enacted in 1973 (Government of Botswana, 1973), with a provision that necessitates that the Minister consult BPC before issuing a generation license above 25 kW. The Act does not mention transmission or distribution separately to generation. A generation licensee is entitled to build transmission infrastructure as required. In practice, the Act is establishing BPC as an integrated monopoly, operating generation, transmission, distribution and retail.

In the 2007 amendment (Government of Bostwana, 2007), the consultation of BPC was waived, thereby allowing the Ministry to grant licenses. In this review, generation, transmission and distribution licenses can be issued separately, which might open possibilities for increasing the number of participants in the generation business, as well as the distribution and retail business, should the case emerge. The revised Act provides for access to/use of transmission facilities and associated infrastructure owned and operated by BPC. The 2016 amendment (Government of Botswana, 2016), tasks the Botswana Energy Regulatory Authority with delivering licenses. Notably, the President may acquire land or rights over land as deemed necessary for the purpose of generation or supply.

In the 2007 amendment, government-owned installations are exempted of licenses. The 2016 amendment no longer mentions exemptions for government buildings.

In the 1973 version of the legislation, power capacities below 25 kW are exempted of licenses for the purpose of self-generation on the owner's premises. The 2007 amendment increases this limit to 100 kW, which is maintained in the 2016 amendment.

The **Botswana Energy Regulation Authority (BERA)** was enacted in 2017 under the Botswana Energy Regulatory Authority Act (BERA, 2016) and is responsible for implementing renewables-based electricity generation policy.

BERA is responsible for ensuring the transparency of tariffs, taking into account cross-subsidies between classes of consumers as per government policy. Since tariffs are regulated, BERA is also responsible for regulating permitted revenues for regulated entities in the regulated sector, and ensuring tariffs are established in a transparent manner. The regulation of allowed revenues ("revenue requirements") demands that BERA monitor the performance of regulated entities.

The Act identifies BERA as a source of expertise in relation to tender procedures, alongside the **Public Procurement and Public Asset Disposal Board** – the latter being established by the Public Procurement and Asset Disposal Act (Government of Botswana, 2008). This entity is mandated to operate all public procurements or the disposal of public assets, both within and outside Botswana.

BERA should encourage the preservation and protection of the environment and conservation of natural resources in accordance with any written law. This provision would make the Environmental Impact Assessment Act of 2005 relevant for regulated activities, including power generation.

Associated regulations are currently being developed to facilitate the smooth operation of the Authority and the BERA Act is currently under review.[12]

12 The details of the review were not discussed during the workshop.

The **Environmental Impact Assessment (EIA) Act** (Government of Botswana, 2005) requires that every licensing authority ensure an authorisation has been issued before delivering a license. Application to obtain the authorisation shall contain a preliminary EIA; while policies or programmes shall contain a Strategy Environmental Assessment (SEA). The authority[13] in charge of granting the authorisation ("the Department"), may require an additional environmental impact assessment. This process entails the applicant submitting terms of reference for the EIA to the authority and hiring external consultancy services to carry out the assessment.

Ongoing policy developments

Progress is required in strengthening the regulatory framework; the National Energy Policy (Government of Botswana, 2020b) launched in December 2020 take into account new developments in the energy space.

In December 2020, the Department of Energy launched an Integrated Resource Plan (IRP) for electricity. The Plan aims to "encourage the efficient use of energy and to assure access to electricity in Botswana with reliable and self-sufficient electricity generation with minimal development impact". The main supply-side strategic objectives of the IRP were identified as follows:

a. Diversification of sources of electricity generation;

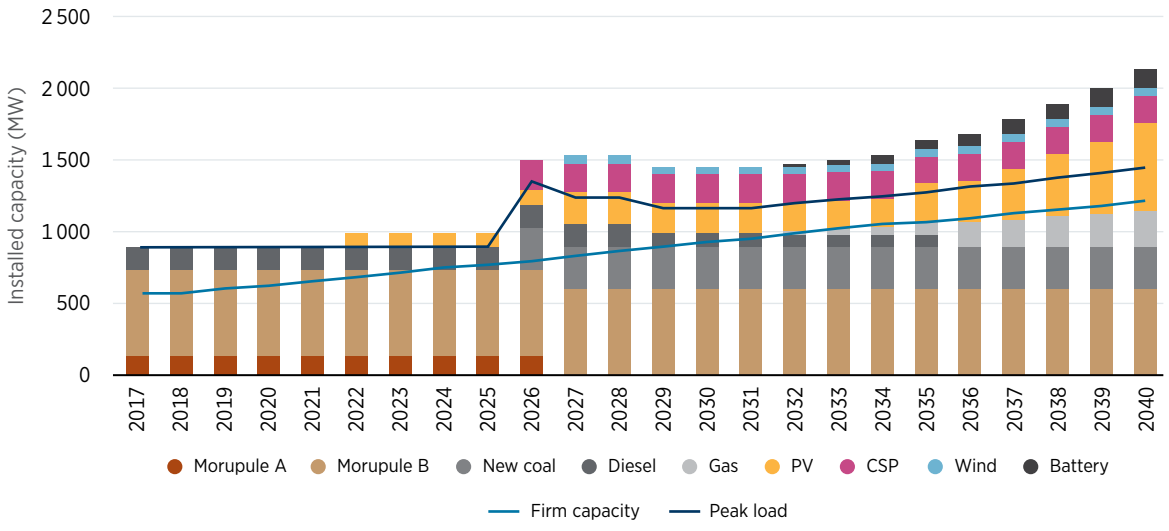
b. Competitiveness in the electricity sector;

c. Security of electricity supply;

d. Self-sufficiency in electricity generation and becoming a net electricity exporter; and

e. Mitigation of environmental impact, through various methods such as using low carbon technologies in coal.

Figure 20 Projected energy mix, 2017



Sources: (Government of Botswana, 2020a)

13 Institutional arrangements concerning this authority required clarification.

The outcomes of the IRP Plan include a projection of generation capacity up to 2040. The plan does not appear to take into account the actual delivery capabilities of Moropule A and B. The BPC projections (BPC, 2020) foresee Morupule reaching full capacity only in 2023, instead of 2017 in the current IRP.

In line with the IRP model results, the Government of Botswana has approved and intends to implement energy projects with a total installed capacity of 1540 MW by the year 2040 to meet the growing energy demand at least cost whilst also reducing the country's carbon footprint. These will be implemented as follows:

- 135 MW solar PV by 2022 (currently under procurement);
- 250 MW coal bed methane (CBM) by the year 2040 (10 to 100 MW by 2025, currently under procurement);
- 200 MW CSP plant by the year 2026 (procurement to start during 2021);
- 300 MW new coal by the year 2026 (procurement to start immediately during 2020);
- 50 MW wind by the year 2027 (procurement to start in 2024 after wind resource mapping is complete);
- 600 MW solar PV by the year 2040 (100 MW solar PV procurement to start in 2025) – the projects will be developed through private sector investment as IPPs; and
- 140 MW battery storage by the year 2040 (18 MW battery storage by 2032, procurement to start in 2029).

The Legal and Regulatory frameworks involve the Electricity Supply (amended) Act of 2016, which makes provision for the licensing and control of undertakings for the generation and supply of electricity. The Petroleum Product Act is currently being developed for immediate promulgation and the Gas Bill is also being drafted to guide the operations of the gas sub-sector. For some sub-sectors, regulations/incentives are under development, such as:

1. Guidelines for rooftop solar installation;
2. Building Control Regulation;
3. A MoU between the Department of Energy and the Solar Association of Botswana has been signed;
4. Solar home systems may eventually be exempted from import duties; and
5. Biodiesel standards are available and await enforcement.[14]

14 As mentioned by stakeholders.

Summary of policy and regulatory frameworks

Table 8 Summary of the regulatory framework based on IRENA's classification

National Policy		Regulatory Instruments	
Renewable Energy Law / Strategy	[15]	Auctions	[16]
Solar Heating Law / Programme		Feed-in tariff	
Solar Power Law / Programme		Premium	
Wind Power Law / Programme		Quota Certificate System	
Geothermal Law / Programme		Hybrid	
Biomass Law / Programme		Net metering	
Biofuels Law / Programme		Ethanol blending mandate	
National Policy		Biodiesel blending mandate	
VAT exemption		Solar mandate	
Fuel tax exemption		Registry	
Income tax exemption		**Finance**	
Import / export fiscal benefit	[17]	Currency hedging	
National exemption of local taxes		Dedicated fund	
Carbon tax		Eligible fund	
Accelerated depreciation		Guarantees	
Other fiscal benefits		Pre-investment support	
Grid Access		Direct funding	
Transmission discount/exemption		**Other**	
Priority/dedicated transmission		Renewable energy in social housing	
Preferential dispatch		Renewable energy in rural access programmes	
Other grid benefits		Renewable energy cookstove programme	
		Local content requirements	
		Special environmental regulations	
		Food–bioenergy nexus	
		Social requirements	[18]

Source: Author's elaboration, based on IRENA's classification framework (IRENA, 2016).

15 Under adoption.
16 through BPC.
17 Solar home systems.
18 Now terminated.

3.2 Institutional framework

Institutional stakeholders

Botswana's institutional stakeholders in the power sector are presented in Figure 21.

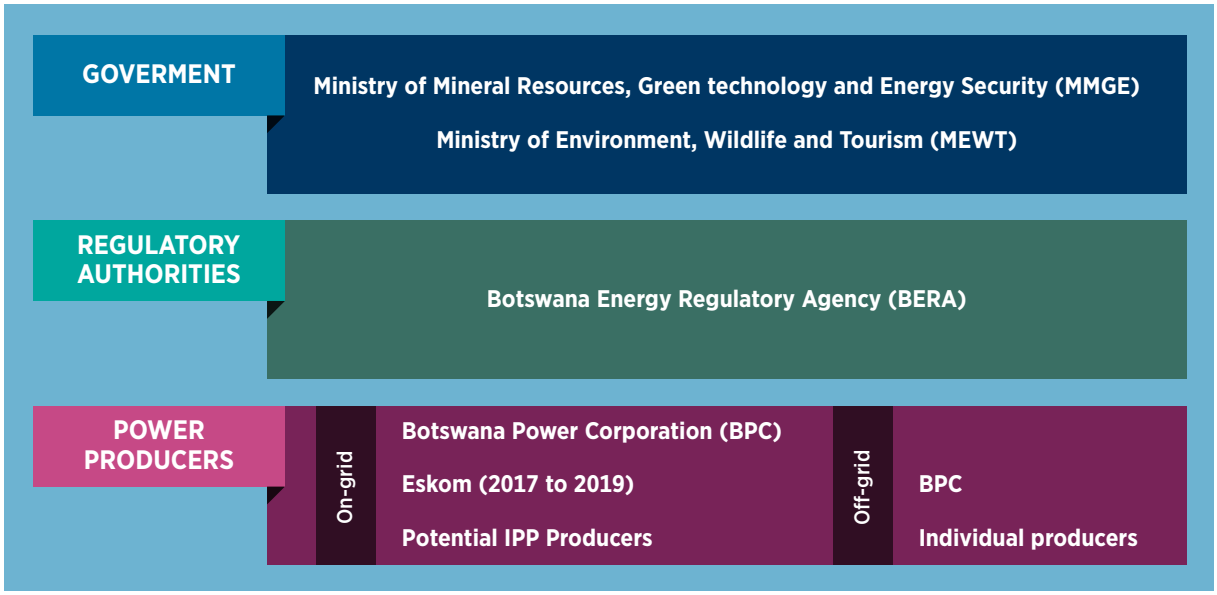
The Ministry of Minerals, Green Technology and Energy Security (formerly the Ministry of Minerals, Energy and Water Resources, MMEWR) is mandated to regulate mining activities and oversee mineral development; and to promote green technology use and a mix of sustainable alternative energy sources to provide energy security.

The Ministry's vision includes ensuring security of energy supply through both conventional and renewable energy sources and enabling the use of green technologies in the advancement of mining and energy.

The **Botswana Energy Regulation Authority (BERA),** established by the Botswana Energy Regulatory Authority Act (BERA, 2016), is mandated with renewable electricity generation policy implementation.

The Ministry of Environment, Natural Resources Conservation and Tourism (MENRCT), through Department of Meteorological Services (DMS), is the focal point for climate change in Botswana. MENT coordinates climate change activities in the country and is responsible for reporting to the UNFCCC. Reporting is in the form of National Communications, Biennial Update Reports and Nationally Determined Contributions. DMS is tasked with producing reliable and accurate weather and climate data, information and related services to enable optimal utilisation of resources and contribute to the safety and protection of life and property. It provides information on the state of the atmosphere. This includes information on past, current and future conditions, as well as warnings and advisories. Benefits to society include policy-making decisions in the climate sensitive sectors for socio-economic purposes and managing risk arising from climate variability and climate change.

Figure 21 Power sector institutional stakeholders



Source: EEP (2017).

Botswana Vision 2036 calls for a renewable energy contribution to the energy mix

The Ministry of Basic Education (formerly Education and Skills Development) is in charge of the Education and Training Sector Strategic Plan (2015–2020), which seeks to promote quality education for all. The five-year strategic programme is articulated around eleven priorities, strongly focused on lifelong learning, designing an inclusive education sector, upgrading ICT infrastructure in the education sector and increasing e-learning; reviewing curricula; and improving governance. The Ministry is relevant to the development of local skills supporting the growth of a renewable energy job market in Botswana.

In line with the aim to ensure consistency in professional curricula, the **Botswana Qualification Authority** was founded in 2013 by the 31st Minister of Education and Skills under the Botswana Qualifications Authority Act. The Authority provides accreditations to learning programmes at all levels. The authority has defined accreditation standards for renewable energy and solar energy in particular.

The Botswana Investment and Trade Centre (BITC) has the role of conveying a positive image of Botswana to foreign investors. This role is fundamental to attracting foreign investors to renewable energy auctions. BITC encourages domestic investment and expansion; promotes locally manufactured goods to regional and international markets; contributes towards improvement of the investment climate through policy advocacy; increases citizen participation in the economy; and creates sustainable job opportunities (BITC, 2021). In August 2018, BITC presented Botswana and its opportunities in the energy sector at the China Business Forum.

Private sector

From 2009 to 2015, the Joint Venture BPC Lesedi subsidiary for rural electrification was jointly owned by BPC (55%) and Electricité de France (45%). BPC Lesedi was placed under voluntary liquidation in 2015, as the business model was not effective (BPC, 2015).

Other stakeholders have entered the power market, such as POSCO Energy (Korea) and Marubeni (Japan), which are participating in the expansion of Morupule B with 2 units (5 and 6) of 150 MW each. The consortium won the construction and operation contract for 30 years (BCCN and JACSES, 2018).

Another expansion phase is under discussion for an additional 300 MW split between two units (7 and 8) with the Korea Electric Power Corporation (KEPCO) and Daewoo. Both projects are foreseen under an IPP scheme; however, problems in reaching an agreement have jeopardised the expansion project of units 5 and 6, which are now on hold (Mmegi, 2016).

Shumba Energy is a locally owned coal and energy company, which has been attempting to develop a solar PV project over 1000 ha in the Maun region. By end-2018, Shumba announced a collaboration with the German H2-Industries to construct a solar power plant with innovative energy storage technology (liquid organic hydrogen carriers) in the framework of the call for tenders for 12 hybrid systems launched by BPC (H2 Industries SE, 2018).

COMPANY	COMPANY ACTIVITY	PROJECTS UNDERTAKEN	COMMENTS
Biodiesel Botswana	Biodiesel production	EEP Africa supported project. *Industrial energy efficiency improvement demonstration project for an existing biodiesel production process from waste vegetable oil*	Project discontinued owing to lack of funds
Biowatt	Solar energy, energy, biogas installations	Installations of solar home systems around the country since 2017	Energy company offering solar energy, energy management and green services
Bostrich Products International	Biogas power generation	EEP Africa supported project. *A feasibility study for 1 MW power generation from biogas in Mmamashia*	Project failed and discontinued
Future Fuels Africa Pty.	Biogas power generation	EEP Africa supported project *Lobatse Green Town Initiative, Botswana* *Waste to energy project in Lobatse, Botswana*	Project failed and discontinued
Golden Links	Biogas power generation	EEP Africa supported project. *Bioelectricity generation from biogas at the Gaborone waste/ water treatment facility*	Project was cancelled because the facility owner did not want to sign agreement
The Diamond Workshop	Solid Biomass production	EEP Africa supported project *Fuel briquettes production from biomass resources in the village of Malolwane*	Project failed and discontinued
iCarbon Botswana	Provision of cutting edge energy management solutions using advanced green technologies in the market that helps businesses provide green services such as replacing traditional sources of energy with renewable energy	Installations ongoing in different parts of the country	
Green Issues Botswana	Promotion and installation of renewable energy technologies as well as offering consultancy services	Installations ongoing in different parts of the country	
SoSolar	Solar PV	Promotion and installation of renewable energy technologies	Installations ongoing in different parts of the country
MultiEnergy	Solar PV	Promotion and installation of renewable energy technologies	Installations ongoing in different parts of the country

Other privately held companies participate in the biomass and solar markets:

Non-governmental organisations

In recent years, non-governmental organisations involved in the renewable energy sector include:

- The Renewable Energy Association of Botswana: functions as an engine to grow renewable energy technologies and services. It supports development of cost effective, sustainable renewable energy generation; promotes consultations, reflections and deliberations on key issues in the field of renewable energy technologies in Botswana; and presents stakeholders with a unique forum for sharing information, analysing the latest developments involving renewable energy technologies, and advocating for partnerships and networks. The association's creation was spearheaded by Network of Excellence in Renewable Energy Technologies for Development (NEED) at Botswana International University of Science and Technology (BIUST) and launched in October 2018.

- Green Energy and Sustainability Association (GESA): promotes the use of Renewable and green energy technologies in Botswana. The organisation was created in 2017 and has been actively engaged in workshops, trainings and pilot projects across the country.

- The Botswana Community-Based Organisations Network (BOCOBONET, 2021) is dedicated to enhancing the technical and institutional capacities of its members to utilise natural resources for their socio-economic well-being; it provides capacity and advocacy.

- The Solar Industries Association of Botswana (SIAB): a solar energy trade group that aims to promote solar energy use, facilitating cooperation between government, industry, academia and others in the field of solar energy in Botswana.

International actors

- The Japan International Cooperation Agency (JICA) supported a 5-year scientific project (completed in 2017) to develop Jatropha for the production of biodiesel; and a rural electrification programme. The UB, DAR and DOE have agreed to extend the Jatropha project by way of undertaking a research project focusing on indigenous plants for oil potential that will result with biofuels guidelines and blending ratios.

- UNDP/GEF funded the Renewable Energy Rural Electrification Programme until 2013.

- The World Bank funded development of the renewable energy strategy and energy efficiency strategy and is currently supporting the Government of Botswana with its plan for a green recovery and for the development of renewable energy.

- USAid Power Africa:

  - Provided support to BPC for a 100 MW solar procurement (2017);

  - Provided support to BERA to create regulatory frameworks, guidelines and regulations; and

  - Supported development of the Southern Africa Regional natural gas strategy.

Local research and training institutions

- The Botswana Institute for Technology Research and Innovation (BITRI) performs outdoor technical tests and research and development on solar thermal systems.

- The University of Botswana Clean Energy Research Centre (CERC) undertakes interdisciplinary research on sustainable and renewable energy. CERC offers relevant education and is an advocate for renewable energy, energy efficiency and environmental protection. The Centre operates the Mokolodi solar research project and is a local partner for the SOLTRAIN initiative.

- The University of Botswana provides a pool of experts from all areas including social, economic and technical that are required by the RE Sector and that are capable of supporting the work in a) Capacity Building (project targeted training, *e.g.* CERC project that specifically trains people to focus on the design, installation and maintenance of Solar Water heaters and the same can be extended to the renewable energy rollout to capacitate IPPs) and b) Research (the Department of Energy in partnership with the University of Botswana are implementing a biodiesel research project and the findings of the project will inform policies and strategies).

Photograph: Shutterstock

4. KEY CHALLENGES AND RECOMMENDATIONS

This section aims to dive into the challenges faced by Botswana in increasing its uptake of renewable energy and provides recommendations on actions to be implemented in the short-to-medium term, covering institutional and policy frameworks, regulation, risk mitigation as well as the human capacities and skills necessary to develop current renewable energy technologies.

These key issues and recommendations are based on an initial analysis that follows the drafting of a background paper. They also arose from the exchange of information held at the initial meeting on the RRA process, the validation workshop, and from various bilateral meetings with key local stakeholders.

4.1 Institutional and policy frameworks

The RRA process and its consultations revealed several plans and strategies in Botswana that relate to the overall energy sector as well as the growing room for renewable energy development. However, it appears that these plans and strategies are only being partly implemented, owing to several factors including misalignment between the objectives of some of these plans. Other factors that were listed by stakeholders at the time of the RRA consultations include the lack of an overarching and binding energy policy (which has since been launched), the lack of a specific renewable energy framework, and the lack of incentives for renewable energy. At this stage, the contribution of renewable energy to the electricity mix is modest.

In this context, fundamental issues that should be examined pertain to institutional arrangements, as well as the roles and mandates of national institutions to draw a long-term vision for renewable energy development in the country.

Promoting and facilitating the implementation of clear long-term vision for renewable energy development

The sector requires coordination between the most relevant stakeholders, chiefly the Ministry of Mineral Resources, Green Technology and Energy Security and the regulator, to clearly set the paths for future investments in line with policy priorities. It must be understood that the strategic priorities of a corporation seeking a healthy balance sheet, or financial sustainability, are not identical to the priorities of a country seeking economic, environmental and social sustainability. The role of policy and regulatory oversight is fundamental to aligning priorities, especially with regard to the declining costs of renewables, which represents an opportunity for major cost savings.

Steady renewable energy capacity increases require vision and stability, embodied in appropriate and implementable planning. In this regard, Botswana can succeed in its uptake of renewable energy by transforming visions and roadmaps into binding commitments that contain specific renewable energy technology targets. It is also important that the targets that have been outlined across the different policy and strategy documents are aligned to provide a consistent, long-term signal to investors.

The experience of other countries such as Morocco have shown that a shift in the energy mix, increasing reliance on local resources, and reduced reliance on imports and costly fossil-based generation plants is possible when the drivers are established. In the case of Morocco, energy independence through harvesting natural resources is coupled with a long-term sustainable vision that includes environmental sustainability and harvesting the social and economic benefits of renewable energy projects – hence the mobilisation of local companies and the development of a local supply chain, supported by a human resources management strategy, towards a "just and inclusive energy transition" (IRENA, 2019).

In this regard, the willingness to issue an IRP is a positive step. Following good practices, the Plan should be open to stakeholder participation and revised on a regular basis to account for economic drivers, technology drivers and the evolution of the regulatory frameworks. The capacity of the DoE to develop and update the IRP, in collaboration with BERA, should be reinforced to include new technologies and smart grids. This would provide BERA with the necessary tools to support this drive.

Operationalise the regulatory authority

The country has embarked on the path to regulatory reform – alongside the 70% of developing countries that have created a regulatory entity and opened private sector involvement through Independent Power Producers (IPPs), (World Bank, 2020). The regulator's independence should rely on expertise, which will require BERA to be equipped with sufficient internal capacities. Operationalising BERA will require development mechanisms to guarantee a sustainable and independent budget over time, as well as a degree of political independence and enhanced capacity to hold the utilities accountable for their operational and financial performance – which is the purpose of a regulator.

In the interim, pressing issues need to be addressed such as:

- The ability to develop and enforce a tariff methodology, based on cost recovery, with elements of performance management;
- The development of grid codes, and a dispatch code; and
- Building the ability to review procurement processes for IPPs, including reviewing the environmental impacts of projects and reviewing the cost implications of the PPA.
- Also, stakeholders have noted delays incurred from the application of the Environmental Assessment Act, which would require mainstreaming.

During the stakeholder consultations, it was noted that the BERA Act 35(2)(a) exempts from license small-scale installations below 100 kW, which was understood as most mini-grid systems or rooftop solar systems being outside the scope of the scrutiny of BERA. Considering these installations may – on an aggregate level – impact the financial and operational performance of the utility, and/or engage end customers (potentially through subsidised tariffs supporting rural electrification), the need for BERA to engage in regulating network access and tariffs in this segment was highlighted. It is also highly recommended that the regulator monitors the enforcement of standards issued by the Botswana Bureau of Standards.

Table 9 Status of operationalisation of BERA with regards to the mandate as set by the BERA Act

SECTION	SCOPE	STATUS
6(2)	Under part VI of the BERA Act. "(..), the Authority shall have the following functions"	
6(2)(a)	*Regulate tariffs, including allowed revenue, for regulated entities in the regulated sector*	Financing is being sought
6(2)(c)	*Subject to the regulated sector legislation, to license activities in the regulated sector*	Not operational
6(2)(d)	*Regulate network access for independent power producers, privately financed projects in the regulated sector*	Financing is being sought
6(2)(e)	*Provide advisory technical expertise on tender procedures to the Public Procurement and Public Asset Disposal Board ..*	Not operational
6(2)(g)	*Monitor and inspect licenses and enforce license obligations*	Most of the manpower capacity is active in new applications for oil and small rooftop installations
6(2)(h)	*Implement policy in relation to the generation of electricity from renewable energy sources, as may be advised by the Minister*	Advisor to the Ministry rather than in charge of implementation
6(2)(i)	*Oversee project development in the regulated sector*	Currently working on regulatory tools for planned inspections
33(2)	Under part VI of the BERA Act, "The Authority shall establish and maintain a non-discriminatory and efficient regulatory framework to be followed by all regulated entities and licensees in the regulated sector. The regulatory framework shall include:"	
33(2)(a)	*Administrative fees payable by licensees*	Not in place and no staff dedicated
33(2)(b)	*Matters related to policy*	Advisory to the Ministry
33(2)(c)	*Tariff setting*	Not operational
33(2)(d)	*Internal and external communication processes*	Not operational
33(2)(e)	*Strategic planning processes for the regulated sector*	The IRP responsibility is hosted by the Department of Energy. BERA is advisor to the process. However, the regulations regarding the development and update of the IRP are not yet developed
33(2)(f)	*Licensing of activities for the regulated sector*	Not operational
33(2)(g)	*Standards for supplies and services in the regulated sector*	Not operational
33(2)(h)	*Processes and methodologies for undertaking tariff reviews*	Not operational
33(2)(i)	*Processes and methodologies for monitoring performance in the regulated sector*	Not operational
33(2)(j)	*Technical codes for licensees and regulated activities*	Not operational
33(2)(k)	*Consumer dispute protection and resolution*	Not operational
33(2)(l)	*Environmental protection*	Under the scope of the Department of Environmental Affairs

Source: interviews.

4.2 Regulatory frameworks and policy support mechanisms

Though critical, establishing adequate institutional and policy frameworks is not sufficient for an effective and sustainable uptake of renewable energy. In the specific context of Botswana, regulation and other policy support mechanisms relating to grid codes and tariff-setting with the aim to support private sector participation will be key in the short and medium terms.

Establish a grid code that is conducive for variable renewable power

Under the authority of BERA, grid codes prioritising access to the grid for electricity generated from renewable energy, and dispatch based on marginal cost, should be developed to govern all current and future electricity generators and replace the BPC operational manual, which governs their transmission function. The elaboration of such a grid code should include the role of renewable energy generators and storage technologies to help system operation remain reliable and secure, where they would specify the ancillary services that variable renewable energy and enabling solutions can offer which may be financially remunerated. This provides transparency for project implementation by IPPs as BPC is currently a vertically integrated utility, potentially transitioning towards a single buyer model. Moreover, a robust regulatory system will be crucial at all levels for sustainability and stability to ensure protection of projects of public interest from failure.

From the outcomes of the workshops and stakeholder interviews, it appears that Botswana's power sector regulatory framework is clearly being challenged by the global transformation affecting the sector worldwide. The attractiveness of variable generation is very high in terms of competitiveness, security of supply access and GHG emissions, but introduces variability both on the supply and the demand sides, which implies deviation from the business-as-usual model and internalised specific competences.

Revise the tariff-setting structure

With the creation of the Botswana Energy Regulation Authority (BERA) in September 2017, the definition of tariffs was brought under its supervision. BERA shall ensure that tariffs are established on the basis of a transparent tariff methodology by means of its Electricity Committee, including some level of performance management.

According to IRENA's internal analysis, the cost recovery ratio is based on net operating expenses. The current price-setting mechanism appears based on 'rate of return' regulation more than 'incentive-based' regulation. The concerns associated with 'rate of return' regulation include pass-through of inefficiencies to end-consumers, which is potentially the case for Botswana. Now that BPC has achieved full cost-recovery, some level of performance management should be introduced, including quality of service and other policy directions (electrification, GHG emissions, security of supply). Presently, basic elements such as the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI) are not yet set by the regulator, although discussions are ongoing.

Also, the current tariff structure averages costs over all customer groups and does not consider the temporal or spatial profile of the consumption. Therefore, pricing is potentially currently uncorrelated from demand as a major cost driver in the generation segment. The tariff methodology and level would potentially require a different approach.

For the time being, the accounting of BPC is presented 'bundled', which does not allow it to define performance objectives per sub-sector. A presentation of accounts per segment would greatly facilitate the task of BERA regarding the establishment of performance standards specific to each segment. However, due to the modest size of its power system, it is unlikely that the country would move towards full unbundling and the creation of a wholesale power market, as would be the ultimate goal of regulatory reform, as the reform costs might exceed the actual benefits for small systems (World Bank, 2006; World Bank, 2020).

4.3 Risk mitigation for renewable energy procurement

The IRP, once adopted, communicated and enforced, will have a positive role in guiding market participants. It is expected that the IRP would include, or be complemented by an electrification plan, encompassing mini-grids and SHS. However, these endeavours will need to be completed by further actions to reduce the level of perceived risk discouraging private sector participation, and the development and integration of variable renewable energy into Botswana's power system.

Define a clear regulatory framework to minimise risks involved in private sector participation

A key concern of the single buyer model is that long-term take-or-pay arrangements may introduce distortions in power dispatch and build contractual rigidity in the power system (World Bank, 2020). In this case, the full benefits of supplying power from renewable energy plants – at zero marginal cost – is jeopardised, in extreme cases leading to curtailments. Such extreme situations of market rigidity create uncertainty for investors in variable generation assets and reluctance for engagement, which translates into risk premiums on investments.

Another issue is the limited financial capacity of BPC.[19] Although improving, the recourse to BPC for the procurement and offtake of the national renewable energy strategy has limitations. In theory, IPPs could participate in adding new generation capacity. In practice, PPAs have not yet materialised. Procurement, contracting and off-taker risks were reported during interviews – for reasons explained previously. A key issue of IPP contracts is finding a balance of risks between the off-taker (the government) and the private investor. Take or pay, capacity charges (*e.g.*, PV + storage, CSP), sovereign guarantees, backstops on liquidity and termination may be in high demand in new markets in order to limit risk premiums – and eventually a higher cost of electricity. Lacking the ability to find the right balance may lead to windfall profits from unaffordable tariffs at one end of the spectrum, or the inability for the private sector to engage in the programme – and the stalling of the private sector development of renewable energy – at the other end of the spectrum.

From a regulatory standpoint, it is a positive element that competitive procurement (auctions) is used for renewable energy IPPs. The scale of participation demonstrates the attractiveness of the market. For future tenders, it remains to be determined if the procurements should be handled by BPC or through a dedicated IPP procurement entity (*e.g.*, IPP office of the REIPPPP). In terms of procurement, a special purpose vehicle could be established in Botswana to handle renewable energy public–private partnerships (PPPs).

In any case, the PPAs would need review by the regulator, as these would eventually impact retail tariffs. BERA should ensure that, while risk-mitigation mechanisms might be needed, these should be limited to meet the legitimate expectations of return. This implies the regulator is equipped with such competence internally. The regulator should be equipped to deliver licenses and monitor compliance to the licensee's obligations, including compliance to grid codes.

19 Debt-to-equity ratio is 109% (from 185% in 2017) with a debt ratio of 54% (from 65.7% in 2017).

Box: Public–private partnership in Morocco

The CSP projects in Morocco involve MASEN, a private entity with public capital that operates under a double-PPA scheme: one with the single-buyer, ONEE, and one PPA with each IPP, supported by a state guarantee. The potential gap between (the IPP and ONEE) PPA prices is compensated by the government, fully addressing the off-taker risk. In terms of contracting, MASEN invests 25% public equity in the projects and acts as debt provider, under contract with major IFIs. The PPAs are contracted under a BOOT scheme, which requires the PPA to specify acceptable reductions in performance over time, and hence stringent quality specifications.

With such scheme, MASEN enables IPPs to access low-cost debt from the IFIs and lowers the cost of equity by fully addressing the off-taker risk. It has achieved high performance in the procurement of CSP, PV and PV-plus-storage assets since its establishment in 2010.

Source: Green Growth Business Partnership (2020).

Perform a location-specific study (pre-feasibility) for renewable energy generation and streamline permitting processes

Experience has demonstrated that efficient investments will build on an integrated spatial master plan. Investments in renewable energy generation require the collection of 1–2 years of bankable resource data, and potentially investments in distribution or transmission assets. Timely investments therefore require careful strategic planning in future project locations.

The risks it addresses are further uncertainties, which would translate into delays and higher costs in the procurement phase. A first step is to perform a detailed geospatial analysis (pre-feasibility), as proposed by IRENA and the World Bank. The World Bank (World Bank, 2019a) proposes a process for the sustainable development of solar energy, which includes three procurement strategies:

- Location-agnostic: a tender for a pre-determined capacity/energy amount is issued by the procurer; the tender is not location-specific.
- Related to a substation: a tender is issued for a certain capacity (MW) at each substation identified by the government.
- Assigned to a specific location: specific sites are identified by the government, which then proceeds to clear land and construct solar park infrastructure. The successful IPP identified in the subsequent tendering process finances, constructs and operates the project.

Additionally, the permitting process in Botswana requires clarification, including establishing the appropriate framework for environmental impact studies, grid connection studies and cost provisions for grid connections.

To further decrease the development risks and fast-track planning permissions, countries around the world tend to perform feasibility studies on the most appropriate sites for development and organise project-specific auctions (IRENA, 2019). The advantage of this approach is to considerably fast-track development, while ensuring the development can be in line with sustainable grid operations. In such a scheme, the government invests in developing the site, at various levels:

- Running a resource measurement campaign and acquiring bankable measurements, which can significantly accelerate project development;
- Developing site infrastructures, such as roads, utilities and securing transportation for large materials; and
- Carrying out environmental and social impact assessments for the site, to fast-track the permitting process.

Conduct a study on the grid capability to absorb power from variable renewable energy sources

In addition to the location-specific pre-feasibility studies, a comprehensive dynamic grid impact study –and support to perform a regular update of the IRP – based on dynamic (time-dependent) simulations, with detailed cost assumptions, new technologies and advanced dispatch strategies is recommended. The implementation and update of the IRP needs to build on grid stability studies of the power system in order to assess the true penetration potential of renewable energy – including grid reinforcement and storage on a cost-efficiency basis. Potentially, the study could also help BERA develop the grid codes and regulations for merit-order dispatch, accounting for the specifics of variable renewable energy sources.[20]

In addition to this recommended action, some countries have considered the installation of local cloud monitoring systems coupled with prediction systems to allow balancing of the grid. Local competences can be federated around this initiative: *e.g.*, research can be recognised at the University of Botswana's Clean Energy Research Centre on solar prediction systems, and BITIRI could be involved in testing and certification.

4.4 Rural electrification and decentralised generation

The rate of electrification in rural areas stood at 28% in 2019. Unfortunately, current approaches are seen as inadequate to solve the structural issue of under-investment in rural areas. An overall rural electrification framework could entice the involvement of private mini-grid operators in rural areas with sufficient density, with a view to rapidly scaling-up electrification. In this regard, the following actions are recommended:

Integrate rural electrification strategies into a single, comprehensive document and consolidate rural electrification activities

The need for adding to the IRP both small-scale distributed generation at scale, and a rural electrification programme, was mentioned in previous sections. During stakeholder consultations, the mini-grids, smart grids, waste to energy and solar home systems market segments were seen as a potentially large – and untapped – economic sector able to drive investment, jobs, entrepreneurship, and gender equity. It is also noted that this sector is currently not open to private sector engagement and competition in Botswana, which is a deviation from current practices across sub-Saharan Africa.

20 Such a "grid assessment" or hosting capacity study would assess the capability of the existing system to accept variable renewable generation with the use of enabling technologies (batteries, other storage), advance technical solutions, and consider the point of connection to the grid and available transfer capacity of the transmission system.

This would contribute to the modification of existing codes and development of grid codes that would specify the role of variable renewable generators and how they can support power system operation (change in operation constraints such as voltage and frequency, low voltage fault ride through, frequency regulation, etc.).

Previous experiences with BPC Lesedi (UNDP, 2011) showed that specific business models and companies are needed in these market segments, away from the traditional utility business – yet, as a regulated market as far as customers are involved. From stakeholder interviews, the actual market potential in terms of location, numbers, capacity and willingness to pay, and demand is mostly unknown (potentially in the range of 100 000 SHS systems, according to expert knowledge). Socio-economic surveys would be required to clarify the actual business potential in each segment. These dimensions are necessary both for grid-tied rooftop solar installations (impact on the load curve) and off-grid in the mini-grid and SHS segment.

As noted earlier, BERA Act 35(2)(a) exempts from license the small-scale installations below 100 kW, which was understood as most mini-grid systems or rooftop solar systems being outside the scope of scrutiny of BERA. Considering these installations may – on an aggregate level – impact the financial and operational performance of the utility, and/or engage end customers – potentially through subsidised tariffs supporting rural electrification – there is an opportunity for BERA to engage in regulating network access and tariffs. Also, monitoring of the enforcement of standards issued by the Botswana Bureau of Standards is highly recommended.

Ongoing programmes in East and West Africa have brought a wealth of knowledge on options and good practices in the mini-grid sector, which is benefitting from steep learning curves in generation and storage, and could be brought into perspective in Botswana to identify the relevant local business models.

Support the growth of solar rooftop and solar home systems through strong incentives and policy instruments

Small-scale systems are not unknown in Botswana. It was reported that the off-grid market is dynamic and already some level of notable success deserves attention, such as commercial centres producing for self-generation, and hotel and farms currently self-producing with PV – apparently in the absence of regulation or a support scheme. The telecom sector, for example, has relied on solar PV (with batteries) for many decades. MTN (telecom operator) foresees the deployment of 5 000 solar-powered towers by 2020 on its network, including in Botswana (TowerXchange, 2019). In the tourism sector, the supply of reliable, affordable energy is a prerequisite to the further development of the sector, especially in eco-tourism expansion. The tourism sector has already invested in the renewable energy sector, in particular solar in eco-lodges and camps. Solar thermal and photovoltaic systems are usually seen as the better solutions compared to the traditional stand-alone diesel systems thanks to their lower O&M costs, as well as the positive image for sustainable tourism.

Rooftop solar

Through the Rooftop Solar Programme, guidelines for rooftop solar installation are undergoing development and will provide an alternative suitable mechanism to increase the uptake of solar energy as well as facilitate private sector participation. Nonetheless, at the moment, excess power generated from small-scale rooftop systems cannot be sold to BPC, which strongly limits the incentives for private investment, where the grid can reliably supply the electricity service. In addition, local banks do not support individual solar rooftop projects.

Furthermore, the management of rooftop solar variability is a source of concern for BPC, as rooftop solar is deduced from demand, which might come online rapidly and disappear with local meteorological changes (*e.g.*, the passage of clouds). Moreover, the sector suffers from a lack of incentives, and much is expected from the ongoing adoption of solar rooftop guidelines. Large-scale rooftop solar projects might sell their excess power production to BPC. The tariffs are to be set by the rooftop solar guidelines. The price is expected to be based on the avoided cost of generation; however, it remains to be determined if the

level of support would incentivise investment. In addition, developers are concerned by the financial viability of BPC, and request that the government extend credit guarantees.

For the promotion of rooftop solar, it is therefore recommended that strong incentives be put in place to support the adoption of this technology. Policy instruments such as net-metering and feed-in-tariffs (FITs) for rooftop solar projects would help facilitate market access for investors. The government should finalise the FITs.

Solar home systems

The household component of OSAP acknowledges that there are 120 unelectrified villages in Botswana, representing 260 000 households. Despite ongoing grid-connection efforts, the plan foresees 240 000 households will still be without access by 2021. The authors foresee that 60% of these households could be eligible for solar home systems (SHS). Previous experience from the RERE programme (UNDP, 2011) was inconclusive. Lessons learnt from this experience did not deny the existence of a demand for services, but rather the need to develop dedicated planning, business models and implementation mechanisms – potentially supporting the engagement of the private sector.

Although potentially impactful – and complementary to grid-connected and mini-grid solutions – the solar home systems (SHS) market segment seems in great difficulty. The funding of the off-grid solar programme was reported as challenging, and one operator reported financial losses while trying to develop the market.

This experience is, however, different in other countries, where SHS proved to be low cost compared to other options (grid extension and mini-grids); in cases where the population density is low, the SHS market segment may be the most effective solution to remote off grid households. A considerable breakthrough was reached in the development of mobile PAYGO technologies, which have optimised the billing costs.

The performance of the RERE programme was unconclusive, and potentially created a negative precedent for this market segment. From the RERE final evaluation report (UNDP, 2011), however, the issue is less on the side of the market scale than the conditions for implementation. The report identified the learnings from the programme and formulated recommendations moving forward. In particular, consistent with the outcomes of stakeholder's engagement, it noted:

- An electrification master plan is required, that covers both grid- and non-grid electrification. The plan should specify clear timeframes and connection rates. The absence of such a plan was identified as a barrier to private sector participation. The plan should be consolidated with strategies for grid expansion and mini grids (hence coordinated with the Integrated Resource Plan).

- The SHS market requires support in the form of technical assistance and dedicated financial instruments (potentially subsidies), as illustrated by the Lighting Global initiative, or the recently released Off-Grid renewable energy fund in Haiti[21].

- The lack of mandatory standards and regulations for materials and installers has led to issues with the quality of the solar material and impacted the image of solar PV technology. The Botswana Bureau of Standards (BoBS) has established a range of technical standards for solar system components, leveraging IEC standards whenever possible and appropriate. BoBS has adopted IEC TS 62257-9-5 pertaining to pico-PV off-grid systems, but it is not compulsory and thus low-quality off-grid solar products are readily available in the country. It should be noted that IEC RS 62257-8 standards are now published, with standards for pico-products and SHS kits up to 350 kW. Those standards are the result of a collaboration with Lighting Global.

21 Operated by Bamboo Capital on behalf of the World Bank.

The opportunity for an SHS value chain deserves to be confirmed, and international experience could be brought to Botswana to exchange best practices, leading to establishing regulations.

For the promotion of a viable SHS and electricity access value chain, it is recommendation that the Government of Botswana explores:

- Testing, certification and import using local certification competences, and establishing quality standards based on international standards;
- Organisation of the payment scheme such as lease, upfront payment or loans involving financial institutions;
- Distribution, installation and maintenance requirements of the devices in remote areas;
- Collection of payments, through pay-as-you-go platforms or in cash;
- Gender equity in the energy sector; and
- Demand side subsidies to cover the affordability gap among poor off-grid households.

4.5 End-use applications

Going beyond the power sector, the RRA process also considered opportunities in the end-use sectors. For instance, the bioenergy sector was found to be unexplored, despite the following promising prospects:

- In the utility-scale segment, proposals were received for the production of biofuels and for a medium-scale biogas plant.
- For stand-alone systems, biogas could be an option for heating, lighting and cooking, through the use of biogas digesters.
- Biodiesel was demonstrated in Botswana for agricultural machinery.

Develop a strategy for renewable energy and agriculture

The agriculture sector is predominantly based on subsistence agriculture, mainly due to traditional farming methods, repeated droughts and limited infrastructure.

In this sector, solar water pumping, biogas cooking, bioenergy (biodiesel) for transport and biogas lighting were identified as relevant for the country. To improve uptake of these energy services, financial resources should be mobilised, locally available and affordable technologies developed, and both regulations and incentives established. It is suggested that Botswana develop a strategy for renewable energy and agriculture that includes the use of renewable energy in the agriculture value chain and the use of agro-residues for renewable energy.

Develop a strategy for renewable energy in the transport sector

Bioenergy for transport is not incentivised at this point, despite the existence of biodiesel standards, in the absence of a specific Act to trigger enforcement. The local market is judged small and unable to generate economies of scale, due to the limited use in the transport sector. The sector also lacks local manufacturing and assembly capabilities.

The Department of Energy (DoE) with the technical support from the University of Botswana (UB) and Department of Agricultural Research (DAR) under the Ministry of Agricultural Development and Food Security, are engaged in a research project that seeks to stimulate the development of the local biofuel industry.

In this sector, electric solar was also mentioned, as a demonstration is ongoing for solar boats in a tourist area. However, the potential for market scale-up are limited. Currently, no plans for electric road transportation were identified, nor has an electric vehicle strategy been defined. Due to the strong dynamic of this market worldwide, it is suggested that Botswana develop an e-mobility strategy.

Promote the role of renewable energy for heating, cooling and cooking

The need for increased uptake of renewable-based heating, cooling and cooking was mentioned in the stakeholder workshops. This can be realised by raising awareness of the technologies available to residences; building the capacity for local manufacturing and installation; and enhancing development of bankable proposals in order to ensure renewable energy companies can access finance. Local financial institutions should also be encouraged to provide finance to private investment in renewable energy solutions. This can be facilitated by providing training to financial institutions on renewable energy project appraisal. Furthermore, incentives can also be provided by government to ensure that citizens can afford the renewable energy services.

4.6 Local skills development

In Botswana, the current uncertainty in long term planning and lack of realisation is limiting private sector engagement, preventing the country from building human capacity, and creating local economic benefits and jobs. Sourcing local competences and people is a must for implementing a renewable energy strategy that is sustainable. First, there is a need for talent and state capacity to design and implement energy strategies. Then, other parts of the value chain can also be localised to maximise the spill-over effects of investments. In economic terms, the objective is to increase the *multiplier effect* of public investments.

The IRP foresees only a small number of one-off projects, separated by years of inactivity. This is inconsistent with an approach that will maximise local job creation. Currently, as each auction is a greenfield project, the private sector has no business case to make investments in the local value chain and human capacities that would initiate a thriving renewable energy sector. Yet, potential for socio-economic benefits – jobs, research, education – are demonstrated by the presence of industry associations and research infrastructures despite modest activity in the renewable energy sector. Auctions can adapt to address issues around a just and inclusive energy transition. Specific design elements for auctions could include small and new players, fostering the development of local industries, creating local jobs, contributing to subnational development and engaging communities (IRENA, 2019).

According to IRENA, auctions can be made compatible with local development through systematic auction schemes – indicating a commitment to a longer auctioning schedule. Under such an approach, a steady stream (rather than a periodic flux) of auctions helps market agents to better adjust their expectations and plan for the long term, and helps the government to promote the local industry (IRENA and CEM, 2015).

Box: South Africa's Renewable Energy Independent Power Producers Procurement Programme

To bring certainty to the nascent renewable energy market, neighbouring South Africa initiated auctions as capacity pipelines, determined initially under the Integrated Resource Plan and further elaborated under the REIPPPP.[22] In terms of job creation, the REIPPP has generated a total of 40 134 job-years (equivalent of a fulltime employment for one year) for South African citizens, of which 33 019 were in construction (101% above planned) and 7 115 in operations .

Source: IRENA (2019).

Develop local human capacities along the project value chain

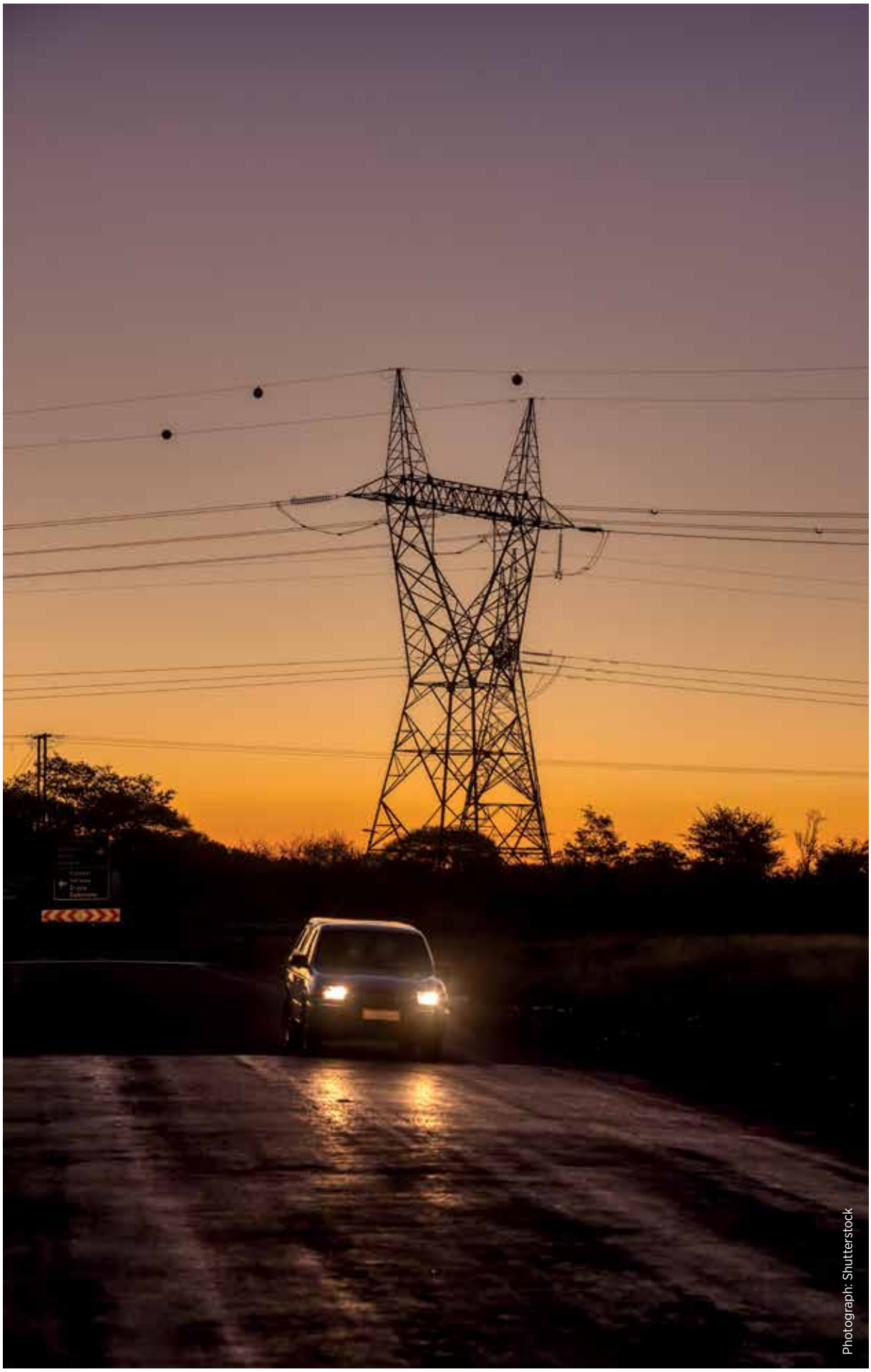
There is an opportunity to develop competences for maintaining and repairing renewable energy infrastructure and equipment, as in remote areas there is a severe lack of training or availability of trained personnel. Private sector engagement in the management of such off-grid and mini-grid facilities can be enabled through PPPs.

Stakeholders also indicated potential for engagement in basic research, certifications, policy development and review, regulatory assessment or market surveys and acceptance of the technology at large. The assessment of the opportunities for solar rooftops, mini-grids and SHS would greatly benefit from the mobilisation of local capacities and perhaps the inclusion of women. Botswana should embark on mobilisation, whereby national competencies can be mapped against the needs along the supply chain. This entails identification and mobilisation of local workforces to ensure local recruitment (IRENA, 2019).

IRENA, in partnership with the SADC Centre for Renewable Energy and Energy Efficiency (SACREEE), launched the SADC Entrepreneurship Support Facility in 2017 to support renewable energy market development in the SADC region through training, mentorship and linkage to financial institutions. Several renewable energy SMEs in Botswana are currently benefitting from the initiative.

Additionally, building local capacity within BPC and BERA is important to ensure that Botswana has the technical capacity to operate a power system with high shares of renewables and tackle all the technical challenges to the system. Capacity building should include how to model the power system and conduct simulation studies, reserve sizing, flexibility analysis, economic dispatch, VRE forecasting, etc., so that Botswana can successfully manage any challenges to the system in the future.

22 Renewable Energy Independent Power Producers Procurement Programme (REIPPPP).



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P.O. Box 236
Abu Dhabi
United Arab Emirates
www.irena.org