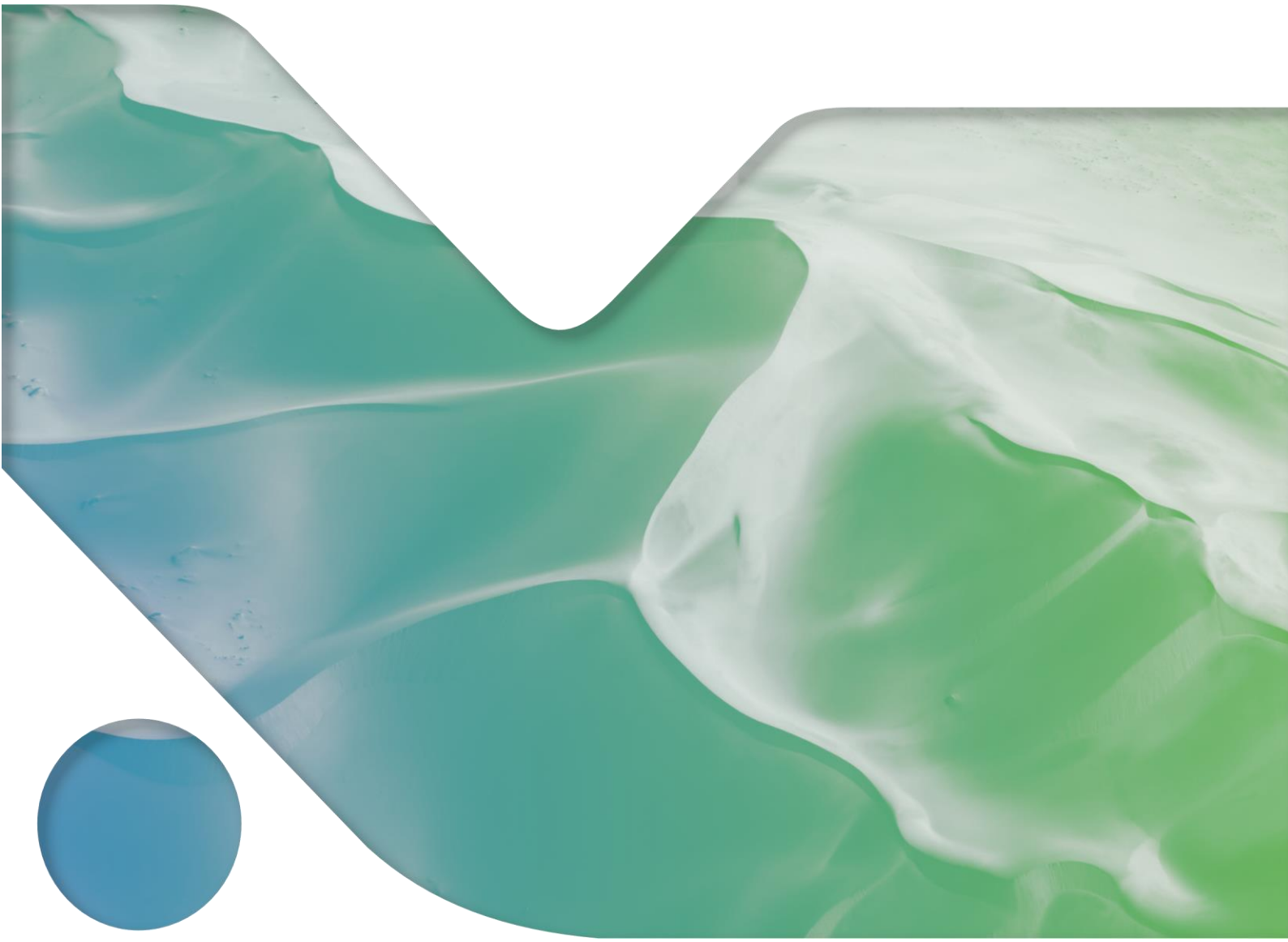
GreeN-H2 Namibia

Feasibility Study for Green Hydrogen in Namibia

Power Sector Fact Sheet

Dr.-Ing. Robin Ruff



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List of abbreviations

Abbreviation	Meaning
AfDB	African Development Bank
BAU	Business As Usual
BMBF	Bundesministerium für Bildung und Forschung
ECB	Electricity Control Board
GCF	Green Climate Fund
GEF	Global Environment Facility
GIZ	Gesellschaft für Internationale Zusammenarbeit
IMF	International Monetary Fund
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
KfW	Kreditanstalt für Wiederaufbau
MME	Ministry of Mines and Energy
MSB	Modified Single Buyer Model
NDC	Nationally Determined Contribution
NEF	National Energy Fund
NEI	Namibia Energy Institute
NGO	Non-Governmental Organization
NIRP	National Integrated Resource Plan
NDP	National Development Plan
NREP	National Renewable Energy Policy
NUST	Namibia University of Science and Technology
PV	Photovoltaics
RED	Regional Energy Distributor
REFIT	Renewable Energy Feed-In Tariffs
REIAoN	Renewable Energy Industry Association of Namibia
SACREEE	SADC Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SB	Single Buyer Model
SEforALL	Sustainable Energy for All
SWAWEK	South West Africa Water and Electricity Corporation
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Versions and Contribution History

This report was prepared within the project GreeN-H2-Namibia and is part of work package 2 "technical aspects". The project is funded by the German Federal Ministry of Education and Research.

The report has been developed as a desk study and is based on public information, research by DECHEMA e.V. and substantive feedback from stakeholders in the energy and Green Hydrogen Industries in Namibia. The report is meant to be publicly available. The authors reserve the right to publish an updated version of the report if there are any significant differences between the information provided and the situation at hand.

An overview of the versions of the document, as well as contributors, can be found below:

Version	Date	Modified by	Reasons for modification
V0	April 2023	Dr. Robin Ruff	1st Draft
	May 2023	Luisa Lopez, Paula Kloecker	Internal Review
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This document is intended as an initial overview on the topic of the electricity sector in Namibia. It is planned that follow-up reports on Green Hydrogen and Power-to-X will follow, which will take a more detailed look at the development and possibilities in Namibia. Further reports and factsheets on the topics of infrastructure needs and socio-ecological aspects are planned within the project GreeN-H2-Namibia.

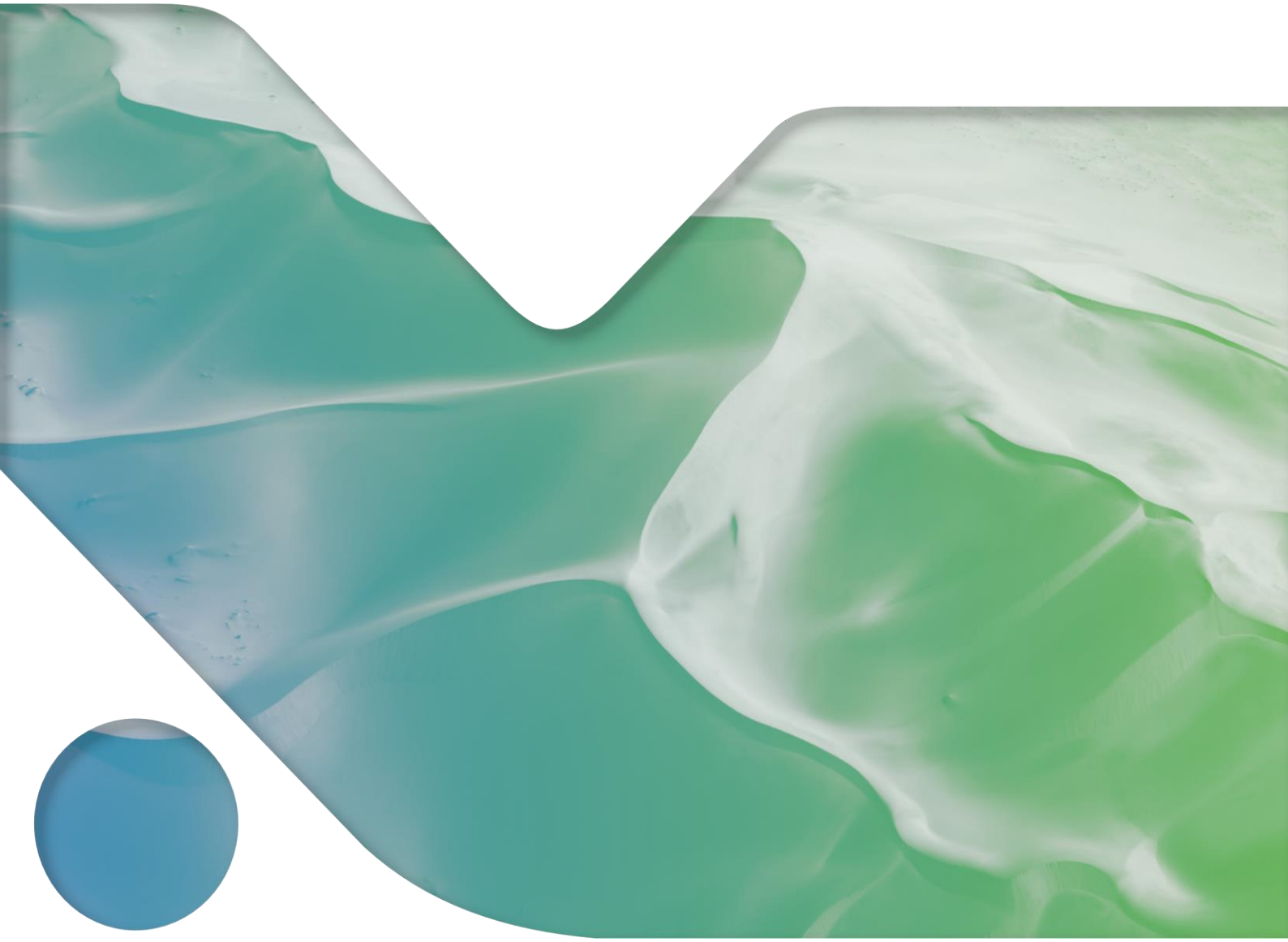
Introduction

The energy sector is a pivotal component of Namibia's economy, driving growth and serving as the backbone of its industrial, residential, and commercial sectors. The energy landscape in Namibia is diverse, encompassing a broad mix of resources that range from traditional fossil fuels to a rapidly expanding renewable energy sector. The country's geographical location, blessed with abundant sunshine and substantial wind resources, presents a significant potential for the transition towards a more sustainable and resilient energy framework.

This document was developed as part of the Green-H2 Namibia project, which is funded by the German Federal Ministry of Education and Research (BMBF). project aims to mediate between the different government funded and private sector initiatives and to answer fundamental questions like: which infrastructure is needed for the development of the hydrogen economy, which potential can be exploited at which locations and how can this development be established as a sustainable economic factor for Namibia.

The factsheet provides an overview of the Namibian energy sector, with a specific focus on the electricity sector. It aims to illuminate the structure of the market, key stakeholders, sources of electricity generation, and the status of renewable energy in the country. It will also delve into the regulatory environment, current challenges, opportunities for growth, and the future outlook for the sector.

1 Stakeholder analysis



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This chapter provides an overview of the international-, national- and regional stakeholders, participating in the Namibian energy sector.

1.1 International Stakeholders

International stakeholders play critical roles in Namibia's electricity sector, contributing to its development and operations through various avenues such as financing, technical assistance, capacity building, and policy advice. It's important to note that the roles of these stakeholders are interconnected and often overlap, requiring a high degree of coordination and collaboration.

International Financial Institutions and Donors

The World Bank, International Monetary Fund (IMF), African Development Bank (AfDB), and various bilateral donors such as Germany's Kreditanstalt für Wiederaufbau (KfW) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), provide crucial financial support for electricity projects in Namibia. This can take the form of loans, grants, or technical assistance.

Global Climate Funds

The Global Environment Facility (GEF) and Green Climate Fund (GCF) support projects that aim to mitigate climate change impacts, including initiatives in renewable energy and energy efficiency.

Multilateral Organizations

Organizations such as the United Nations Development Programme (UNDP) and Sustainable Energy for All (SEforALL) offer technical support, policy advice, and capacity building in areas like renewable energy development, energy efficiency, and energy access.

Southern African Power Pool

As the common electricity market of the countries in southern Africa, the Southern African Power Pool (SAPP) plays a significant role in coordinating power interchanges between member countries, including Namibia. It encourages investment in regional power projects, facilitates power trading, and harmonizes regulatory frameworks among member states.

Research Institutions and NGOs

Various international research institutions and non-governmental organizations (NGOs) such as the International Renewable Energy Agency (IRENA) also contribute to Namibia's electricity sector by conducting research, advocating for sustainable energy, and implementing pilot projects.

1.2 National Stakeholders

There are several national stakeholders in Namibia's electricity sector that play a crucial role in its operations, development, and regulation.

Ministry of Mines and Energy

The Ministry of Mines and Energy (MME) in Namibia has several key tasks in the country's electricity sector. These include developing policies and regulations to guide the sector's development, promoting the use of renewable energy sources and energy efficiency measures, approving licenses, and facilitating investment in the sector. The MME is also responsible for regulating the operations of NamPower, the state-owned electricity utility, and ensuring compliance with safety and environmental regulations. Additionally, the MME works to increase access to electricity, particularly in rural areas, and participates in regional and international initiatives related to the electricity sector.

Electricity Control Board

The Electricity Control Board (ECB) was established in 2000 under the Electricity Act of Namibia. The ECB's primary task is to regulate the electricity sector in Namibia, including the generation, transmission, distribution, and supply of electricity. Its mandate includes ensuring the provision of reliable and efficient electricity services, promoting competition and investment in the sector, and protecting the interests of consumers. The ECB has the power to issue licenses for the generation, transmission, and distribution of electricity, as well as to regulate the tariffs charged by electricity service providers. It also monitors and enforces compliance with safety, technical, and environmental standards. Over the years, the ECB has played a critical role in promoting the development of Namibia's electricity sector, particularly in expanding access to electricity in rural areas. The ECB has also been involved in several regional initiatives aimed at increasing the availability and affordability of electricity in southern Africa.

NamPower

NamPower is the state-owned electricity utility in Namibia, which emerged from the 1964 founded South West Africa Water and Electricity Corporation (SWAWEK) after Namibia's independence. Its main function is to generate, transmit and distribute electricity to customers in Namibia. Until around 2015, all power generation assets in Namibia were owned by NamPower (Kruger, 2022).

NamPower has played a critical role in the development of Namibia's electricity sector, including the expansion of the national electricity grid, the development of new power generation facilities, and the promotion of energy efficiency measures. In addition to its role as an electricity provider, NamPower is also involved in regional power trading initiatives, selling, and buying electricity to and from neighboring countries, such as South Africa and Zambia. It is a key player in the Southern African Power Pool, which aims to enhance regional power trade and electricity supply security. NamPower is regulated by the Electricity Control Board, which sets tariffs and ensures compliance with safety and environmental standards.

National Energy Fund

The National Energy Fund (NEF) was established in Namibia in 1998 as a government initiative to provide funding for energy projects and promote energy efficiency and renewable energy development in the country. The NEF's tasks in Namibia's electricity sector include the provision of funding for energy projects that contribute to the country's energy security and sustainability, as well as the promotion of energy efficiency measures and renewable energy development. The NEF also provides financial support to communities and businesses to help them adopt energy-efficient technologies and practices. It is funded through levies imposed on the consumption of petroleum products and electricity. The funds are then used to finance energy projects, conduct research on energy-related issues, and promote public awareness of energy efficiency and renewable energy technologies.

Electrification Fund

The government has set up an electrification fund to specifically finance rural electrification projects. The fund is supported by contributions from electricity consumers and the national budget.

Namibia Energy Institute (NEI)

As part of the Namibia University of Science and Technology (NUST), the NEI conducts research, provides education and training, and offers policy advice in the energy sector.

Renewable Energy Industry Association of Namibia

The Renewable Energy Industry Association of Namibia (REIAoN) is a representative body for renewable energy businesses, professionals, and advocates. A list of its prioritized tasks is given below.

Industry Advocacy: REIAoN is the voice of the renewable energy industry in Namibia. It advocates for policies, regulations, and practices that support the growth of renewable energy in the country. It engages with government bodies, regulators, utilities, and other stakeholders to ensure that the industry's perspectives and interests are considered in decision-making processes.

Information Sharing: REIAoN plays a crucial role in disseminating information about the renewable energy industry. This includes market trends, policy updates, technological developments, investment opportunities, and best practices. Such information can facilitate informed decisions by businesses, investors, policymakers, consumers, and other stakeholders.

Capacity Building: REIAoN organizes training programs, workshops, and conferences to build the capacity of its members and other stakeholders in various aspects of renewable energy. This helps to enhance the competence and competitiveness of the renewable energy industry in Namibia.

Standardization and Quality Assurance: REIAoN works towards promoting high standards and quality assurance in the renewable energy industry. It encourages its members to adhere to ethical business practices, technical standards, and customer service standards.

Public Awareness: REIAN promotes public awareness and understanding of renewable energy. It communicates the benefits of renewable energy, dispels misconceptions, and encourages the adoption of renewable energy technologies by consumers.

1.3 Regional Stakeholders

At the regional level various stakeholders are responsible for the supplying of energy to end customers.

Independent Power Producers

Independent Power Producers (IPPs) have played a significant role in Namibia's electricity sector in recent years. The government of Namibia began promoting the development of IPPs in the early 2000s to increase private sector investment in the sector and reduce the country's dependence on imported electricity. IPPs in Namibia are typically small-scale renewable energy projects, such as solar and wind power plants. The ECB is responsible for issuing licenses to IPPs and regulating their operations. The tasks of IPPs in Namibia's electricity sector include increasing the country's electricity supply, particularly in rural areas, and promoting the use of renewable energy sources. IPPs also contribute to the diversification of Namibia's energy mix, reducing the country's reliance on fossil fuels and imported electricity.

REDs

Regional Electricity distributors (REDs) are entities established by the government to manage the distribution of electricity to customers within specific regions of the country. Of the five REDs originally planned in Namibia, NORED (Northern Namibia) in 2002, CENORED (Central-northern Namibia) in 2003 and Erongo RED (Erongo Region) in 2005 were successfully implemented. Still pending is the establishment of the originally planned REDs in Central Namibia (Central RED) and Southern Namibia (SORED).

REDs are responsible for maintaining and expanding the electricity distribution networks in their respective regions, setting tariffs for the distribution of electricity (subject to approval by the ECB), and collecting revenue from customers. In addition, REDs are also involved in promoting energy efficiency measures and renewable energy development in their respective regions. The establishment of REDs was part of the government's efforts to reform the country's electricity sector and improve access to electricity for all Namibians. By having regional entities responsible for electricity distribution, the government aims to ensure that electricity is distributed efficiently and effectively, and that customers receive reliable access to electricity services. A map with the area covered by each RED is given in Figure 1.

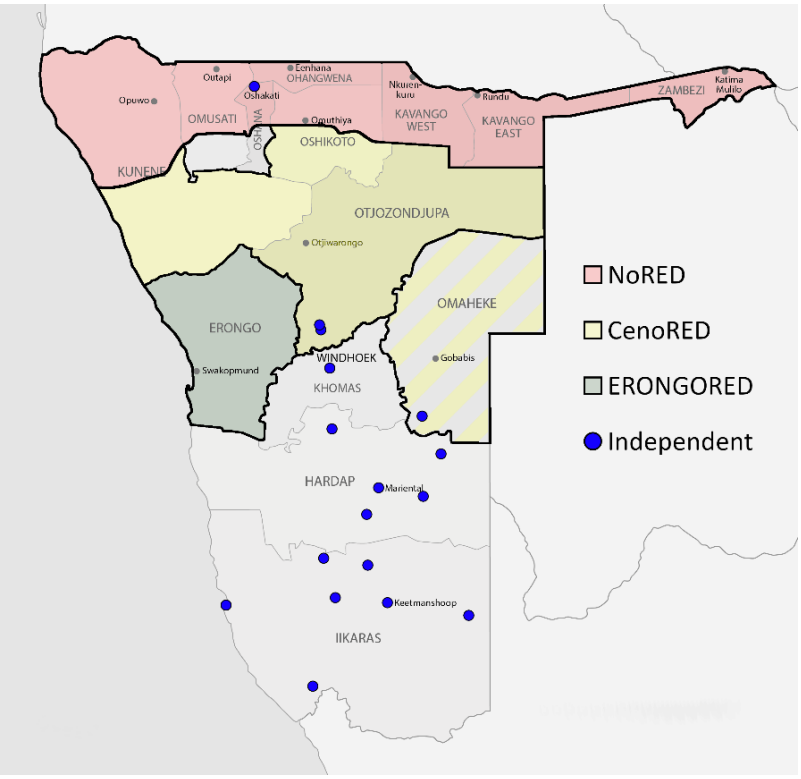


Figure 1: Map of REDs in Namibia, own illustration with information from (ECB, 2023)

NoRED

NORED was the first Namibian RED, established in 2002, responsible for the above-described tasks in the Zambezi-, Kavango East-, Kavango West- and Ohangwena Regions as well as parts of the Kunene, Omusati, Oshana and Oshikoto-Regions.

CenoRED

Established in 2003, CENORED covers the entire Otjozondjupa region, as well as parts of the Oshikoto and Kunene regions. Furthermore, some outposts are operated in the Omaheke region (see Figure 1), which would actually have to be attributed to the Central RED, which has not yet been established.

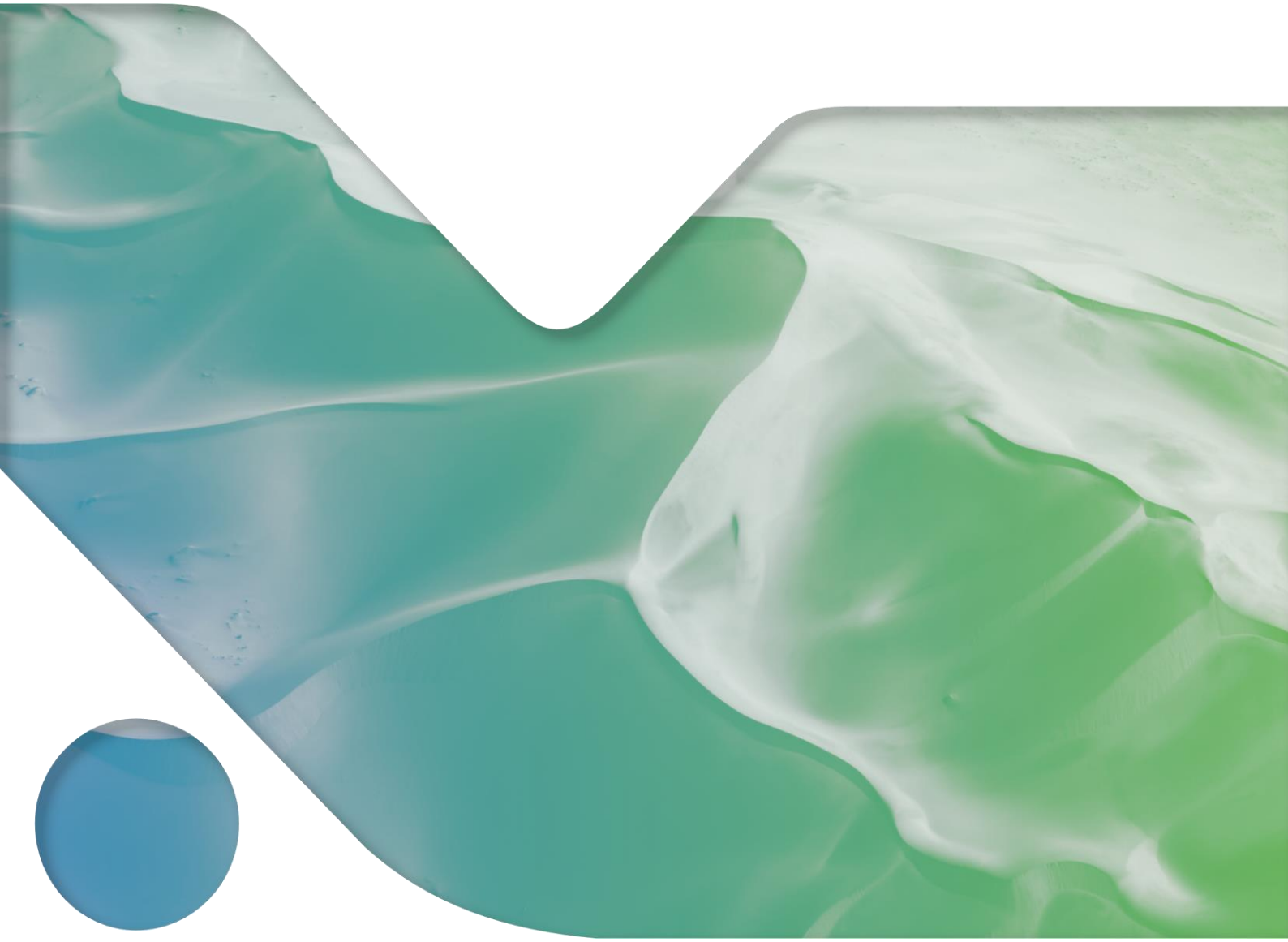
Erongo RED

Established in 2005, Erongo RED's jurisdiction covers the area of the region of the same name in western Namibia.

Independent

Particularly in the south of the country, which is not served by the established REDs, selected local authorities and regional councils are responsible for distributing and delivering electricity to end users.

2 Regulative Framework



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2.1 Structure of the electricity market in Namibia

The electricity market in Namibia follows a vertically integrated model, which is organized into three main segments: generation, transmission, and distribution.

Generation: Electricity is generated by a mix of power plants operated by the national power utility, NamPower, and IPPs. NamPower's and IPP's generation assets are further discussed in section 3.2.

Transmission: After generation, electricity is transmitted across the country through a high-voltage network managed by NamPower. The transmission network consists of high-voltage lines connecting major power plants, load centers, and neighboring countries for electricity import and export. This network has generally been maintained well and serves the main urban centers efficiently. However, as renewable energy, particularly wind and solar, becomes a more significant part of the energy mix, upgrades and expansions of the transmission infrastructure are necessary to accommodate these decentralized sources of power. A map of the transmission-line-network as well as the NamPower owned generation utilities is given in Figure 2.

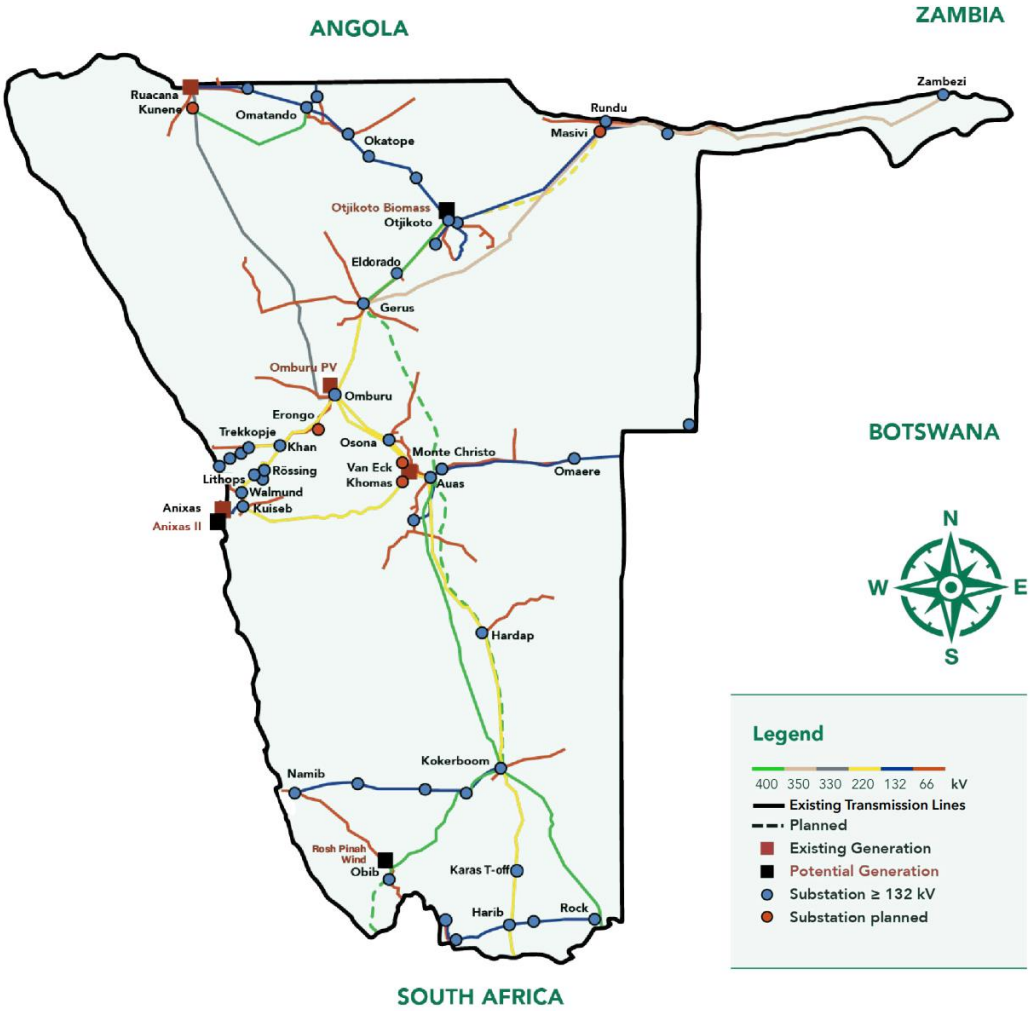


Figure 2: Transmission and generation map (NamPower, 2022)

Distribution and Supply: The distribution of electricity to end-users is managed by a combination of NamPower (in certain areas), REDs, local authorities, and regional councils. While the distribution network effectively serves urban and peri-urban areas, challenges remain in extending electricity access to rural and remote areas due to the country's vast geographic spread and low population density. Off-grid and mini-grid renewable solutions are being explored as potential cost-effective alternatives to grid extension in these areas (NamPower, 2022).

2.2 Legislative framework

In the years following independence from South Africa in 1990, initial efforts began to fundamentally restructure the energy sector in Namibia. This resulted in several different policies and laws that have a direct or indirect influence on the country's energy supply.

2.2.1. Electricity Act

The Electricity Act of Namibia is a comprehensive piece of legislation that governs the generation, transmission, distribution, supply, and use of electricity in the country. The Act was first enacted in 2000 and has been amended several times since then, with the last time being 2007, to keep pace with changes in the electricity sector. The key objectives of the Electricity Act are to ensure reliable, safe, and affordable electricity for all Namibians, to promote competition and efficiency in the electricity market, and to encourage the use of renewable energy sources. The Act establishes a regulatory framework for the electricity sector and provides for the establishment of regulatory bodies, including the ECB, which is responsible for regulating and overseeing the electricity sector in Namibia. The Act also sets out the licensing requirements for electricity generation, transmission, and distribution, as well as the conditions and standards that must be met by licensees. It establishes the legal framework for the Single Buyer Model (SB) and the Modified Single Buyer Model (MSB), which govern the purchasing and sale of electricity in the country. In addition, the Act provides for the establishment of the NEF, which is used to finance renewable energy projects and other initiatives to promote the development of the energy sector in Namibia.

2.2.2. Single Buyer Model

The SB was introduced in Namibia's electricity sector in 2000 as part of the government's efforts to reform the sector and improve access to electricity for all Namibians. Under the SB, NamPower serves as the sole purchaser of electricity from all power producers in the country, including IPPs. NamPower then sells the electricity to the regional electricity distributors REDs for distribution to customers. The SB is intended to promote competition in the electricity sector and reduce costs for consumers. By having a single buyer of electricity, the government aims to avoid the need for multiple contracts and negotiations with different power producers, which can lead to inefficiencies and higher costs. The SB also provides greater transparency and accountability in the electricity sector, as all power producers are required to sell their electricity to NamPower at a regulated tariff. This helps to ensure that electricity is priced fairly and that consumers receive reliable access to affordable electricity.

2.2.3. Modified Single Buyer Model

The SB explained above resulted in a monopoly position of NamPower in the electricity sector, which led to a slow development that was criticized by numerous stakeholders. As a result, the MSB was developed as a modification of the existing SB and gradually implemented since 2019. Under the new model, IPPs are allowed to sell their generated electricity directly to end users under certain conditions. This eliminates the need for NamPower to be involved in each individual electricity trade. NamPower retains the role of power producer and transmitter, as well as operator of some distribution networks. Furthermore, under the MSB, NamPower is obliged to supply electricity customers who cannot purchase electricity from other market participants. The introduction of the MSB was seen as an important developmental step towards the liberalization of the electricity market in Namibia. The role of the various stakeholders in the MSB is depicted in Figure 3.

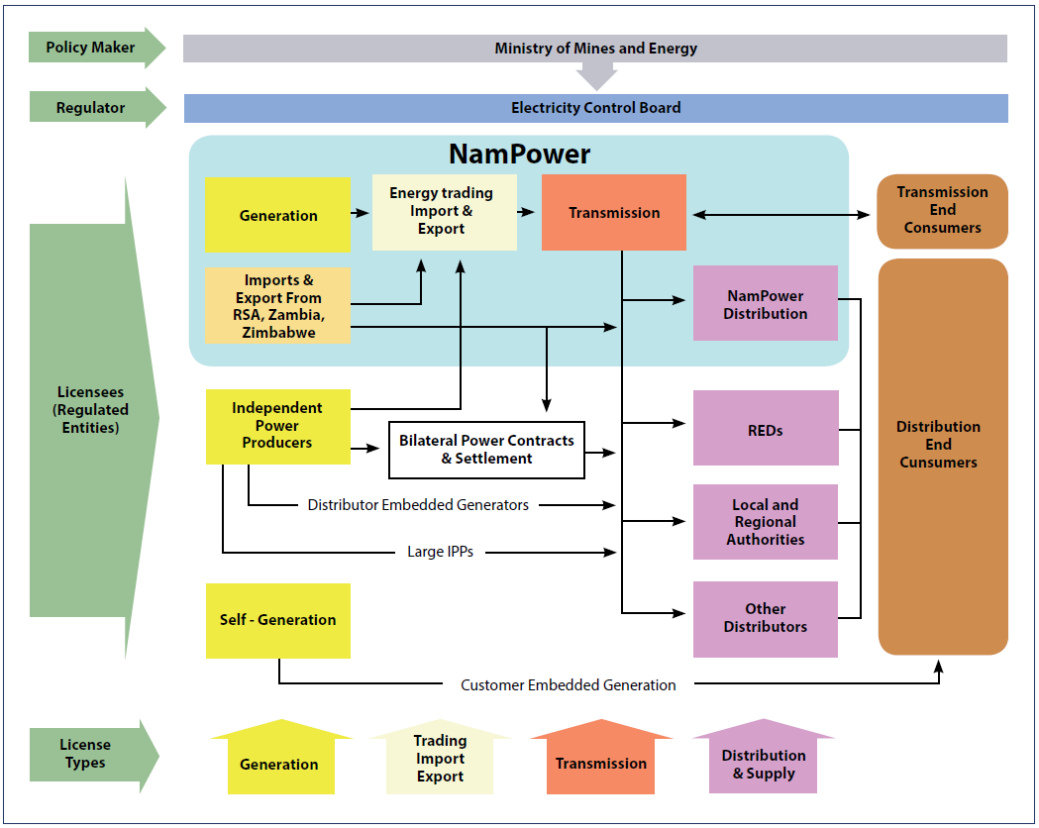


Figure 3: MSB in Namibia (Ministry of Mines and Energy, 2018)

2.2.4. National Developments Plans

The National Development Plans (NDPs) of Namibia are a series of medium to long-term development plans that outline the government's vision and priorities for economic and social development over specific periods of time. The plans are developed by the National Planning Commission in consultation with various stakeholders, including government ministries, civil society organizations, and the private sector.

The fifth NDP, covering the period from 2017 to 2024 (2022 originally), aims to build on the achievements of the previous plans and focuses on accelerating economic growth, reducing inequality,

and promoting social development through targeted investments in key sectors, such as agriculture, energy, and transport.

Goals defined by NDP 5 for the electricity sector until 2022 include:

-Increase of generation capacity to at least 755 MW
-Increase the national electrification rate to at least 50 %
-promotion of know-how and human capital in the electricity sector
-Expansion of the infrastructure for transmission and distribution of electricity
-Promoting the market entry of IPPs
-Decrease of monopolies
-Cost reduction

NDP 6 is currently under development and is expected to accompany development from 2024 to 2031 (Aipanda, 2023).

2.2.5. Harambee Prosperity Plan

The Harambee Prosperity Plan was launched by the President of Namibia, Hage Geingob, in 2016 as a strategic roadmap to accelerate the nation's development and improve the living standards of its people. With the first phase running from 2016 to 2020, the second part was introduced in 2021, running until 2025. The plan outlines key priorities across several pillars, one of which is infrastructure development, with the first goal of this pillar being a secured and cost effective energy supply. Specific targets include increasing electric generation capacity from 624 MW in 2020 to 879 MW, as well as electrifying 18,000 homes and 213 schools and health facilities by 2025. The expansion of the energy supply is distributed between both IPP and Nampower plants. While several renewable power plants are planned, each with a maximum capacity of 50 MW, there are also plans to expand the Anixas Power Station in Walvis Bay (The Government of Namibia, 2021).

2.2.6. Vision 2030

Launched in 2004, the Vision 2030 sets key development challenges for the year 2030. It has significant implications for the electricity sector in Namibia with one of it being to increase access to electricity, particularly in rural and remote areas of the country. The plan recognizes that access to electricity is essential for economic growth and social development and is committed to expanding electrification to all Namibians by 2030.

To achieve this goal, Vision 2030 emphasizes the need to develop a sustainable and reliable electricity supply that can meet the growing demand for power in Namibia. This includes promoting the use of renewable energy sources such as solar and wind power, which can help to reduce the country's reliance on imported fossil fuels and promote environmental sustainability. Another key aspect of Vision 2030 is the need to increase investment in the electricity sector, both from the public and private sectors. Among these, it entails investing in the expansion and upgrading of electricity infrastructure, such as transmission and distribution networks, as well as in the development of new power generation projects.

2.2.7. Rural Electrification Distribution Master Plan:

This plan from the year 2010 outlines the government's strategy for extending the electricity grid to rural areas, including the identification of priority areas and the mobilization of necessary resources.

2.3 Role of International Treaties and Agreements for the Electricity Sector in Namibia

International treaties and agreements play a pivotal role in shaping the electricity sector in Namibia, particularly in terms of cross-border electricity trade, integration of renewable energy, and climate change mitigation.

Namibia is a member of the SAPP, an initiative of the Southern African Development Community (SADC) that aims to optimize the use of energy resources in the region through coordinated planning and operation. This membership enables Namibia to import and export electricity with neighboring countries, enhancing the security and reliability of its electricity supply. Furthermore, SAPP's renewable energy strategy and other initiatives influence Namibia's approach to renewable energy development and regional power market integration.

On a global level, Namibia is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. These agreements commit Namibia to reduce its greenhouse gas emissions and transition towards a more sustainable and low-carbon electricity sector. For instance, in its Nationally Determined Contribution (NDC) under the Paris Agreement, Namibia has committed to an unconditional greenhouse gas emission reduction target of 91% by 2030 compared to the Business As Usual scenario (BAU). The BAU scenario refers to projected emissions if no further actions were taken to reduce them (United Nations Development Programme, 2023).

Namibia also benefits from various international funding mechanisms and partnerships aimed at promoting sustainable energy and combating climate change. These include the Global Environment Facility, the Green Climate Fund, and the Sustainable Energy for All initiative, among others. Such international support not only provides financial resources for sustainable energy projects but also facilitates technology transfer and capacity building.

2.4 Promoting Renewable Energies

Several strategies and policies have been put in place to facilitate the growth of renewable energies. These include the National Energy Policy, the Renewable Energy Policy, and the National Integrated Resource Plan, which set the vision, objectives, and strategies for developing renewable energies and integrating them into the national energy mix. Specific targets have been established for renewable energy capacity and generation, and for the share of renewable energies in the electricity supply.

2.4.1. Policies

The Namibian government has shown a strong commitment to promoting renewable energy to improve energy security, reduce reliance on imported electricity, and contribute to environmental sustainability. Several policies and initiatives reflect this commitment:

National Energy Policy: This policy emphasizes the importance of renewable energy and energy efficiency. It aims to ensure access to affordable, reliable, and sustainable energy services for all Namibians.

Renewable Energy Feed-In Tariff (REFIT) Program: Implemented by the ECB, the REFIT program offers fixed, above-market tariffs for energy generated from renewable sources. This incentivizes IPPs to invest in and develop renewable energy projects.

Net Metering Rules: These rules allow consumers who generate their own electricity from renewable sources to feed any excess power back into the grid, effectively turning them into mini power producers. This encourages the adoption of solar PV systems by businesses and households.

National Integrated Resource Plan (NIRP): The NIRP is a roadmap for the future development of Namibia's electricity supply industry. It highlights the need to increase the share of renewable energy in the country's energy mix and provides a planning framework to achieve this.

Investment Incentives: The government offers various incentives to attract investment in renewable energy projects, including tax benefits and customs duty exemptions on the import of renewable energy equipment.

These policies represent a concerted effort by the Namibian government to foster a conducive environment for the growth of the renewable energy sector. As a result, the country has seen a steady increase in renewable energy projects, particularly in solar and wind energy, and this trend is expected to continue in the future.

2.4.2. Challenges and opportunities in renewable energy development

Namibia’s renewable energy sector presents a blend of challenges and opportunities that will influence the country's trajectory towards a more sustainable and secure energy future.

Starting with the challenges, the primary one is financial. Despite the falling costs of renewable technologies globally, the initial capital investment required for renewable energy projects can still be significant. Access to affordable financing is often a hurdle for both large-scale projects and small-scale installations such as rooftop solar panels. In addition, while the government has implemented favorable policies such as the REFIT program, further regulatory and policy support may be required to create an even more conducive environment for investment.

Technical challenges also exist. For example, the intermittent nature of solar and wind power requires effective solutions for energy storage and grid management to ensure a reliable power supply. The country's wide geographic spread and low population density also pose challenges for the transmission and distribution of electricity, particularly in remote rural areas.

Infrastructure development is another challenge. While significant progress has been made, further development and modernization of the electricity grid are necessary to accommodate a higher share of renewable energy and ensure its efficient distribution.

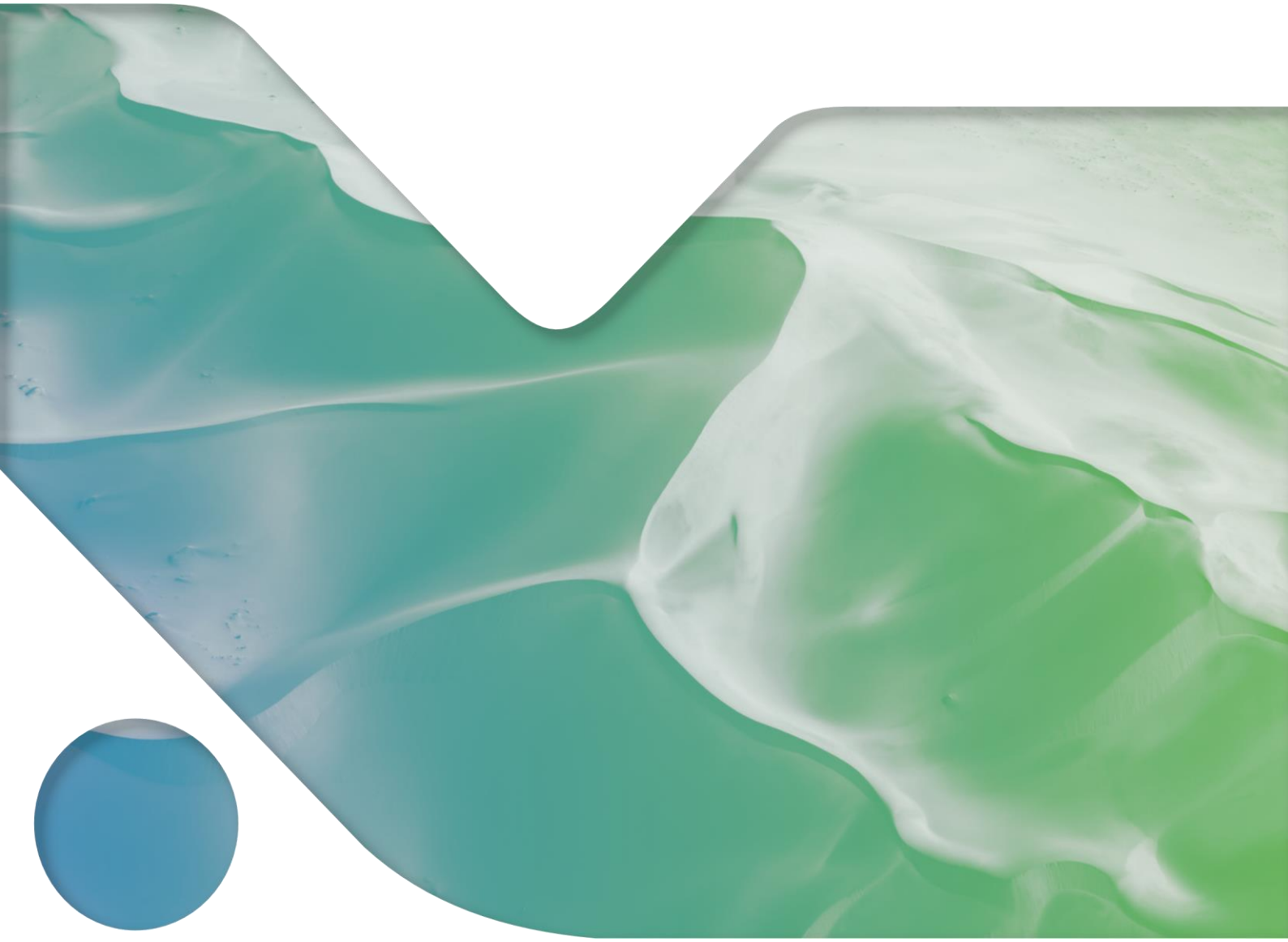
On the other hand, these challenges are matched by considerable opportunities. Namibia's abundant solar and wind resources offer immense potential for renewable energy generation. The vast areas of bush encroachment could be turned into an asset by utilizing the biomass for energy, providing a sustainable solution to both the country's energy and environmental challenges.

Advancements in renewable energy technologies and declining costs present another opportunity. These trends make renewable energy an increasingly viable and cost-effective option for electricity generation. Off-grid and mini-grid solutions could be a cost-effective way to extend electricity access to remote areas, reducing the reliance on expensive grid extension.

Government commitment to renewable energy, as demonstrated by favorable policies and initiatives, is another encouraging sign. The growing interest of IPPs in the Namibian market is testament to this positive environment.

Lastly, transitioning to renewable energy could have broader socio-economic benefits. Besides enhancing energy security and environmental sustainability, it could stimulate local industries, create jobs, and foster skills development, contributing to the overall economic development of the country. For example, the largest project currently under development claims to create up to 15,000 construction jobs as well as 3,000 permanent jobs, expected to be mosty filled with Namibians (Stratmann, 2023).

3 Electricity sector overview



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3.1 Major energy sources in Namibia

Namibia's energy landscape is characterized by a diverse mix of energy sources, reflecting the country's unique geographical attributes and natural resource endowments. It is important to note that Namibia imports a significant portion of its electricity from neighboring countries, primarily South Africa, due to the current shortfall in local electricity generation. However, the country is working towards achieving energy independence through increased exploitation of its vast renewable energy resources.

Fossil Fuels: Namibia has some reserves of oil and natural gas, although it relies heavily on imports for its fossil fuel needs. The Kudu Gas Field, located offshore in the Orange Basin, is a significant natural gas reserve, but its exploitation has been delayed due to various challenges (The Namibian, 2019). In recent years, development has once again become a matter of greater public interest due to Namibia's growing energy needs (Hitradio namibia, 2023). Recently, the first commercially viable oil fields have also been identified. Between February 2022 and March 2023, a total of three separate oil discoveries were recorded approximately 200 km offshore Namibia, near Oranjemund (Reuters, 2023).

Hydroelectric Power: Namibia's hydroelectric power potential is largely harnessed from the Kunene River on the northern border with Angola. The Ruacana Power Station is a major hydroelectric plant that provides a significant portion of the country's electricity needs.

Solar Energy: Namibia is one of the sunniest countries in the world, receiving around 300 days of sunshine annually and the average annual sum of solar radiation reaching values above 2.400 kWh/m^2 in vast parts of the country (Hauser, 2018). This makes solar energy a significant resource for the country. There has been a growing focus on solar power in recent years, with several photovoltaic (PV) projects being developed across the country. Furthermore, approaches to using solar thermal technology to reduce dependence on electricity imports are discussed (Ileka & Fenni, 2019).

Wind Energy: Namibia's coastal areas, particularly around Luderitz and Walvis Bay, have strong and consistent wind speeds that make them ideal for wind energy generation. According to (Ministry of Mines and Energy, 2023) this results in a theoretical wind potential in 50 m height of 4936 kWh/m^2/a or 3047 kWh/m^2/a respectively. While wind energy is not yet a major energy source in Namibia, it has immense potential and has been identified as a promising area for future development.

Biomass: Biomass, mainly in the form of firewood and charcoal, plays a significant role in Namibia's energy mix, particularly in rural areas for cooking and heating purposes (Ministry of Mines and Energy, 2017)

Initial plans also exist regarding the use of biomass to generate electricity. Namibia has been grappling with the issue of bush encroachment, a phenomenon where indigenous bushes grow excessively dense and reduce the utility of the land for farming. Covering over 30 million hectares of Namibian farmland, this issue has led to a significant decrease in agricultural productivity. However, it also presents an unexpected opportunity for energy generation. The government of Namibia and

various stakeholders have recognized the potential of using this invader bush as a source of biomass energy. Preliminary plans and studies have been undertaken to establish biomass power plants that can convert these bush materials into electricity (Namibia-Biomass industry Group, 2023).

Uranium: Namibia is home to significant uranium reserves and is one of the top producers globally. While it doesn't directly contribute to the country's energy mix, it holds potential for nuclear energy should the country decide to pursue this path.

3.2 Energy mix of Namibia

In Figure 4, primary energy consumption in Namibia is shown with reference year 2020. This shows that the largest share is accounted for by oil products, which are mainly used in the mobility sector, with a tiny fraction also being used in the electricity sector. A further 22.2 % is attributed to traditional use of biomass and waste, which is used for cooking and heating applications. The remaining 10.9% is accounted for by the electricity (hydropower, coal, wind power and photovoltaics). The electricity sector is the only one of the three sectors with a centralized and state-owned supply infrastructure. In recent years, however, an increased decentralized development can also be observed here.

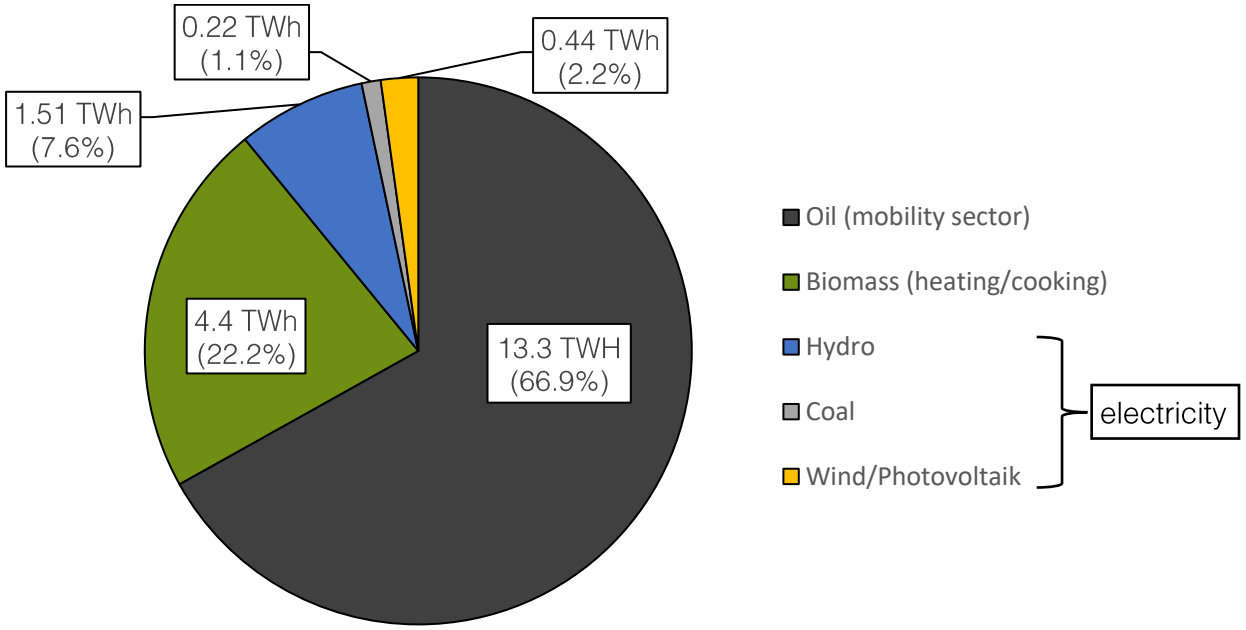


Figure 4: Namibian primary energy consumption by source as of 2020 (IEA, 2023)

The current electricity supply is based on three pillars. Self-generation through coal, diesel and hydropower plants owned by NamPower, self-generation through wind power and photovoltaic projects driven by IPPs and import from neighboring countries. The installed generation capacities with reference year 2023 are given in Figure 5.

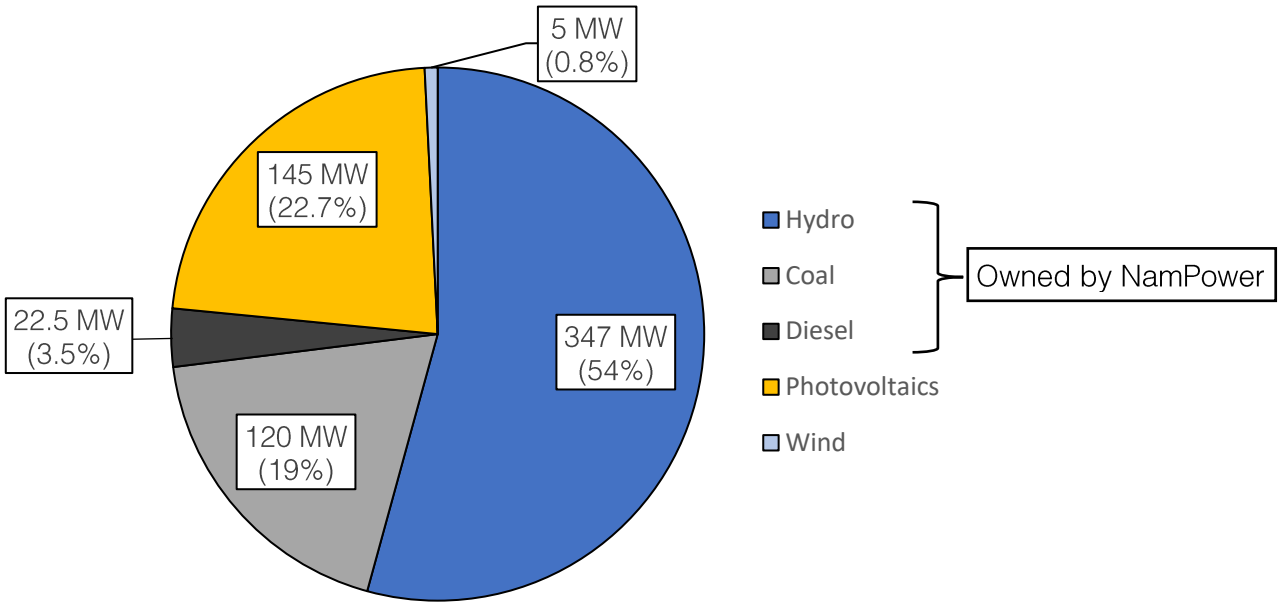


Figure 5: Installed capacity of electricity generation facilities in Namibia as of 2023 (African Energy, 2023; Kruger, 2022; NamPower, 2022)

Hydroelectric Power: Hydroelectric power, predominantly from the Ruacana Power Station with a rated capacity of around 347 MW, accounts for a substantial portion of the domestic electricity supply. This source, however, is subject to seasonal variations and rainfall patterns.

Thermal Power: The secondary source of locally produced electricity comes from thermal power plants.

- The coal fired Van Eck Power Station with a rated capacity of 120 MW, located in Windhoek. According to NamPower, the power station is operated as an emergency standby plant (NamPower, 2022). Due to several constraints, only between 60 and 80 MW of output can be achieved (Kruger, 2022).
- The diesel fueled Anixas Power Station with a rated capacity of 22,5 MW, located at Walvis Bay. Like the Van Eck Power Station, it is operated as an emergency backup plant (NamPower, 2022).
- In the past, the diesel fueled Paratus power station with a rated power of 24 MW was also operated in Walvis Bay. It was decommissioned in 2016 (Kruger, 2022).

Renewable Energy: Solar and wind power are gradually gaining ground, thanks to Namibia's abundant solar radiation and consistent wind speeds in certain regions. The government had been encouraging the development of these sources through various policy measures, and several solar and wind projects are operational or under development with a combined rated power of around 150 MW. A complete list including specifications of documented renewable energy power plants in Namibia is given in Table 2 in appendix A1. It must be noted here that development in the Namibian energy sector is very swift. There are numerous projects in various stages of development

and the documentation of existing plants is often inadequate. It can therefore not be ruled out that individual smaller projects are missing from the list or that new ones will be launched soon.

Imports: Namibia traditionally imported a significant portion of its electricity needs from neighboring countries, primarily South Africa, through the Southern African Power Pool. This reliance on imports underscored the country's energy deficit and the need to boost local generation capacity. To reduce its dependence on the South African power supplier Eskom, NamPower has entered into bilateral agreements with power companies from Zimbabwe and Zambia in recent years (NamPower, 2022). The government of Namibia had been working to reduce the country's reliance on imported electricity by increasing domestic generation capacity, particularly through investments in renewable energy sources like solar and wind power. The development of the share of own generation and electricity imports is shown in Figure 6.

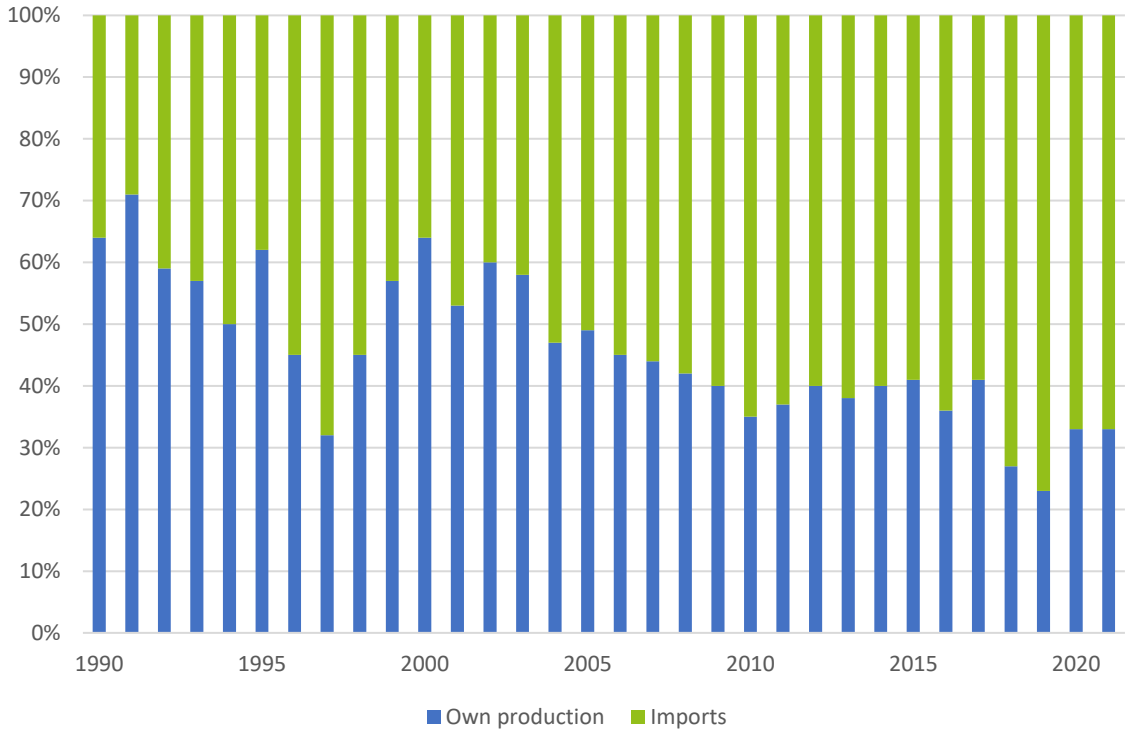


Figure 6: Development of electricity imports in Namibia from 1990 to 2021 (Hangula, 2019; Countryeconomy.com, 2023; oec.world, 2023)

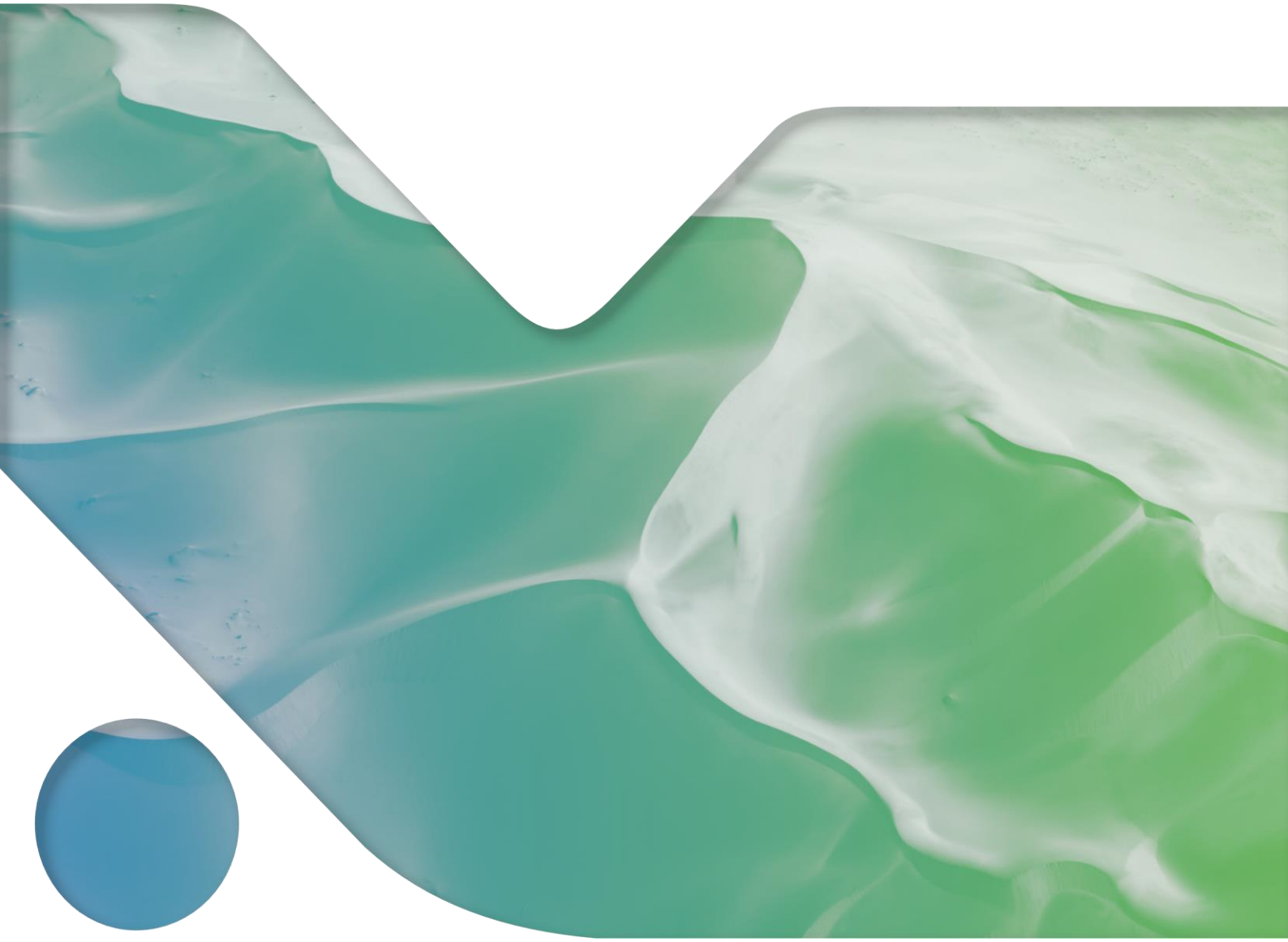
3.3 Electricity consumption in Namibia

Electricity consumption in Namibia is characterized by a diverse mix of industrial, commercial, and residential usage. The mining sector, a key pillar of Namibia's economy, is a significant consumer of electricity, accountable for roughly 35 % of domestic electricity consumption in 2018 (Brandt, 2019). It uses power for extraction, processing, and related operations. Other substantial industrial consumers include the manufacturing and construction sectors.

In the commercial and services sector, electricity is used extensively for lighting, heating, cooling, and operating various appliances and systems. This sector's consumption is driven by businesses like retail outlets, offices, hotels, and restaurants.

Residential electricity consumption varies widely across the country. The national average electrification rate is approximately 56 % but is distributed unevenly. While the rate in urban areas is about 70 %, only about 30 % of households in rural areas have a connection to the grid (Matthys, 2022; Gross, 2022). Rural electrification in Namibia remained a significant challenge due to the country's vast geographic area, dispersed rural population, and the high costs associated with extending the national grid to remote areas. Given the high cost of grid extension in remote areas, off-grid and mini-grid solutions, particularly using renewable energy sources, are being increasingly considered. Urban households typically use electricity for a range of purposes, including lighting, cooking, heating, and powering electronic devices. In contrast, rural households, particularly those not connected to the grid, had much lower electricity consumption, often relying on alternative energy sources like firewood and charcoal for cooking and heating.

4 Electricity pricing in Namibia



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4.1 Composition of electricity prices in Namibia

First, it is important to note that there is no generally applicable electricity price in Namibia, it rather depends on a variety of factors. A comprehensive documentation of the applicable electricity prices can be found on the ECB website. The amount of the electricity price may depend on the following factors, among others:

- Responsible RED
- Type of user (residential or commercial)
- Type of tariff (prepaid or usage-based)
- Type of connection (one phase or three phases)
- Time of use (peak time, standard time, off-peak time)
- Municipality
- Availability of special tariffs (for example, for pensioners or institutions)

As an example, the individual components of a residential customer's electricity price are shown in the CENORED and Erongo RED in Table 1 with a short explanation of the individual components given below.

Table 1: Exemplary illustration of electricity prices for two residential customers in the REDs CENORED (City of Grootfontein) as well as Erongo RED (ECB, 2023)

	CENORED		Erongo RED	
Type of Tariff	Postpaid		Postpaid	
Energy Charge	1.8	NAD/kWh	2.2598	NAD/kWh
Network Charge	160	NAD/month	-	-
Capacity Charge	19	NAD/A	11.72	NAD/A/month
ECB levy	0.0212	NAD/kWh	0.0212	NAD/kWh
NEF levy	0.0160	NAD/kWh	0.0160	NAD/kWh
Local Authority Surcharge	0.34	NAD/kWh	-	-

- **Energy Charge:** The amount charged by the respective RED for the use of a single kWh.
- **Network Charge:** The amount charged monthly by the respective RED for the use of the electricity grid.
- **Capacity Charge:** The amount charged by the respective RED depending on the highest amount of energy a customer uses during one month.
- **ECB levy:** Fee per kWh charged by the ECB to fund its operations.
- **NEF levy:** Fee per kWh charged by the NEF to fund its operations.
- **Local Authority Surcharge:** Charge levied by some municipalities for use of distribution networks.

4.2 Electricity price development in recent years

Reliable and publicly available data on electricity prices in Namibia date back to around 2014. The data indicates a significant increase in electricity prices in the corresponding period. According to NamPower's managing director Simson Haulofu, the reason for the strong price increase is mainly the high inflation of the last years, which is due to the poor exchange rate of the Namibian dollar to

the USD dollar (The Namibian, 2020). It is therefore useful to first look at the development of inflation and currency stability in the same period, which are depicted in Figure 7 and Figure 8 respectively. Between 2014 and 2022, inflation in Namibia ranged from 2.21% to 6.73%. Namibia was thus in the middle of the international league table (~ 95th place) and consistently above the global benchmark during the period under review.

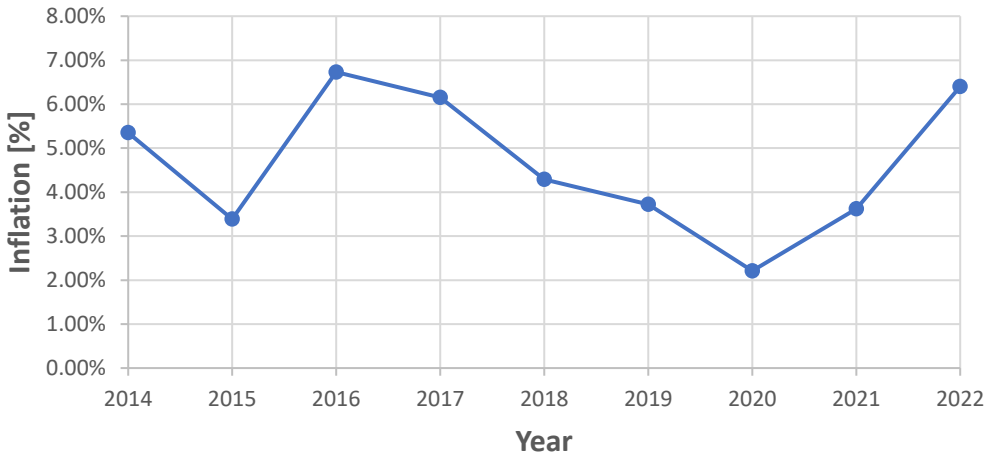


Figure 7: Inflation in Namibia per year (as of 01.07.) from 2011 to 2022

According to the IMF, the high inflation rates are mainly due to the negative development in the value of the Namibian dollar (Fillemon & Amukeshe, 2023). The exchange rate fell from 0.0937 USD/NAD in 2014 to 0.0631 USD/NAD in 2022, representing a loss of almost 33%. A variety of reasons exist for the poor exchange rate performance, but the details of these are not part of this report. Among the causes cited are the effects of the Corona pandemic and the linkage of the NAD to the South African rand. (The Brief, 2023) also cites the Namibian central bank's low foreign exchange reserves by international standards and the associated high volatility during crises such as the prolonged drought of recent years as arguments.

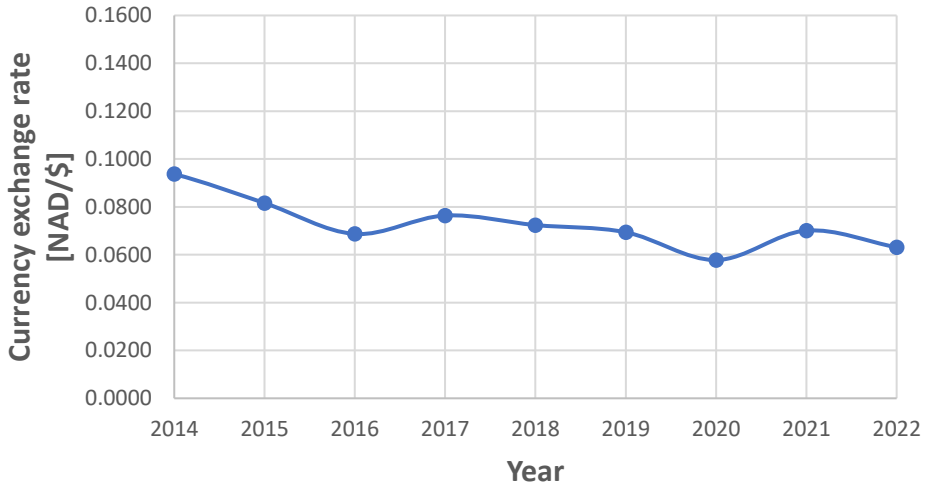


Figure 8: Currency exchange rate NAD/$ per year (as of 01.07.) from 2011 to 2022

In Figure 9, the development of electricity prices for residential and business customers of CENORED and Erongo RED is shown as an example. For comparison, the price development of bulk electricity sold by NamPower is also shown. It should be noted that this is only a small sample of all electricity customers in Namibia. Electricity prices vary depending on the RED, the type of tariff (prepaid or usage-based), and the type of connection selected. In some cases, there are also special tariffs for institutions or pensioners, as well as surcharges levied by individual municipalities. The values shown are therefore only to be understood as examples, but they do reflect the general price development reasonably well.

The price increases per kWh were thus between 22% and 56% in the period under review. The 22% and 25% price increases for CENORED business and residential customers, respectively, appear relatively low at first sight. However, this is revised by the fact that the associated network-charges and capacity-charges payable monthly increased by 45% and 129% respectively over the same period. These cannot be readily converted to a price in NAD/kWh and are therefore not included in Figure 9. The actual prices for customers therefore rose even more sharply than can be derived from the chart.

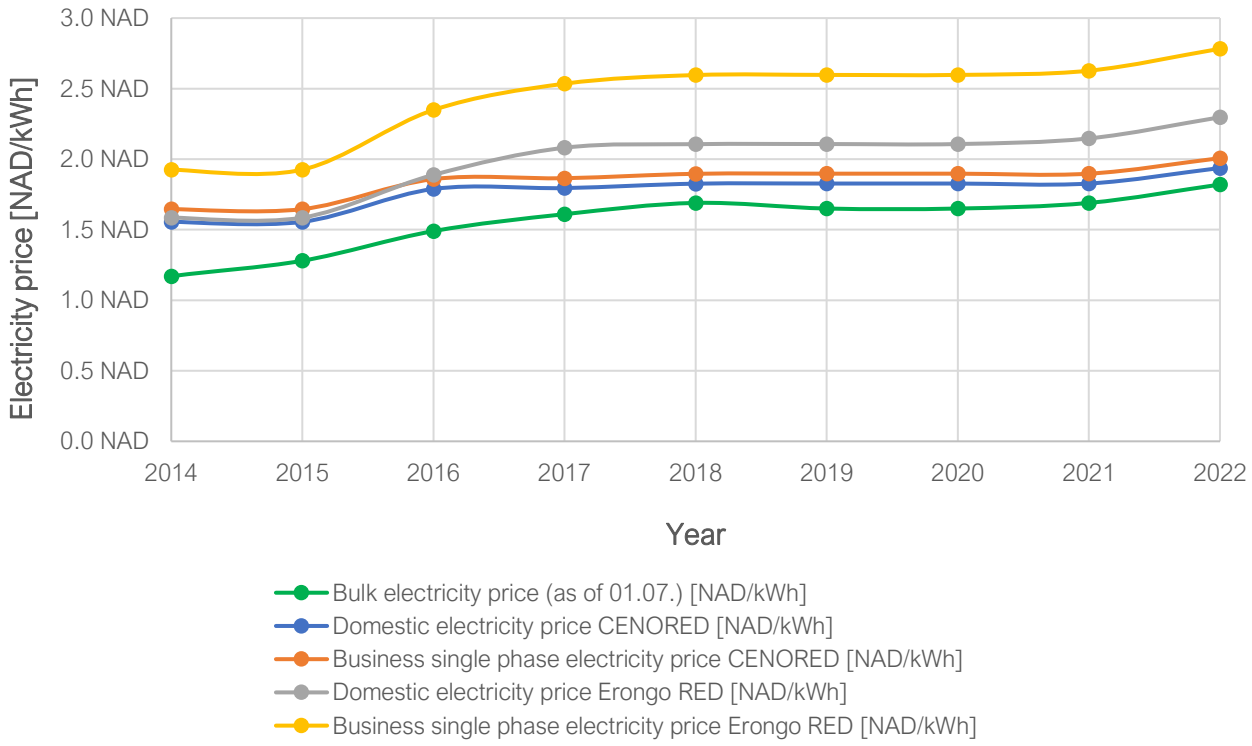


Figure 9: Development of electricity prices in CENORED and Erongo RED for domestic and business use (single phase) from 2014 to 2022. Cost given in NAD. Own illustration with information from (ECB, 2023)

When the exchange rate to the USD is considered, the situation is clearly different. In Figure 10, the development of the same electricity prices in the same observation period is shown, but this time the prices are given in USD. In almost all cases, a slight decrease in electricity prices can be observed in the period under review. Only the prices for bulk energy showed an increase of about 4 % in the period under consideration. The network charge, collected by CENORED, also shows a slight decrease, while the capacity charge still shows an increase, even in USD. This is about 50%

but is compensated by the lower costs per kWh. It can thus be stated that the argumentation put forward by Haulofu, according to which the increase in electricity prices is due to the poor exchange rate to the USD, appears to be conclusive.

4.3 Discussion

Although at first glance it seems unclear why the Namibian electricity price should be linked to the exchange rate to the US dollar, there are several conclusive arguments for this.

- To reduce its dependence on the South African power supplier Eskom, NamPower has entered into bilateral agreements with power companies from Zimbabwe and Zambia in recent years. Payment for the power provided is made in US dollars (NamPower, 2022).
- Apart from hydropower, Namibia generates most of its national electricity through one coal-fired and one diesel-fired power plant. The fuels required for this must be imported in their entirety, with the world market price being defined in USD.
- To maintain the infrastructure for generation, transmission and distribution of electricity, the import of technology, equipment is necessary, which is paid for in US dollars.
- In addition, there could be financial arrangements between the Namibian energy sector with international institutions. Examples of this are loans for infrastructure development, which are also granted in USD.

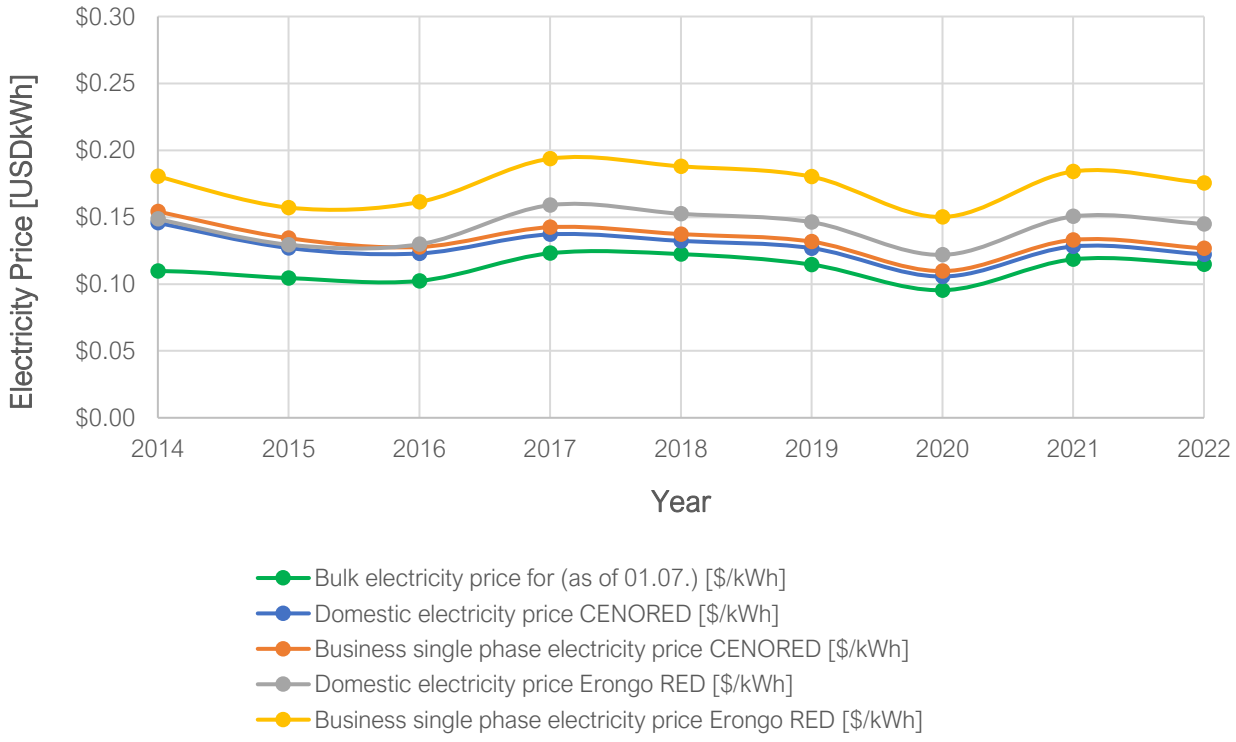
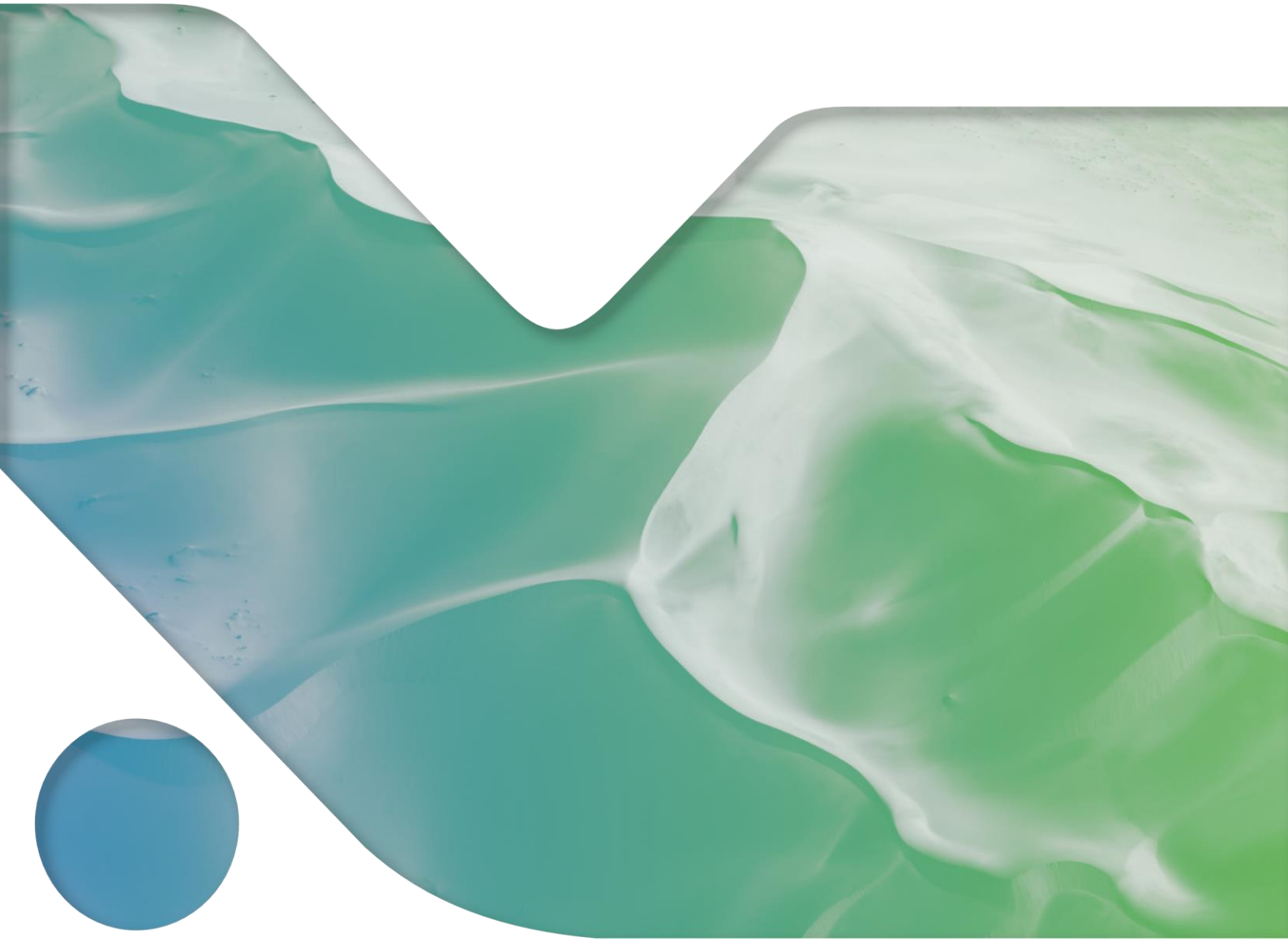


Figure 10: Development of electricity prices in CENORED and Erongo RED for domestic and business use (single phase) from 2014 to 2022. Cost given in USD/kWh.

5 Outlook



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Namibia's energy and electricity market is poised to undergo substantial changes driven by both internal and external factors.

Increasing Renewable Energy Integration: Given Namibia's abundant solar and wind resources, it is expected that the proportion of renewable energy in the electricity mix will continue to rise. This will be facilitated by falling costs of renewable technologies, supportive policy frameworks, and increasing climate consciousness. There is potential for Namibia to become a regional leader in renewable energy, especially solar power.

Energy Efficiency Measures: As energy efficiency gains traction in policy planning, more ambitious measures to decrease energy waste across residential, industrial, and commercial sectors are anticipated. These will involve improved standards, regulations, and incentives for energy-efficient appliances, buildings, and industrial processes.

Infrastructure Development: Upgrades and expansions to transmission and distribution networks will be critical in supporting the growth of the electricity market. The government will likely continue investing in grid infrastructure, including strengthening cross-border connections to facilitate energy trade.

Rural Electrification: With ongoing efforts to improve access to electricity in rural areas, more off-grid and mini-grid solutions incorporating renewable energy technologies, like solar home systems or community-scale wind or solar installations, are likely to be implemented.

Decentralization of Power Generation: With the increasing affordability of renewable technology and the drive for energy independence, there may be a rise in decentralized power generation. Households, businesses, and communities might produce their own electricity and feed excess power back into the grid.

Energy Prices: Even though there are numerous valid reasons for the sharp rise in electricity prices, the high prices represent a heavy burden for many Namibian households (Karuuombe & Matthys, 2013). A further price increase is considered likely in the coming years due to the aforementioned problems. This will not only lead to a further increase in the country's already high inflation but will also jeopardize the objectives of numerous national strategies and policies that aim to achieve nationwide prosperity and progress for the population.

Electricity Market Liberalization: Reforms may continue to open the electricity market, encouraging competition and private sector participation, and leading to better services and potentially lower prices for consumers.

Impact of Climate Change: As climate change may influence the availability of water resources, hydropower, which currently plays a substantial role in Namibia's electricity supply, might face challenges. At the same time, increasing temperatures could drive up energy demand for cooling purposes.

International Cooperation: Namibia is expected to continue participating in regional and international initiatives aimed at promoting sustainable energy, combating climate change, and facilitating technology and knowledge transfer.

Despite these optimistic projections, challenges such as regulatory hurdles, technical constraints, financial limitations, and the need for capacity building remain. The actual trajectory of Namibia's energy and electricity market will depend on how these trends and challenges are navigated by the government, industry, and society at large.

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Appendix

Appendix A1: List of established wind and photovoltaic energy projects in Namibia

Table 2: List of established wind- and photovoltaic energy projects in Namibia. If not explicitly stated otherwise, the powerplants are operated by IPPs. (African Energy, 2023; Kruger, 2022; NamPower, 2022)

#	Name	Rated Power	Operational since	Source
1	Hardap Alten	37 MW	2019	PV
2	Omburu Solar Power Station[1]	20 MW	2022	PV
3	GreeNam I	10 MW	2018	PV
4	GreeNam II	10 MW	2018	PV
5	Hopsol	5 MW	2016	PV
6	Osana	5 MW	2016	PV
7	Momentous	5 MW	2017	PV
8	Aloe Investment	5 MW	2017	PV
9	MetDecci	5 MW	2017	PV
10	ALCON	5 MW	2017	PV
11	Ombepo	5 MW	2017	Wind
12	Ejuva 1	5 MW	2018	PV
13	Ejuva 2	5 MW	2018	PV
14	Camelthorn	5 MW	2018	PV
15	Sun EQ Four[2]	5 MW	2018	PV
16	Sertum	5 MW	2019	PV
17	Unisun	5 MW	2023	PV
18	Omburo	4.5 MW	2015	PV
19	OLC Arandis	3.8 MW	2018	PV
Sum		150.3 MW		

[1] Operated by NamPower
[2] Embedded Generation – Ohorongo Cement

Appendix A2: Map of electric power plants and green hydrogen projects.

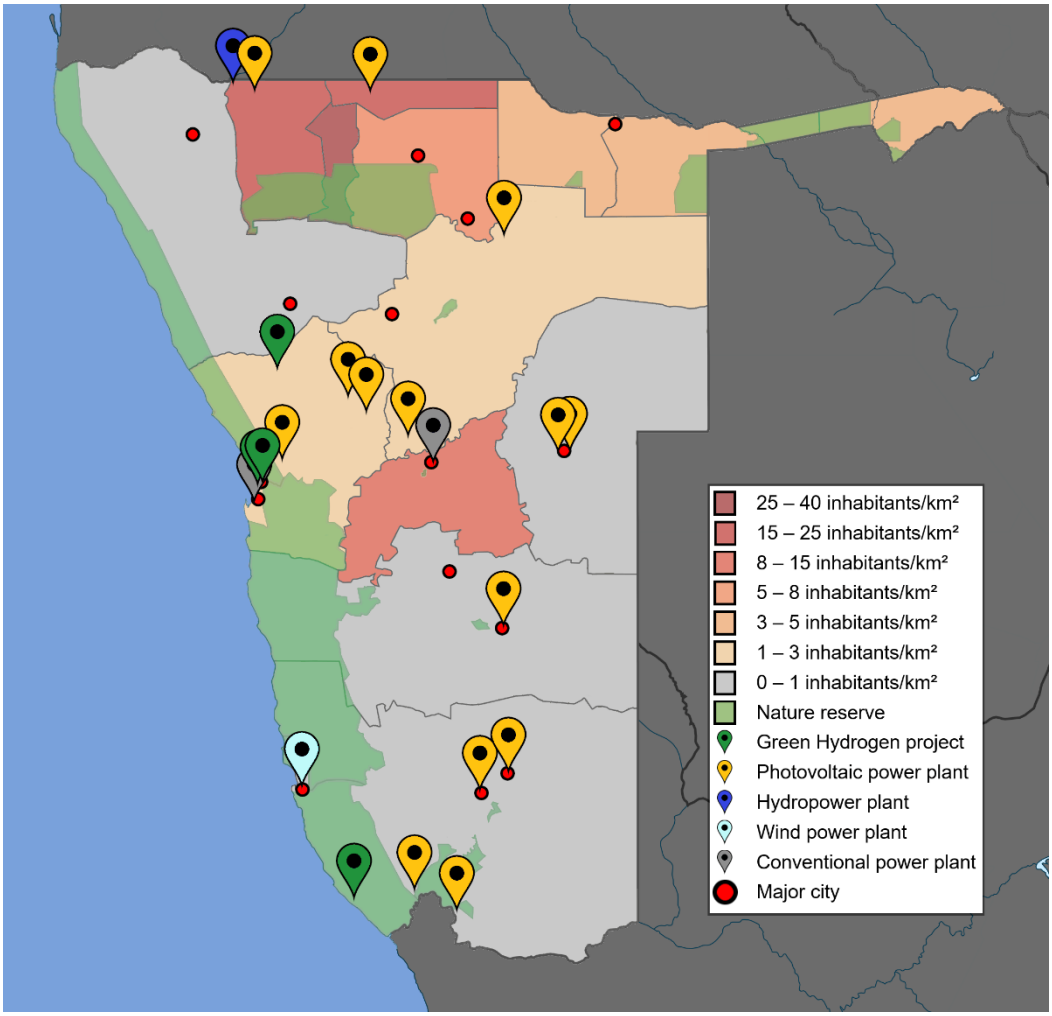

Figure 11: Map of electric power plants and green hydrogen projects. Own illustration with use of information from: (FuelCellsWorks, 2022; Mbathera, 2022; mapsofworld, 2012; NordNordWest, 2022; Picard, 2016; von Oertzen, 2019)