RENEWABLE READINESS ASSESSMENT

PARAGUAY

IRENA
International Renewable Energy Agency

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international 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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This report was developed under the guidance of Gürbüz Gönül and Binu Parthan (IRENA) and authored by Fabian Barrera (IRENA), José Torón (IRENA), Edna Soto (IRENA), Fernando Anaya (IRENA Consultant) and Fabio Lucantonio (IRENA Consultant).

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Renewables Readiness Assessment

PARAGUAY

Foreword

From the Minister of Public Works and Communications

Paraguay's main renewable energy resource is hydropower, thanks to the great resource potential offered by the Paraná and Acaray rivers and the tributaries that it shares with neighbouring countries. The development of the country's electricity sector is planned and executed by the National Electricity Administration (Administración Nacional de Electricidad, ANDE), a vertically integrated state-owned company. ANDE has carried out large investments in infrastructure, enabling electricity coverage for more than 99% of the population in addition to supporting economic development and supplying growing electricity demand. The local industries that produce ethanol and biodiesel also play an important role as renewable and sustainable energy sources, supplying around 7% of the fuel demand for road transport.

According to a study on energy prospects developed by the Vice-Ministry of Mines and Energy of the Ministry of Public Works and Communications (VMME-MOPC), the existing power supply will be surpassed in the medium term due to increased and sustained demand. Therefore, one of the most important challenges is diversifying the energy mix through the deployment of renewable energy sources. The invaluable support and recommendations of the International Renewable Energy Agency (IRENA) have contributed to the development of this report, which identifies the conditions for the wide implementation and use of renewables in Paraguay's national territory.

Paraguay has adopted various international climate commitments, such as the Paris Agreement, in the fight against climate change. These commitments are reflected in the guidelines provided by the 2040 Energy Policy of the Republic of Paraguay, which aims to promote the use of alternative energy sources, encouraging energy projects to mitigate and adapt to the effects of climate change, as well as to implement environmental services.

The VMME-MOPC, which is responsible for the implementation of energy policy, is the key actor to follow up on this Renewables Readiness Assessment (RRA). The actions described in the report will lay the foundations to make the necessary adjustments and further promote the optimal exploitation of Paraguay's endowed renewable resources, helping to incorporate renewable technologies into the energy system in the most efficient way.

We express our gratitude to IRENA and to all the people who participated in this assessment. In addition, we ratify our commitment to developing initiatives that allow for the deployment of renewable energy and that position Paraguay, thanks to its strategic geographical location, as a pivotal country for regional energy integration based on the sustainable use of its natural resources.

Arnoldo Wiens Durksen
Minister of Public Works and Communications
Paraguay

Foreword

from the IRENA Director-General

The Republic of Paraguay is a global leader in the use of renewable energy, with hydropower providing most of its electricity generation, an important renewable energy source in Latin America. The country has also successfully developed bi-national power generation projects, promoting the wider deployment of renewables, and supporting the region's sustainable energy future.

In recent years, the share of fossil fuels in Paraguay's energy mix has grown. The country's increasing dependence on these fuels has resulted in rising greenhouse gas emissions from the energy sector, adversely affecting Paraguay's energy security and climate commitments. This fossil fuel use is driven mainly by the transport sector, opening an opportunity to discuss the potential deployment of renewables and low-carbon technologies beyond power generation that would lead towards decarbonisation of the energy sector. Already, the effects of climate change have impacted the country's power generation, affecting not only the supply but also revenues from electricity exports. Thus, the need to diversify the energy mix has become a key driver for the promotion of clean energy technologies.

These aspects are clearly highlighted in Paraguay's National Energy Policy 2016-2040 and, more recently, in concrete actions outlined in the Energy Agenda 2019-2023, which focuses on the key pillars for enhancing energy security through the use of renewables, encouraging renewable-powered electrification and promoting sustainable mobility. These key components aim to support the economic growth of the country in line with the 2030 Sustainable Development Goals.

The RRA process has been led by the Ministry of Public Works and Communications, represented by the Vice Ministry of Mines and Energy (VMME) in co-operation with IRENA. The consultation process of the RRA involved a co-ordinated dialogue among the most relevant national energy institutions in Paraguay, as well as regional partners working in the country, identifying key actions to expand renewable energy development. These examine Paraguay's energy institutions and their governance, long-term energy planning practices, and the socio-economic benefits of promoting renewable and low-carbon technologies in the end-use sectors. The RRA process took place in synergy with the country's revision of its National Determined Contribution (NDC). The report highlights the strong link between diversifying the energy mix, scaling up renewable energy use, and promoting low-carbon technologies such as green hydrogen and electric vehicles, alongside climate action.

The Renewables Readiness Assessment (RRA) aims to contribute to the country's pathway towards carbon neutrality. It identifies short- and medium-term actions that would enable the accelerated deployment of indigenous renewable energy technologies, facilitate meeting the Paris Agreement commitments while supporting economic growth. Since 2011, nearly 40 countries, spanning Latin America and the Caribbean, Africa, the Middle East, Asia and the Pacific have undertaken RRAs, exchanging knowledge and fostering international co-operation to accelerate the deployment of renewables.

IRENA wishes to thank the team from the Vice-Ministry for its support and collaboration during the RRA process. We also recognise the active participation of government agencies, and national and regional stakeholders during the discussion part of this study. IRENA will continue to support the Government of Paraguay in the implementation stage of the recommendations identified herein and looks forward to continuing a close collaboration with all the country stakeholders to bring these actions to reality.

I am convinced that the recommendations from this RRA will strongly contribute to the decarbonisation of Paraguay's energy sector, enhancing economic growth, supporting ambitious climate action and improving the welfare of the population. IRENA will continue to support the country's transition towards a net zero future.

Francesco La Camera
Director-General, IRENA

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Abbreviations

°C	Degrees Celsius
AECID	Spanish Agency for International Development Cooperation
AFD	Paraguay's Development Finance Agency
ANDE	National Electricity Administration
ARPEL	Association of Oil, Gas and Biofuels in Latin America and the Caribbean
AZPA	Paraguayan sugar company S.A.
CAF	Development Bank of Latin America
CIER	Regional Energy Integration Commission
CNEE	National Committee for Energy Efficiency
CO_2	Carbon dioxide
CONACYT	National Council of Science and Technology
CONAPTIE	National Council for Independent Production and Transport of Energy
COVID-19	Coronavirus disease
DGEEC	General Directorate of Statistics, Surveys and Census (National Institute of Statistics)
DRE	Directorate of Energy Resources
EEP	Energy Efficiency Plan
FAO	Food and Agriculture Organization of the United Nations
GCF	Green Climate Fund
GDP	Gross domestic product
Gg	Gigagram
GWh	Gigawatt hour
IDB	Inter-American Development Bank
INPASA	Paraguayan Alcohol Industry S.A.
IRENA	International Renewable Energy Agency
KfW	German state-owned Development Bank
$kTCO_2e$	Kilotonne of carbon dioxide emissions equivalent
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
LCOE	Levelised cost of electricity

LPG	Liquefied petroleum gas
LTS	Long-term strategies
m^3	Cubic metre
MADES	Ministry of Environment and Sustainable Development
MERCOSUR	Southern Common Market
MIC	Ministry of Industry and Trade
MITIC	Ministry of Information Technologies and Communications
MoPaDual	Paraguayan Model of Dual Vocational Training
MOPC	Ministry of Public Works and Communications
MW	Megawatt
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Program of Action
NDC	Nationally Determined Contribution
OLADE	Latin American Energy Organization
PETROPAR	Petróleos Paraguayos National Oil Company
PJ	Petajoule
PROEZA	Poverty, Reforestation, Energy and Climate Change Project
PV	Photovoltaic
PYG	Paraguayan Guaraní
RRA	Renewables Readiness Assessment
SDG	Sustainable Development Goal
SIN	National Interconnected System
SNPP	National Service for Professional Promotion
STP	Technical Secretary of Planning and Economic Development
TFEC	Total final energy consumption
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VMME	Vice-Ministry of Mines and Energy
µg	Microgram

Executive summary

The energy mix of the Republic of Paraguay is dominated by clean energy sources, with one of the highest shares of renewable energy in South America. Hydropower accounts for the largest share of the country's power generation, representing around 99.5% of the installed power capacity. Consequently, Paraguay is highly dependent on the hydrological conditions of the rivers that feed the main hydropower plants of the country, where most of the electricity produced is exported to neighbouring countries.

Paraguay's economy is based mainly on agriculture, livestock and the services sector, which has been growing in recent years. However, the global crisis caused by the COVID-19 pandemic has affected the country's economy, reducing its Gross Domestic Product (GDP) by around 1% during 2020. Regardless of persistent challenges, Paraguay has experienced social and economic progress over the last two decades, with national policies and strategies increasingly contributing to the achievement of the Sustainable Development Goals (SDGs) and reiterating Paraguay's commitment to reducing its greenhouse gas emissions by 2030. Advances include the ratification of the Paris Agreement in 2016, the National Climate Change Law of 2017, and the updated Nationally Determined Contribution (NDC) under the Paris Agreement submitted in July 2021.

Paraguay's renewable energy resources are vast and diverse and have an important role in enhancing energy security, mitigating climate change and promoting economic growth aligned to the United Nations 2030 Agenda for Sustainable Development and to the net zero objectives of the Paris Agreement. By 2020, renewables had reached a total installed capacity around 8 832 megawatts (MW). Hydropower capacity alone accounted for 8 810 MW and bioenergy for 22 MW. Despite renewables being the largest source of Paraguay's total energy supply, emissions have been increasing gradually due to the growing use of fossil fuels, mainly in the transport sector. During the period of 2010-2019, the import of oil derivatives (mostly petrol and diesel) increased rapidly, an average annual growth of 5.1%, making it the second-largest source of energy in the country.

Paraguay sees the need to encourage the diversification of its energy mix through the adoption of renewable energy and net zero technologies. This would contribute to the decarbonisation of end-use sectors, the mitigation of greenhouse gas emissions, the promotion of energy efficiency, and the achievement of net zero emissions, while attracting investment and bringing diverse socio-economic benefits to the country's population.

These aspects are clearly highlighted in the National Energy Policy 2016-2040, which promotes the use of Paraguay's endowed renewable energy sources to improve energy access, enhance energy security, implement energy efficiency and, thanks to its geographical position and to existing bi-national hydropower projects, consolidate the country's key role in regional energy integration. The national energy policy also provides clear implementation guidelines that are leveraged in the recently developed Sustainable Energy Agenda 2019-2023. The agenda focuses its efforts on promoting sustainable mobility, with the aim of greatly reducing imports of oil derivatives to the country. Likewise, the National Development Plan 2030 highlights the crucial role that renewable energy will play in increasing national income and contributing to the sustainable development of the country.

The Renewables Readiness Assessment (RRA) process for Paraguay has identified key actions for accelerating the deployment of renewable energy in the country. The consultative process led by the Ministry of Public Works and Communications, represented by the Vice-Ministry of Mines and Energy (VMME), and facilitated by the International Renewable Energy Agency (IRENA), aims to help unlock Paraguay's renewable energy potential. The identified actions are grouped in six areas, where the main challenges have been identified.

Challenges and key recommendations

1. Strengthen energy institutions and governance

Paraguay's current institutions face capacity constraints to guarantee the rapid implementation of policies, programmes and strategies in the energy sector. The key energy institutions require additional human resources, capabilities and budgetary resources in order to lead multi-sectoral responsibilities, implement national energy programmes and provide technical assistance in the design of business models, installation, maintenance and certification of renewable energy technologies.

Therefore, it is essential to prioritise enhancing the governance of energy institutions in the country by strengthening capacities and increasing the budgets of existing entities or creating specialised agencies to implement strategic pillars of the energy policy, such as energy efficiency and renewable energy. For instance, a short- to medium-term approach could reside in the creation of an Energy Committee as a transitory measure towards the eventual creation of a leading institution for the energy sector, such as a Ministry of Energy. This Committee would enhance co-ordination among the different institutions of the energy sector, following up on implementation of the National Energy Policy and assessing the potential benefits of energy reforms in the country.

Furthermore, Paraguay needs to establish an independent regulatory environment, either by increasing this capacity in an existing institution or by considering granting these responsibilities to a new one. The regulatory body should guarantee adequate and independent supervision of different aspects of the energy sector and work closely with the key energy institutions in the country. Additionally, there is a need to streamline administrative procedures when granting permits and concessions to accelerate the deployment of renewable energy projects. The creation of a "single-window agency", as an independent legal body or under the mandate of an existing institution, can facilitate more efficient and rapid awarding of licences for faster advancement of renewable energy projects.

2. Enhance planning, policy and the regulatory frameworkfor renewable energy

The development of the energy sector in Paraguay requires better guidance given by a robust national energy plan that includes clear guidelines for all end-use sectors, including power, transport, industry and buildings. The current planning responsibilities in the country are scattered among different institutions, hindering utilisation of the full renewable energy potential in the country. Likewise, the Paraguayan energy sector would benefit from the definition of clear renewable energy targets beyond the power sector – which could integrate the economic, social, environmental and governance dimensions of sustainable development – as well as from a clear linkage and contribution to climate action in the framework of the NDCs and the Long-Term Strategy (LTS).

The Paraguayan renewable energy sector has a strong nexus with different aspects of the SDGs and having a clear link to these goals would benefit the achievement of a sustainable energy future and net zero emissions by 2050. The development of a cross-cutting strategy highlighting the nexus areas of the energy sector with the SDGs would position the sector as a national priority and highlight its contributions towards improved land use, modernisation of the agricultural sector and women's empowerment, among others.

Furthermore, there is a need to prioritise actions to establish clear enabling frameworks for the development of renewable energy projects in the country. Creating transparent and effective rules and legislation for renewable energy projects – including incentives, regulations and guarantees – could help attract new investments into the country.

3. Develop policy instruments and implementing initiatives to foster energy efficiency

Energy efficiency is one of the pillars of the country's National Energy Policy, and some actions have been implemented to foster more efficient use of energy in Paraguay. For instance, the country has developed an inter-ministerial co-ordination mechanism and has established guidelines across the economic sector through the National Energy Efficiency Committee (CNEE) as well as the development of a National Energy Efficiency Plan.

However, these efforts have not yet led to concrete outcomes, and energy efficiency still requires wider promotion and targeted implementation in the country. The development of legislation on energy efficiency can provide conditions for the implementation of targets and clear initiatives throughout different sectors, including buildings, transport, industry, etc., while promoting the adoption of renewable energy and energy efficiency technologies for different applications. Moreover, there is a need for programmes that raise general public awareness about the responsible use of energy, helping to shift the prevailing view that the country has infinite hydropower resources. The development of integral policies that offer a more relevant role for the population in its approach to energy consumption could favour raising awareness about responsible energy use in Paraguay.

4. Promote the use of renewable energy beyond the power sector

The deployment of renewable energy can benefit many different sectors in the country, by assessing the potential and impact of clean energy technologies in end-use sectors such as transport, industry, buildings, etc. Nevertheless, institutional co-ordination to execute cross-cutting strategies demands co-ordination among ministries and vertical coherence across other government institutions.

Paraguay has a rich diversity of renewable energy resources that have not yet been clearly assessed and developing resource maps could help in the identification of zones with potential for the development of renewable energy projects that serve power generation or other applications. Additionally, it would be beneficial for Paraguay to develop roadmaps that assess the potential penetration of clean energy technologies, highlighting the diverse benefits brought about by these types of projects, such as enhanced food security, the mitigation of emissions from the transport sector, the modernisation of the industrial sector, among others.

The development of roadmaps across different sectors will require strengthening institutional and stakeholder co-ordination beyond the power sector, with the aim of having all relevant actors involved and committed to moving forward the actions identified in the roadmap. The institutional co-ordination could also fill the need to assess the capacity to invest in low-carbon technologies and to design business models to install and deploy renewable energy technologies. Likewise, Paraguay can leverage its work on existing regional initiatives to foster international cooperation for the promotion of renewables and contribute to the regional energy integration in Latin America.

5. Foster investment in renewable energy technologies

Paraguay's strengthened macroeconomic framework is based on fiscal rules, inflation reduction targets, low public debt and adequate foreign exchange reserves. At the beginning of 2020, its favourable investment conditions positioned it among the five countries in Latin America with the lowest risk premium. However, the country faces challenges to attract investments in certain areas of the energy sector.

To accelerate investments in renewable and energy efficiency projects in Paraguay, direct incentives can be created in the form of tax exemptions and discounts for high-efficiency and renewable energy equipment, among others. Additionally, the country can consider providing technical assistance to study the economies of scale for developing the use of renewable energy in strategic sectors, to support the organisation and professional development of small- and medium-sized enterprises, and to create capacities in commercial banks and borrowers to increase access to financing.

More financing opportunities should be created in the country to boost the rapid development of renewable energy projects. For instance, guarantees, credit lines and other dedicated financing mechanisms can help attract the interest of project developers and investors. Additionally, climate finance support from international institutions should be considered for the development of renewable energy and energy efficiency projects.

6. Reinforce the continuous creation of institutional and human capacities

Currently, Paraguay is experiencing an imbalance between supply and demand for trained personnel with skills in energy-related activities, including energy policy, regulation, installation and maintenance of renewable energy systems, certification of technologies and project development, among others.

It is necessary to map the labour skills that are in demand and to develop adequate education, capacity-building programmes and training to satisfy the growing demand of professionals and technicians in the energy sector. This can be done in collaboration with academia, by identifying current and future skills needed in the energy sector and reinforcing existing educational programmes.

Collaboration among the different stakeholders from the public and private sectors involved in the development process of the RRA will be key in bringing these actions to reality. The implementation of these steps is expected to pave the way for the energy transition and associated climate action in Paraguay.

View of a sugar cane factory in Troche, Paraguay.
Image credit: Shutterstock

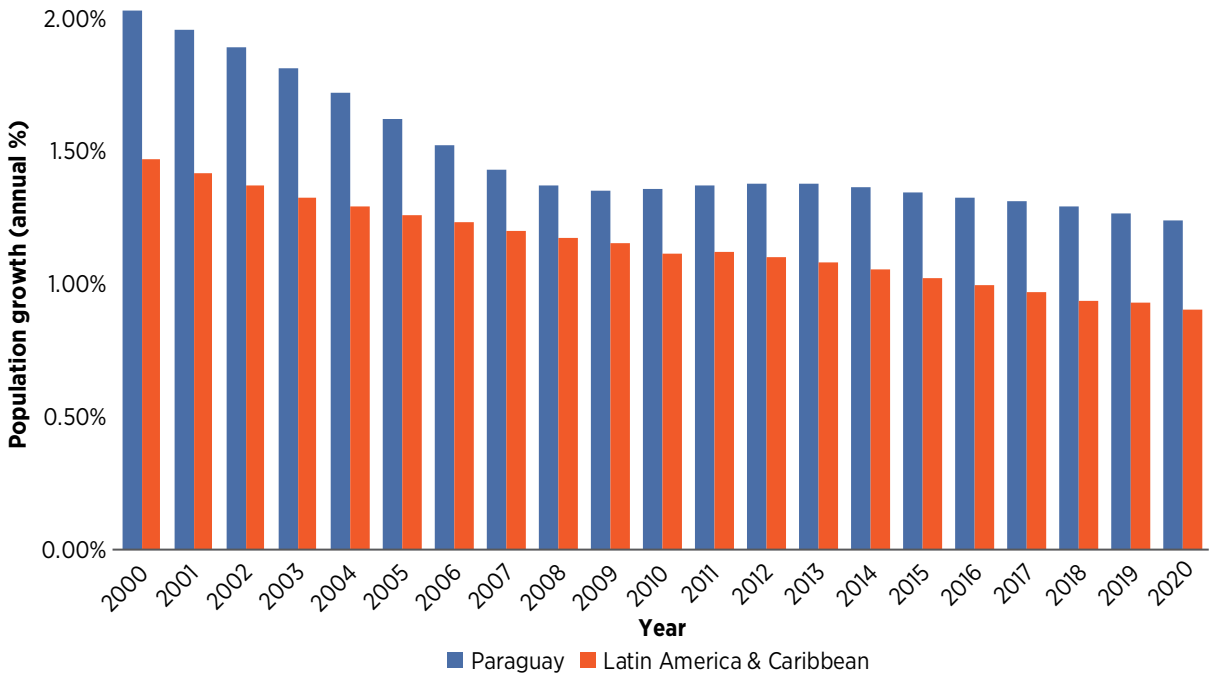
1. Introduction

Country profile

The Republic of Paraguay is located in central South America and bordered by Argentina, Bolivia and Brazil. The country has a landlocked area of 406 752 square kilometres, divided into two natural regions by the Paraguay River. The eastern zone contains 90% of the population, while the western zone, known as the Paraguayan Chaco, represents 60% of the territorial surface. The eastern region is dominated by the Amambay, Mbaracayú and Caaguazú mountain ranges. The Paraguay River is the main fluvial system, navigable by deep-sea vessels from Paraná to Asunción and by medium-sized fleets from Asunción to Corumbá (Brazil). The next largest river is the Paraná River, which extends for 679 kilometres bordering the east-south limits of Paraguay.

Paraguay's population, estimated at 7.3 million, is growing at an average annual rate of 1.5%, exceeding the 1% average annual growth rate for Latin America and the Caribbean overall (Figure 1). Of this population, 62.5% is located in urban areas and 37.5% in rural areas (DGEEC, 2015). The most populated cities are Asunción and Ciudad del Este in Alto Paraná. In 2018, the Human Development Index value for Paraguay was 0.72, below the regional average of 0.76 for Latin America and the Caribbean, ranking Paraguay in 98th place out of 198 countries worldwide.

Figure 1. **Annual population growth, 2000-2020**



Source: World Bank, 2020a

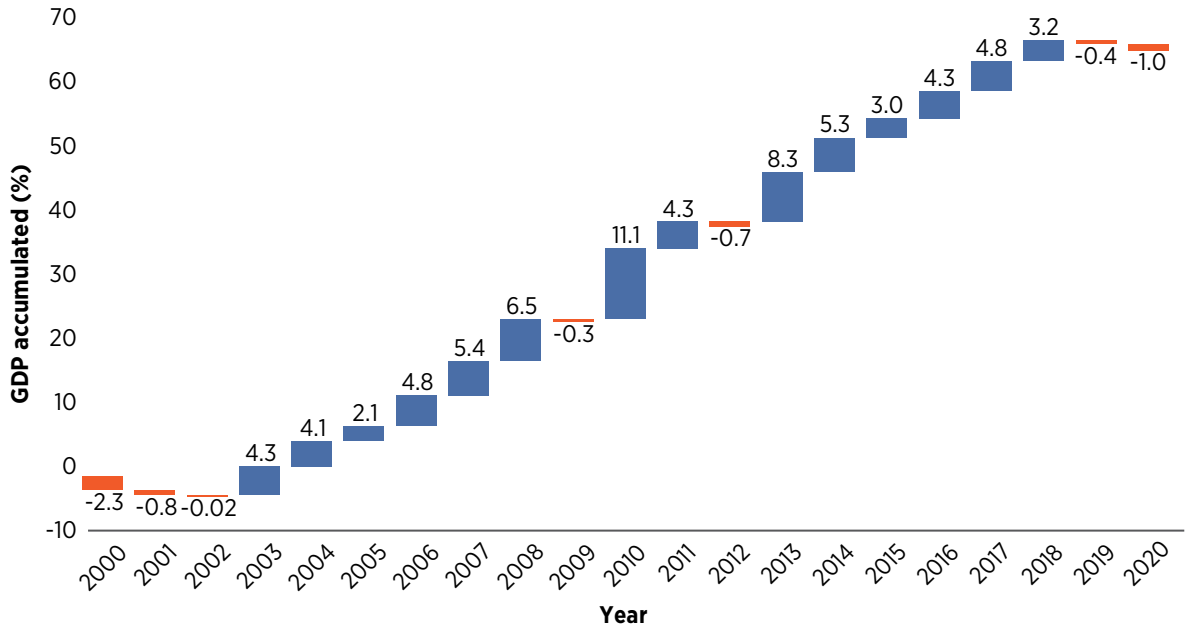
By the end of 2019, 99.95% of the population had access to electricity, and 69% used modern energy sources – such as liquefied petroleum gas (LPG) or electricity – for cooking purposes (ANDE, 2019a). Between 2015 and 2016, the country's energy intensity (energy consumption per unit of gross domestic product, (GDP) decreased by 1.85%, from 10 267 kilojoules per USD to 10 080 kilojoules per USD (DGEEC, 2015).

In October 2015, the Government of Paraguay submitted its Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC). The NDC established a global target for reducing the country's greenhouse gas emissions of 20% by 2030 (10% conditional and 10% unconditional), using the year 2000 as a baseline (UNFCCC, 2016). In July 2021, Paraguay submitted an updated NDC, which ratifies the commitments presented in the first NDC. The revised NDC includes cross-cutting axes used for the generation of instruments necessary to manage climate risk, regulatory aspects, gender perspectives, inclusion of indigenous people, climate empowerment and promotion of the United Nations' Sustainable Development Goals (SDGs) by 2030. The energy sector is presented with three objectives, aimed at: 1) improving electricity services, 2) conserving water basins where hydroelectricity is generated, and 3) developing and promoting alternative energy sources (UNFCCC, 2021).

Between 2012 and 2019, the transport sector expanded steadily. The motorcycle fleet grew at an average annual rate of 16.3%, followed by cars (11.6%), buses (4.6%) and trucks (6.6%). In 2015, the country generated close to 50 000 kilotonnes of carbon dioxide equivalent (CO_2e), with the energy sector (mainly transport) accounting for 12% of total CO_2 emissions (SIEN, 2019).

In 2019, Paraguay ranked fourth in competitiveness among the Southern Common Market (MERCOSUR) countries, its main strength being macroeconomic stability based on the fulfilment of inflation targets and prudential levels of debt (DECI, 2019). It achieved a GDP per capita of USD 12 684. For the period 1999-2020, the country's GDP grew at an average annual rate of 2.93% (World Bank, 2020b) (Figure 2), which fell to -1.0% in 2020 due to the COVID-19 pandemic; meanwhile, the share of the population in poverty[1] declined from 44.7% in 1999 to 23.5% in 2019 (DGEEC, 2019). The services sector contributes the largest share of GDP, at 32% in 2018, followed by agriculture and livestock (including meat and dairy) at 14.8%, trading at 11.7%, and electricity and water at 8.8% (BCP, 2019).

Figure 2. **Paraguay GDP growth (annual %), 2000-2020**



Source: World Bank, 2020b

[1] The poverty line corresponds to the population with incomes lower than the estimated basic basket of consumption. For 2019, the values were estimated at USD 101 for urban areas and USD 72 for rural areas.

In 2019, climate phenomena such as droughts affected agricultural production and electricity generation in some areas, while the country was also affected by heavy rains that caused floods and impacted livestock production and the construction sector, with effects on the national economy (ECLAC, 2019). Table 1 shows the main indicators related to the energy, transport and environment sectors.

Table 1. **Relevant indicators related to energy and the environment**

Energy consumption from fossil fuels (2019)	40%
Electricity generation capacity (2019)	8 848 MW
Electricity production (2019)	49 456 GWh
Electricity production from renewable sources (2019)	99.5%

Growth of the vehicle fleet (2012-2019)	215.9%
Growth of the motorcycle fleet (2012-2019)	287.2%
Growth of the bus fleet (including minibuses) (2012-2019)	123.4%
Growth of the truck fleet (2012-2019)	34%

Total greenhouse gas emissions[2] (2015)	51 293 $kTCO_2e$
Share of greenhouse gas emissions from the energy sector (2015)	12%
Particulate matter (PM2.5) emissions, City of Asunción (2018)	30 $\mu g/m^3$

NDC's aspiration for greenhouse gas emission reduction by 2030	20%
Number of hectares of new forest plantations by 2030 (in thousands)	160
Number of energy efficiency programmes to be implemented by 2030	3

Source: SIEN, 2019; VMME, 2016; MADES, 2019, 2021; DRA, 2021; IRENA, 2021a

The National Development Plan for 2030 proposes strategies to guarantee employment, social security, competitiveness, innovation, product diversification and the valorisation of environmental capital.

The energy policy framework promotes new developments on renewables through sustainable production of energy and direct use of natural resources. For this purpose, Paraguay aims at taking advantage of alternative energy sources such as solar and wind energy, in addition to further developments in small and large hydropower. The policy also proposes strengthening energy research and innovation and the country's resource management capacity (for details, see section 2.4).

[2] Includes carbon dioxide, methane and nitrous oxide.

Renewables Readiness Assessment (RRA)

The RRA is a country-led consultative process developed by the International Renewable Energy Agency (IRENA) to identify appropriate policy and regulatory choices that support an accelerated transition towards renewable energy and low-carbon technologies in all energy sector applications.

The RRA Paraguay has been initiated by the Ministry of Public Works and Communications, represented by the Vice-Ministry of Mines and Energy (VMME) in co-operation with IRENA, with a view to supporting the country's efforts in enabling the wider penetration of various renewable energy technologies.

IRENA developed the RRA as a tool for carrying out a comprehensive evaluation of the conditions for renewable energy deployment in a particular country. The RRA provides a venue for multi-stakeholder dialogue to identify existing challenges for renewable energy deployment and devise solutions to overcome existing barriers.

Short and medium-term recommendations are presented to governments for the structuring of new policies or or reform existing ones and establish a more conducive enabling environment for renewable energy deployment. The RRA also consolidates existing efforts and mobilises resources for priority action. Since 2011, the RRA methodology has been used to conduct more than 40 country assessments, often resulting in extensive stakeholder engagement and improvements in policies and institutional frameworks.

The RRA process in Paraguay started with a literature review of research in the energy sector and interviews with key stakeholders from government institutions, regional partners, academia and the private sector. The process continued with the hosting of a Consultation Workshop in February 2021 to discuss the main challenges hindering the accelerated deployment of renewable energy in Paraguay.

A series of recommendations were then developed and presented to the country's stakeholders during a Validation Workshop in May 2021, aiming to validate the short- and medium-term proposed actions streaming from this study. Workshops and meetings with experts and agents from relevant sectors such as transport, energy, industry and agriculture were conducted throughout 2020 and 2021 in a hybrid setting, combining on-site and virtual meetings due to COVID-19-related measures.

The RRA Paraguay has a strong focus on promoting diversification of the energy mix and the use of renewable energy and low-carbon technologies beyond the power sector, linking the potential socio-economic benefits and contribution to the UN 2030 Agenda for Sustainable Development, and climate action from the Paraguayan energy sector.

2. Energy Conext

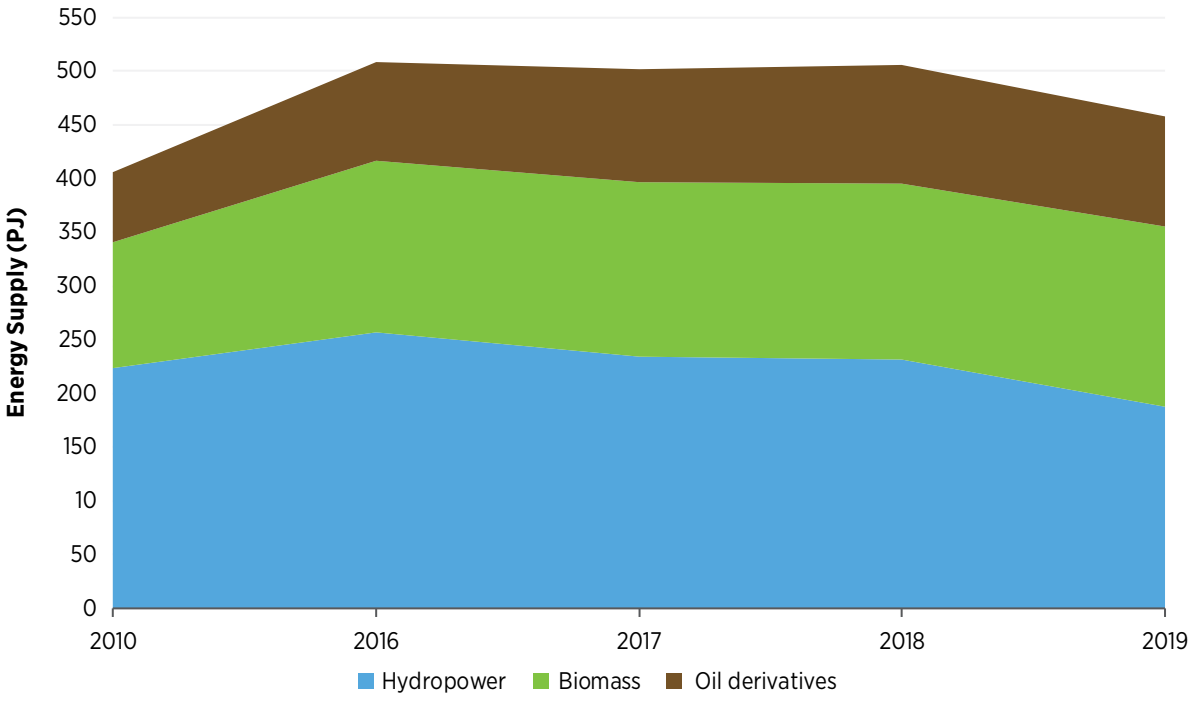
Energy sector overview

Energy supply

The energy supply in Paraguay is dominated mainly by hydrologic and biomass resources, which represented 41.0% and 36.8%, respectively, of energy use in 2019. Between 2010 and 2019, energy supply grew at an average annual rate of 1.3%, to reach a total of 457.4 petajoules (PJ) in 2019 (Figure 3). There are no recorded imports of crude oil since the closing of the operations of the Petróleos Paraguayos refinery (PETROPAR) in 2005. Paraguay depends heavily on imports of oil derivatives, mostly petrol and diesel, which account for nearly 90% of liquid fuel imports. The import of oil derivatives has increased rapidly in recent years, growing 5.1% annually on average during the period 2010-2019, driven primarily by the increase in the country's vehicle fleet.

Paraguay's energy supply is mostly used for power generation and for obtaining charcoal and alcohols (bioethanol). During the period 2010-2019, electricity exports represented an average of 75.2% of total production.

Figure 3. **Total energy supply in Paraguay, 2010-2019**



Source: VMME, 2020a

Table 2. **Main bioethanol producing companies**

Company	Location	Installed capacity (million litres/year)
INPASA	Department of San Pedro	252
	Department of Canindeyú	144
PETROPAR	Department of Guairá	80
AZPA S.A.	Department of Guairá	30
Ingenio San Luis S.A.C.I.C.	Department of Canindeyú	20
ALPASA	Paraguarí Department	15

Source: PETROPAR, 2019; AZPA, 2019; INPASA, 2019; IP Agency, 2018; FAO, 2018

Table 3. **Supply of forest biomass for energy purposes**

Areas	Tonnes per year
Productive native forests in the eastern region	289 000
Productive native forests in the western region	1 500 000
Forest plantations	600 000
Total	**2 389 000**

Source: FAO, 2018

Paraguay is home to around 14 bioethanol plants, which are distributed among 12 alcohol producers authorised by the Ministry of Industry and Trade (MIC). In 2018, the national bioethanol production capacity reached 550 million litres. The current production, 55% from corn and 45% from sugar cane, doubled the cultivated area of these raw materials during the period 2008-2018 (FAO, 2018). Table 2 shows the six companies with the highest installed bioethanol production capacity, led by Paraguayan Alcohols Industry S.A. (INPASA) and PETROPAR.

Biodiesel production capacity has grown steadily, achieving total production of 376 million litres in 2019, up from 138 million litres in 2010 (SIEN, 2019). By 2014, around nine companies had a combined annual capacity of 45 million litres (MIC, 2018). Since 2019, ECB Paraguay S.A. (part of the ECB Group) has been planning to build a second-generation plant with an installed capacity of 3 million litres per day for the production of biodiesel and biokerosene, equivalent to one-third of the conventional diesel currently consumed in the country (MIC, 2019).

Furthermore, mono-culture forest plantations occupy an area of nearly 12 000 hectares, equivalent to a supply of 600 000 tonnes per year for electricity and mostly heat purposes (FAO, 2018). Nearly 60% of the planted area is located in the districts of Alto Paraná, San Pedro and Caazapá. Table 3 summarises the supply of forest biomass for energy purposes.

The installed capacity of biogas (from agricultural residues) comes from a biomethane production plant commissioned in 2017. The plant, owned by Itaipú and CIBiogas, has an installed capacity of 300 cubic metres (m^3) per day and is used mainly to supply the power plant's vehicle fleet. The plant has the capacity to handle 600 kilograms of food scraps, 1.5 tonnes of vegetable residues, and 10 m^3 of sewage sludge (Itaipú Binacional, 2017).

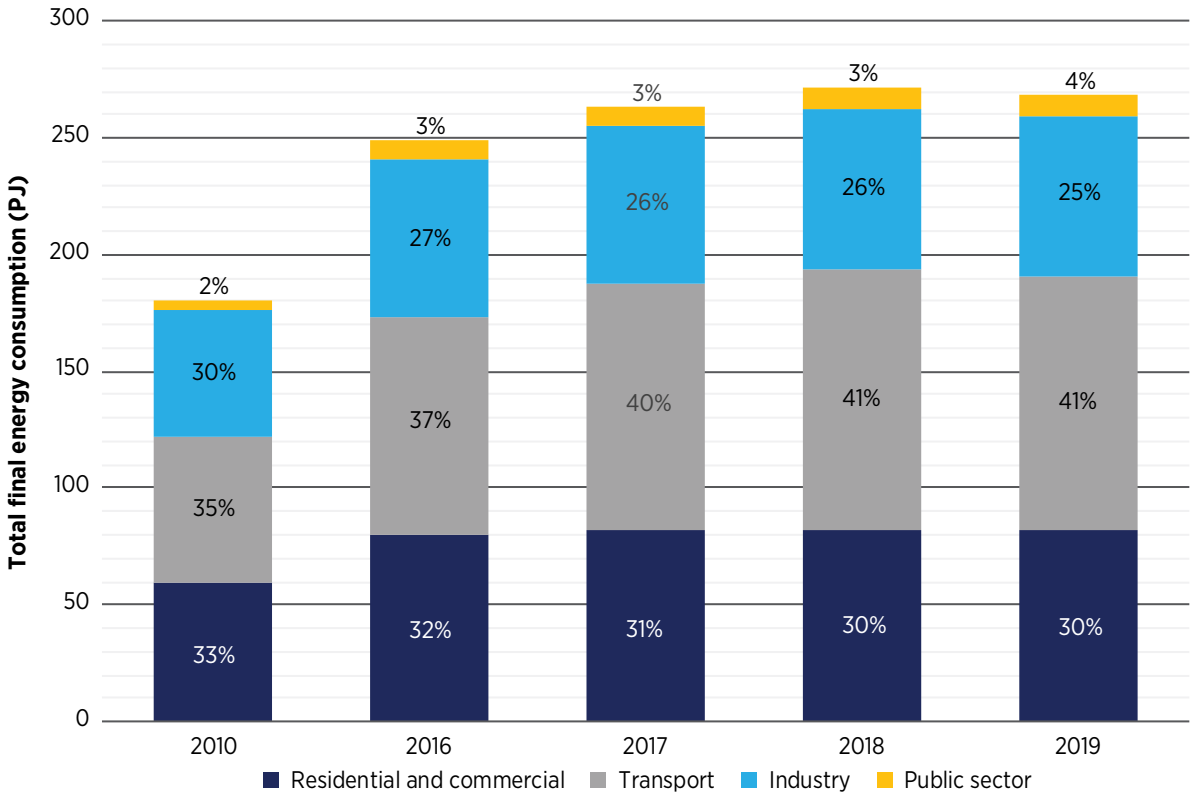
Energy consumption

Between 2010 and 2019, total final energy consumption (TFEC) increased by 48.8%, from 180.4 PJ to 268.5 PJ. The transport sector accounted for the largest share, followed by the residential, commercial, industrial and public sectors (VMME, 2012, 2020a), as shown in Figure 4.

Between 2010 and 2019, the consumption of biomass increased in the residential and commercial sectors by 20.7% and in the industrial sector by 23.7%. In 2019, biomass supplied 41.3% of the TFEC, mainly from firewood (69.8%) and charcoal (8.1%). Firewood was mainly used for cooking purposes, which has traditionally been based on the use of inefficient stoves. In the same period, the use of electricity increased by 91%, and transport increased its consumption of derivatives (diesel and petrol) by 68.6%. The consumption of LPG at the residential level increased by 7.2% and displaced part of the consumption of firewood for cooking (DGEEC, 2016).

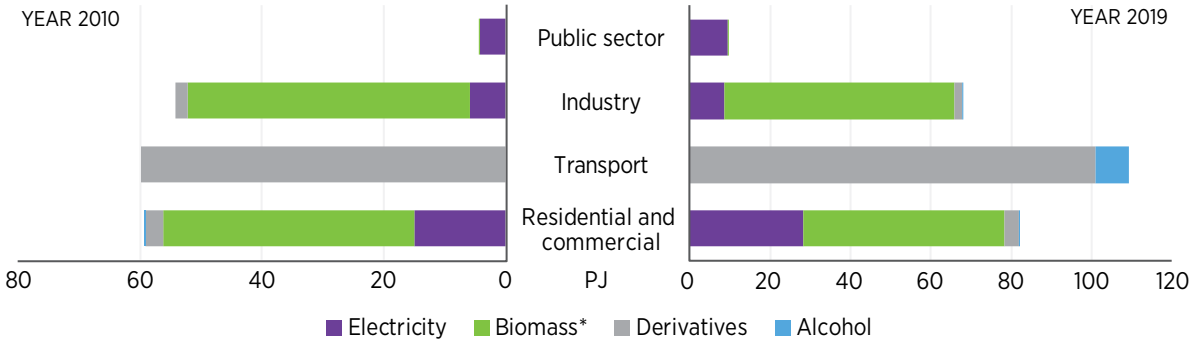
The consumption of liquid biofuels doubled, due to the implementation of projects to produce the fuels following the 2005 Law to Promote the Use of Biofuels. As shown in Figure 5, the final energy consumption of the public sector is composed of 97% electricity, with the remainder being biomass (mainly firewood).

Figure 4. **Total final energy consumption by sector, 2010-2019**



Source: VMME, 2012, 2017, 2019a, 2020a

Figure 5. **Total final energy consumption by source, 2010 and 2019**



* Includes charcoal

Source: VMME, 2012, 2020a

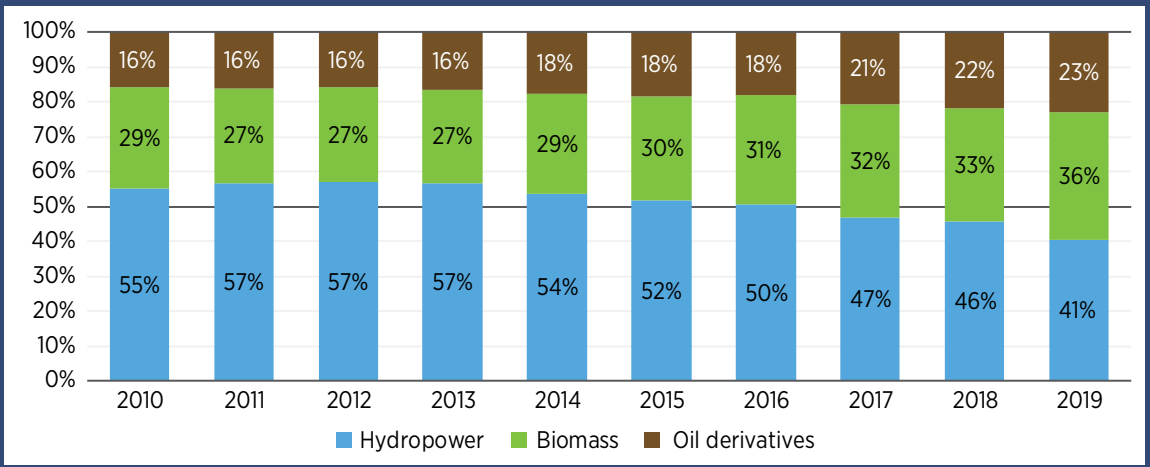
Box 1. **Renewable energy in the energy mix**

The energy mix in Paraguay is characterised by high participation of renewable sources. In the last decade, hydrologic and biomass resources contributed an average of 82% of the total final energy supply. In the last five years, the contribution of biomass has increased, driven by the growing demand for sugar cane, corn and other energy crops for the production of biofuels (VMME, 2019a). The growth in biomass use relates to national policies and laws to promote the blending of biofuels into regular petrol and diesel. Conversely, the contribution of hydropower decreased because of increased imports of oil-based fuels. Figure 6 shows the shares of renewable sources in the total final energy supply.

The residential and industrial sectors have high wood consumption, together accounting for 58.5% of the country's biomass consumption in 2019. Combined, they created a demand for forest exploitation that, according to data from the Food and Agriculture Organization of the United Nations (FAO), is above the sustainable supply of forests in some regions in the country (particularly the eastern region) (FAO, 2019).

The policies of access to efficient fuels aim to control the pressure on the country's native forests and displace part of the consumption of firewood from the residential sector.

Figure 6. **Shares of renewables in the total final energy supply in Paraguay, 2010-2019**



Note: Figure excludes exports and unused energy potential.

Source: SIEN, 2019

Power sector

The Itaipú and Yacyretá hydropower plants represent the largest installed generation capacity in the country and are integrated with the electricity systems of Brazil and Argentina. The Acaray hydropower plant is the third largest, followed by small thermal plants using diesel, bagasse and biogas that are mostly managed by the National Electricity Administration (ANDE). Table 4 shows the installed generation capacity by type in 2020; the capacity shares have remained similar for the past decade, with small variations in the installed capacity from bioenergy.

The existing installed capacity of variable renewable energy serves primarily isolated systems and pilot projects in remote locations (see Table 5). Examples include the solar photovoltaic (PV) system for 35 indigenous people's centres in areas of the Paraguayan Chaco, the wind and solar plant of the Joel Estigarribia military base, and the solar PV plant of a military base located in Mayor Pablo Lagerenza. Wind turbines have also been installed for research purposes.

Hydropower has traditionally dominated electricity production, accounting for 98.8% of the country's total power generation in 2018 (IRENA, 2021a). In the previous two decades, between 75% and 80% of Paraguay's electricity production was destined for export. Between 2001 and 2018, domestic electricity consumption roughly tripled, from 6 000 gigawatt-hours (GWh) to 17 000 GWh; this is equivalent to an annual growth rate of 6.2%, which is above the historical average of electricity supply in countries in Latin America and the Caribbean (3.2% per year) (IDB, 2020a).

Table 4. **Installed power capacity, 2020**

Generation plants	Installed capacity (MW)	%
Itaipú (hydropower)	7 000	79.1%
Yacyretá (hydropower)	1 600	18.1%
Acaray (hydropower)	210	2.26%
Thermal power plants	26	0.29%
Bioenergy	22	0.25%
Total	**8 858**	**100%**

Note: Excludes off-grid pilot projects.
Source: IRENA, 2021a

Table 5. **Selected variable renewable energy projects in Paraguay**

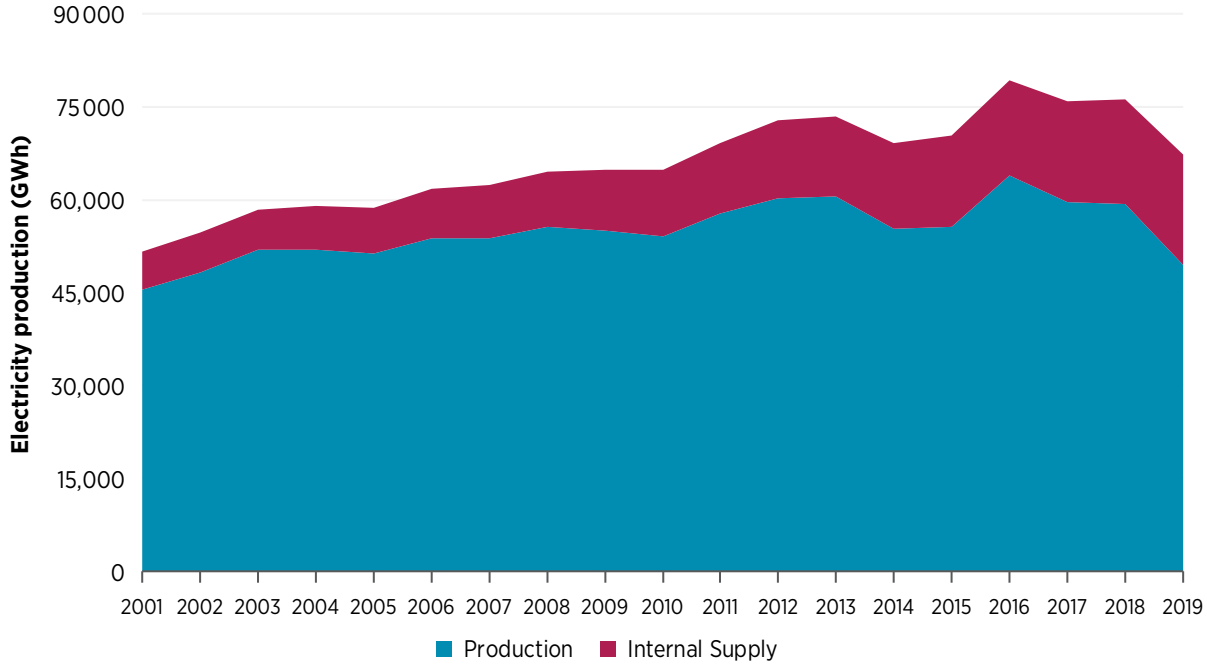
Project	Responsible body	Maximum power installed
Solar PV plant for indigenous peoples in isolated areas of the Paraguayan Chaco	Itaipú Binational – INTN	≈ 20 kW
Solar-wind farm at Joel Estigarribia military base, Paraguayan Chaco	Renewable Energy Consulting Itaipú Binational	Solar = 40 kW Wind = 5 kW
Solar PV park at Mayor Pablo Lagerenza military base, Paraguayan Chaco	Renewable Energy Consulting Itaipú Binational	40 kW
Wind Turbine Engineering Faculty of the National University of Asunción (FIUNA)	FIUNA	15 kW
Solar PV plants in 45 communities in the eastern region of Paraguay	VMME	50.4 kW

Source: FIUNA, 2019; CONACYT, 2019; ANDE, 2016a; Itaipú Binacional, 2018

Several factors have contributed to the increase in domestic electricity consumption, including GDP growth, which averaged 3.87% during the 2001-2018 period (World Bank, 2020b); the low cost of electricity; and growing energy intensity in the industrial sector (where average consumption per user grew from 7.7 kilowatt hours (kWh) per month to 90 kWh per month) and in the residential sector (where average consumption per user grew from 231 kWh per month to 363 kWh per month) (ANDE, 2018a).

Between 2001 and 2018, the electricity consumption of the public sector grew at an average annual rate of 8.2% (SIEN, 2019), with an average tariff of PYG 250.9 per kWh (4.9 US cents per kWh) (ANDE, 2019a). Residential electricity consumption increased 6.1% annually, at an average rate of PYG 351.5 per kWh (6.9 US cents per kWh) (SIEN, 2019). This increase in internal energy supply was balanced by 31% growth in dispatched energy to the national system. Figure 7. Total production and domestic consumption of electricity, 2001-2019 shows the evolution of total production and domestic consumption of electricity.

Figure 7. **Total production and domestic consumption of electricity, 2001-2019**



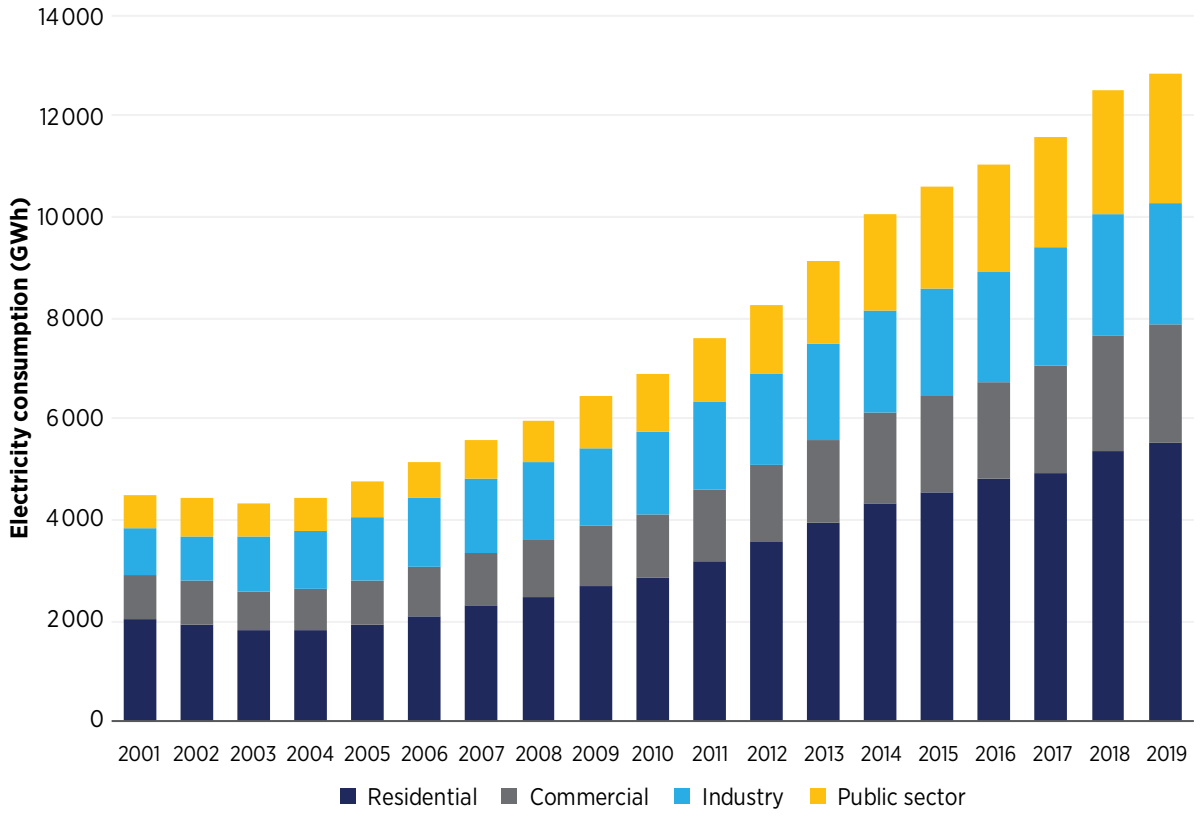
Source: SIEN, 2019

Electricity consumption

During the period 2001-2019, final electricity consumption grew 15.8% annually on average, from 4 502 GWh to 12 840 GWh. The residential and public sectors had the largest shares, with 43.1% and 20.2%, respectively. This was followed by the industrial sector (18.6%) and the commercial sector (18.1%) (SIEN, 2019). Figure 8 shows the evolution of final electricity consumption by sector.

Paraguay has one of the highest levels of access to electricity among countries in Latin America. In 2019, the electrification rate was 99.95%, equivalent to serving a population of 7 198 913 and 3 601 people without access (ANDE, 2019b). Of the total number of Paraguayans without access, 88% live in rural areas, and the rest live in urban areas.

Figure 8. **Final electricity consumption by sector, 2001-2019**



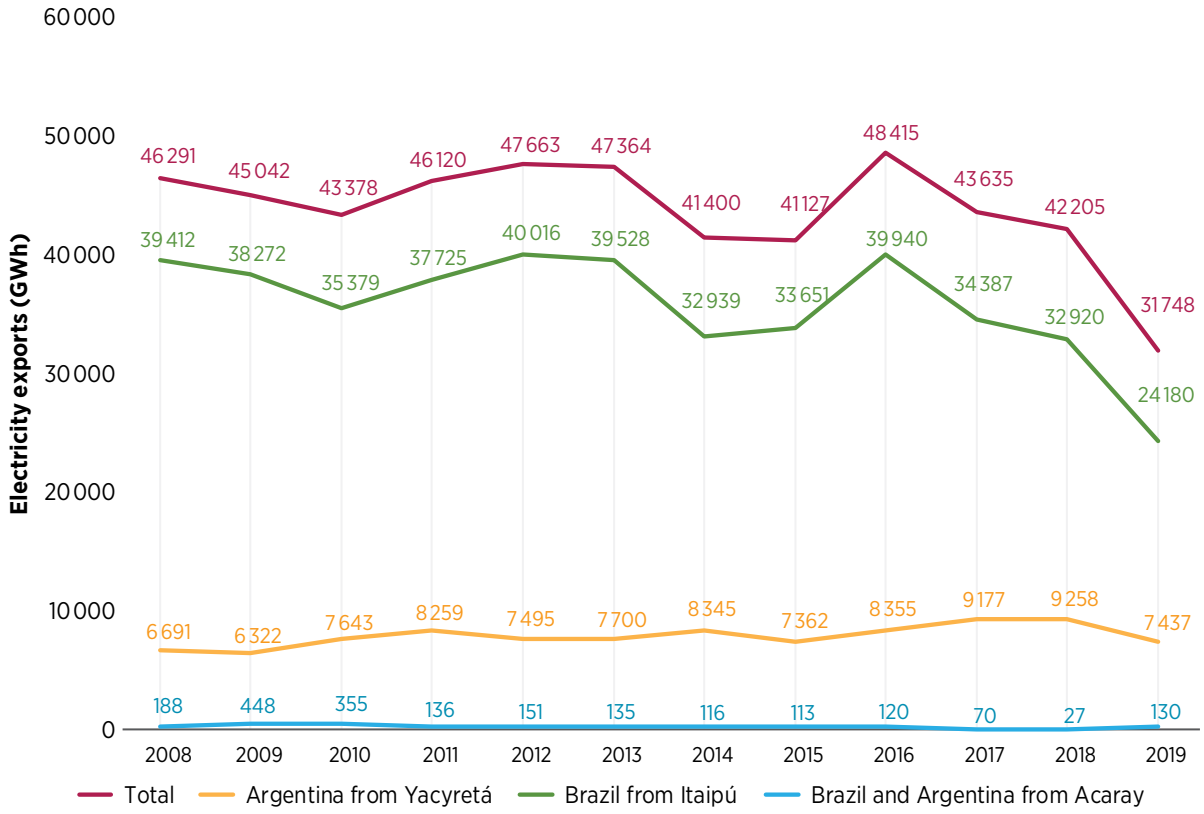
Source: SIEN, 2019

International power trade

Paraguay is considered a net power exporter. In 2019, it sold 64% of the total power produced to Brazil and Argentina, equivalent to 31 748 GWh. Electricity sales to neighbouring countries represented 6.0% of the GDP that year (VMME, 2020b).

Over the last decade, however, Paraguay's electricity exports have been declining. In 2019, energy exports fell 25%, mainly driven by the increase in domestic consumption and the dry hydrological years in the Paraná River Basin. Figure 9 shows the evolution of exports from the country's main hydropower plants.

Figure 9. **Exports from hydropower plants, 2008-2019**

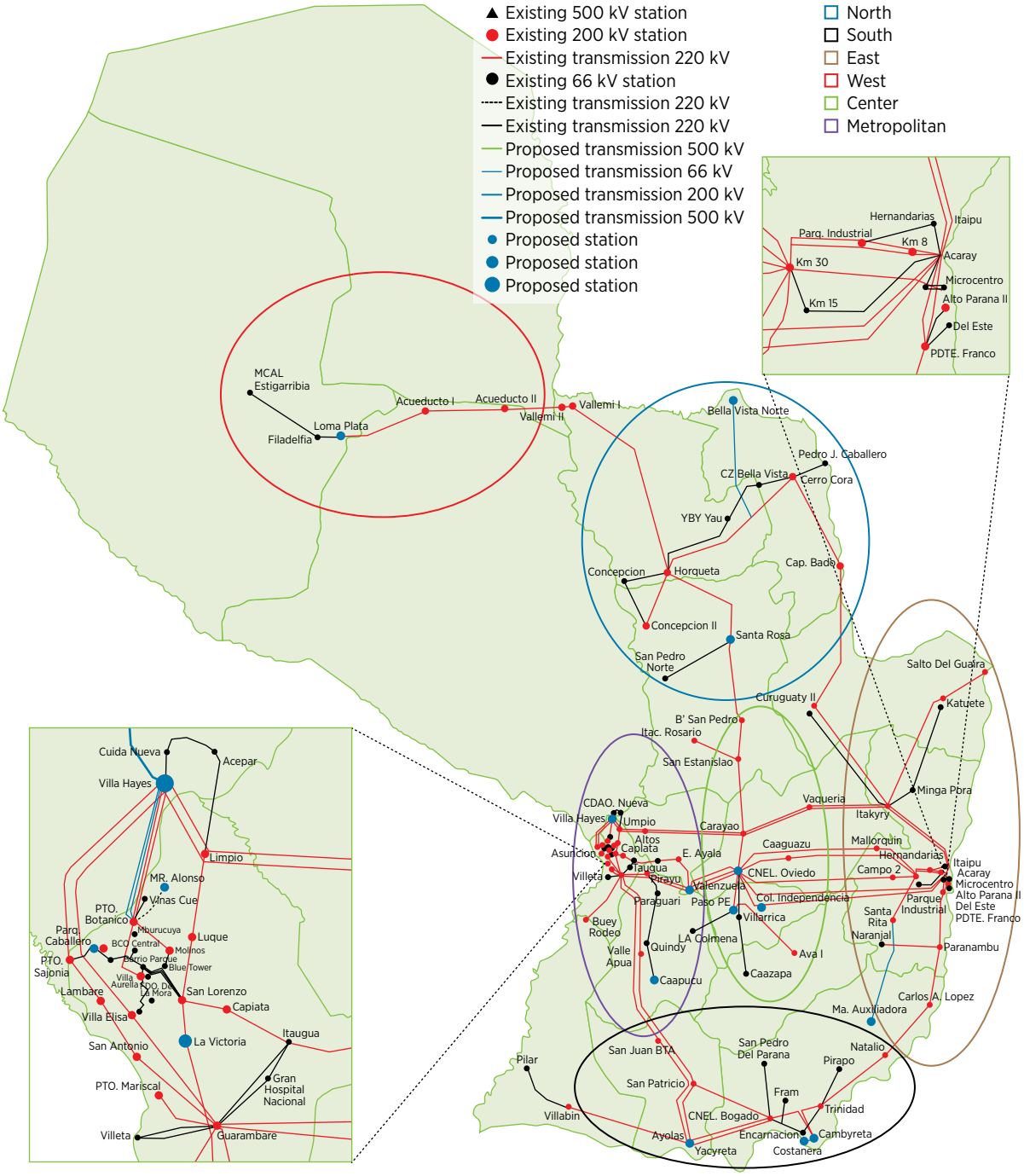


Source: SIEN, 2019

Transmission and distribution network

In 2019, the National Interconnected System (SIN) comprised 6 682 kilometres of transmission networks. Of the total, 10.6% corresponded to 500 kilovolt (kV) lines, 69.1% to 220 kV networks, and the remaining 20.3% to 66 kV lines. The installed power in transformers reached 15 585 megawatts (MW) distributed in 94 sub-stations. The electricity distribution networks comprised 68 331 kilometres of medium-voltage lines and 85 913 transformers with an installed power of 6 561 MW (see Figure 10) (ANDE, 2019a).

Figure 10. **Transmission system in Paraguay**



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.

Source: MOPC, 2019

The operational capacity of the transmission system needs to be improved to ensure the quality of the electricity supply. In hours of high demand for the Metropolitan System, the 500 kV transmission lines and the 500 kV to 220 kV transformation sub-station operate at near-maximum capacity, leading to increasing technical losses and risks due to unscheduled interruptions (IDB, 2020b).

Paraguay is among the countries with the highest electricity losses in Latin America. In 2019, the electricity losses represented 25.8% of the internal supply of electricity, equivalent to 4 470 GWh; of this, 5.2% was transmission losses and 20.6% was distribution losses (ANDE, 2019a).

Within the framework of measures to improve technical and commercial management, ANDE is carrying out actions to reduce losses. These efforts prioritise strengthening the high-voltage network infrastructure, implementing direct measurement instruments, modernising meters, mapping the installed street lighting and increasing customer awareness, among others.

Upgrading power infrastructure

The largest ongoing projects in the energy sector aim to modernise existing power plants and strengthen the transmission system. In November 2018, the Inter-American Development Bank (IDB) approved a USD 125 million loan for the Acaray Hydropower Plant Rehabilitation and Modernization Program. The funds for updating the transmission system came from two operations approved in 2017 and 2019 by the Development Bank of Latin America (CAF).

The first, approved in May 2017, is the Program to Strengthen Transmission of the SIN and Rural Electricity Distribution, which allocated USD 170 million to provide greater reliability and security of electricity supply in the eastern, northern, southern and central systems of the country. Two years later, in 2019, a USD 250 million operation was initiated to execute the Programme to Improve the Transmission and Distribution System of Electricity and Modernise the Management of Distribution in Paraguay.

Finally, the IDB project Expansion of the High Voltage Transmission System and Energy Efficiency Actions supports the improvement of the reliability and efficiency of the high-voltage transmission system and improves the efficiency of ANDE's commercial buildings and street lighting. The programme was approved with co-funding from the IDB (USD 70 million, approved in May 2020) and the Japan International Cooperation Agency (JICA) (USD 85 million, approved in July 2021) (IDB, 2018, 2020c; CAF, 2013, 2019).

Electricity prices

The Executive Branch, in co-ordination with the National Council for Economic Coordination, sets the internal prices of oil-based fuels and electricity rates. In the case of hydrocarbons, prices are determined based on the proposal of PETROPAR and in agreement with the Ministry of Industry and Commerce.

The tariff schedules for electricity are set following a review by the Board of Directors of ANDE followed by executive power approval. The tariff schedules maintain social tariffs (expanded in 2011) that subsidise up to 75% of the electricity use of users who consume less than 300 kWh per month (ANDE, 1964). The tariff structure is based on operating expenses and the guarantee of earning an annual net income of no less than 8% and no more than 10% of the investments in a fixed asset (ANDE, 1964). Operating expenses encompass electricity supply activities, from production to sale, including administrative expenses, depreciation of physical assets and amortisation of intangible assets.[3] ANDE disaggregates expenses into energy costs, staff,[4] travel, materials, fuel, contracted services and depreciation. Energy costs represent around 50% of the total expenses. The investment in fixed assets corresponds to the value assigned to the physical and intangible assets affected by the service, in the state and condition of use in which they are found, plus the working capital necessary for ANDE's operations (ANDE, 1964).

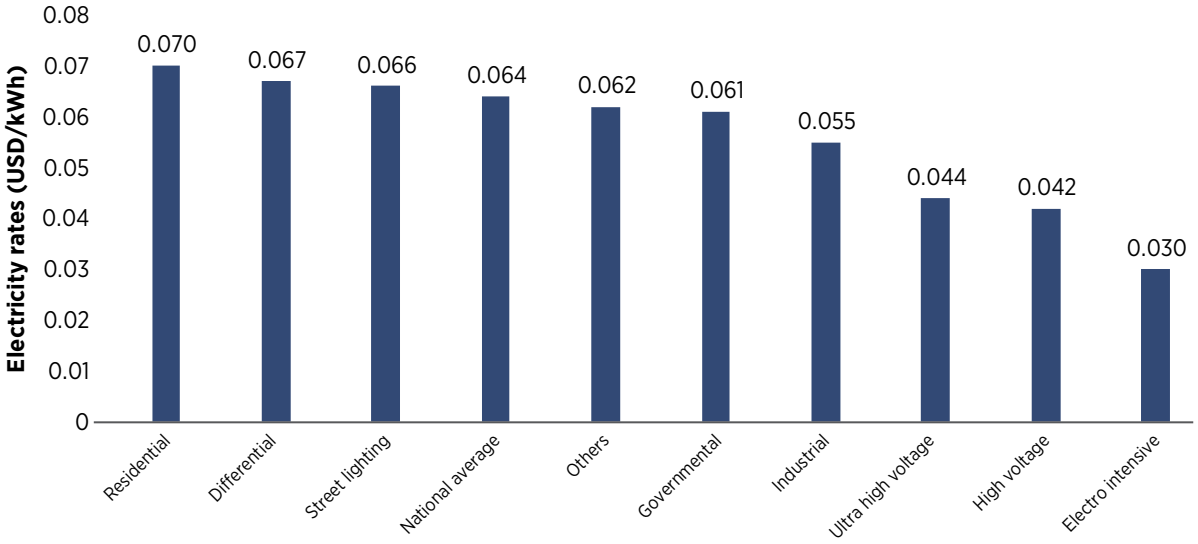
[3] Excludes capital interest and other financial charges related to financial services.

[4] Includes salaries, social laws, collective agreements on benefits and retirement programmes.

In 2018, the national average electricity rate remained the lowest in Latin America. Hydropower generation reached an approximate cost of US cents 5.7 per kWh and an average sales price of US cents 6.4 per kWh, representing a surplus of 12%. The main income from the exploitation of water resources comes from the sale of electricity and to a lesser extent from income sources such as profits and compensation received by the bi-national companies. Historically, 40% of ANDE's turnover comes from the residential and commercial sectors. Around 87% of all customers are residential, while 0.12% are from the industrial sector and represent 7.5% of the company's turnover (ANDE, 2018b, 2019a). Figure 11 shows the rates by consumption group.

Paraguay applies a subsidy to electricity rates that favours users whose consumption is 0 - 300 kWh per month. In the last decade, this subsidy represented between 0.020% and 0.029% of the GDP. The budget for the subsidy decreased 0.6% between 2010 and 2019 (Table 6).

Figure 11. **Electricity rates, 2019**



Note: The exchange rate used is USD 1 = PYG 6 138

Source: ANDE, 2019a

Table 6. **Subsidies applied to electricity tariffs, 2010-2019**

	2010	2016	2017	2018	2019
Million USD	9.88	10.17	10.31	10.48	9.37
% of GDP	0.029%	0.024%	0.023%	0.023%	0.020%

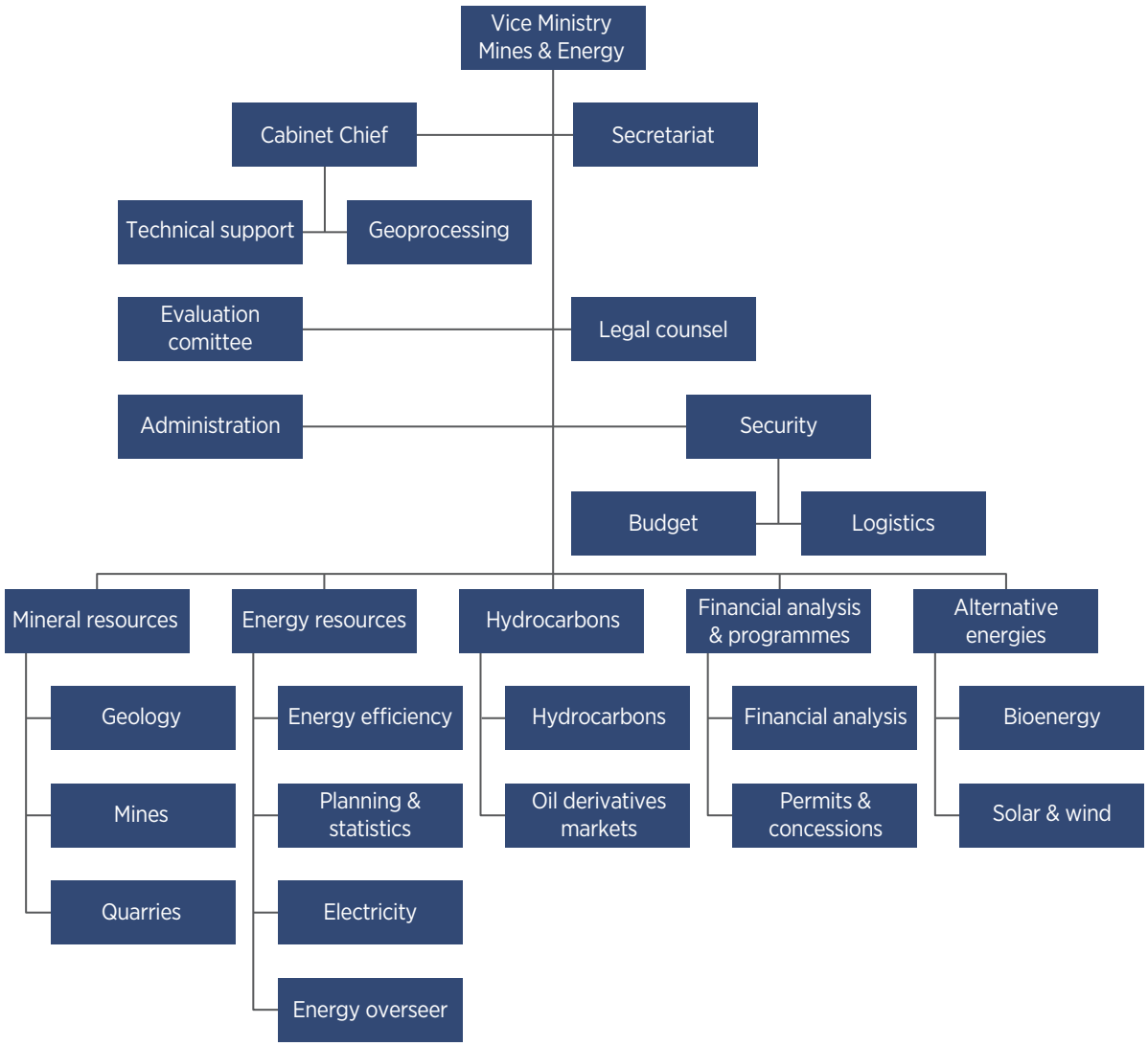
Source: Republic of Paraguay, 2021; ANDE, 2010, 2016b, 2018a, 2018b, 2019a

Energy sector institutions

The Ministry of Public Works and Communications (MOPC) manages Paraguay's energy sector through the Vice-Ministry of Mines and Energy (VMME). In 1993, the VMME was created to be responsible for establishing and guiding policy regarding the use and management of the country's natural mineral and energy resources. The MOPC exercises its mandate in co-ordination with three entities: the Ministry of Industry and Trade (MIC), which has authority over downstream activities in the electricity and hydrocarbon sub-sectors, the National Electricity Administration (ANDE), which oversees the electricity service sector, and the Ministry of Foreign Affairs (MRE), which manages and oversees international agreements in the sector.

The VMME (Figure 12) distributes its functions in five directions: 1) Mineral Resources, 2) Energy Resources, 3) Hydrocarbons, 4) Financial Analysis and Programmes and 5) Alternative Energies. The latter elaborates on the strategies for the promotion of investment projects in renewable energy; in doing so, it promotes research and development, increases supervision, and controls the production processes of biofuel, wind and solar energy. In the area of hydrocarbons, the company PETROPAR controls the only refinery in the country that is currently dedicated primarily to the import of oil derivatives as well as their storage and distribution in the national market.

Figure 12. **Institutional structure of the VMME**



Source: VMME, 2019b

Historical site of Encarnacion and jesuit ruins - Paraguay

Image credit: Shutterstock

The VMME's Directorate of Energy Resources (DRE) oversees the electricity sector in close co-ordination with ANDE and the National Council for Independent Production and Transport of Energy (CONAPTIE). ANDE, originally created in 1964, is responsible for reporting to the MOPC on the activities of the power sector. Its current capabilities include proposing electricity tariffs and approving contracts for the purchase, sale and exchange of energy within and outside of the country. ANDE also supervises the operation of the National Interconnected System (SIN) and guarantees its safety and quality of service.

CONAPTIE supports ANDE with the analysis and preparation of tariff schedules and evaluating the impacts of energy policies with the MOPC. CONAPTIE was created in 2006 and includes the ministers of Public Works and Communications, Industry and Trade, and Foreign Affairs, together with representatives from the Technical Secretary of Planning and Economic Development (STP) and the Secretary of Environment. CONAPTIE reviews and approve licences for independent generation or transport of energy in Paraguay.

Institutional framework for the power sector

The power sector is vertically integrated and has a monopoly on energy sales. ANDE controls activities in the generation, transmission, and distribution of electricity and street lighting throughout the country. The sector lacks an independent regulator, with ANDE exercising certain regulatory functions. In addition, it is the only state agency with the authority to delegate its electricity distribution rights to other companies that supply energy and public lighting services.

The main hydropower plants in the country, Itaipú and Yacyretá, are managed on an equal footing based on bi-national treaties established with Brazil and Argentina, respectively. The operation of these plants, applied by international statutes and independent administrative bodies, is assigned at the national level to ANDE through Law 966 of 1964, which creates ANDE as an autonomous entity representing Paraguay in bi-national energy treaties (Republic of Paraguay, 1964). Overall, the future of the country's electricity sector will be defined through ANDE, the revision of treaties, and legislation (such as Annex C to the Treaty of Itaipú) that seeks to promote modernisation and competition in the sector; thus, it would be key to ensure a sustainable ratio of local generation to the import/export of electricity.

This law also regulates the production and independent transport of electricity, including co-generation or self-generated electricity, and defines national policies for regional energy integration, energy mix diversification for sustainable development, and the adoption of new technologies to strengthen the reliability and security of the energy supply while minimising environmental impacts. Furthermore, this law opens the participation of private individuals in the generation or transmission of energy for self-consumption or export. The provisions of the law include contracts that could be incorporated into the SIN according to the rules of dispatch and operation established by ANDE.

Legal and regulatory framework

Policy framework for the energy sector

The National Energy Policy 2016-2040 was released in October 2016 (Decree 6092) and followed a planning process based on energy governance, strengthened institutional co-ordination and capacity building while considering productive integration, the environment and society. It defines the objectives of: 1) guaranteeing energy security with social and environmental responsibility while prioritising self-supply at a low cost as well as high efficiency; 2) ensuring access to good-quality energy services while protecting consumer rights; 3) using national energy resources and promoting the production of oil-based products as strategic resources to reduce energy dependency and increase value-added in the country; 4) consolidating Paraguay's role in regional energy integration by harnessing its geographic location and natural resources; and 5) creating public awareness on the importance of energy and its sustainable use.

The implementation process of this policy considers specific objectives and action plans in four strategic areas: 1) electricity, 2) bi-national entities and energy integration, 3) bioenergy and 4) hydrocarbons. In particular, the policy defines Action Plans that establish specific objectives, strategic lines, tools, goals and deadlines in 10 spheres: 1) institutional, 2) energy matrix, 3) infrastructure for energy supply, 4) energy integration, 5) society and environment, 6) financing, 7) energy efficiency, 8) international co-operation, 9) information and planning, and 10) research, development and education (VMME, 2016).

At the same time, the Sustainable Energy Agenda 2019-2023 establishes the goal to promote the transition to sustainable mobility, which will lead to the replacement of imported fuel by energy produced in the country. Therefore, the implementation of an electric mobility programme is included in the Action Plan of the Energy Matrix as a tool to expand the share of electricity in consumer sectors with criteria of technical and economic efficiency. In 2020, Paraguay created the Mobility Board (Resolution No. 44,334 of 22 October, 2020) to assess and define electricity rates for charging vehicles.

The Technical Secretary of Planning and Economic Development (STP) is responsible for the long-term planning of the country's strategic sectors, including the power sector (Law No. 312 of 1962). In this sector, the STP partially shares its responsibilities with the VMME after Law No. 167 of 1993 assigned to this institution the responsibility of preparing energy projections and proposing energy policies. Currently, the long-term energy planning process is partially documented; there could be an opportunity for an accepted flowchart across key energy institutions that would highlight the necessary order and interdependence of activities in achieving goals, estimated budgets and projected timelines. Additionally, this flowchart may include indicators to anticipate risks when implementing budgets and mitigation measures.

A significant aspect of the evolution of the legal and regulatory framework in the last three decades was the creation of the state-owned company PETROPAR as well as the industry legislation regarding natural gas, the promotion of biofuels, and opening the country to independent energy production and transport. Paraguay's energy sector is mainly based on five laws that regulate the use and/or exploitation of resources:

1. The hydrocarbons law (Law No. 779 of 1995), which establishes the legal regime for the prospecting, exploration and exploitation of oil and other hydrocarbons. Under the law, the State may grant permits or concessions to hydrocarbon entities for a limited period. The application for a prospecting permit and exploration concession and subsequent exploitation must be presented to the MOPC, with a maximum surface area for prospecting of 2 400 000 hectares. The concession for exploration offers the exclusive right to explore the granted area for a four-year term, during which the concessionaire shall fulfil the minimum work plan and investment. The exploitation lots must be between 20 hectares and 5 000 hectares in size, with concessions granted for up to 20 years (Republic of Paraguay, 1995).

2. The law for natural gas (Law No. 3,254 of 2007), which provides the regulatory framework for activities in the natural gas value chain. It establishes the legal framework for the natural gas industry and applies to activities related to transport, distribution of natural gas or other fuel gas networks, import, transit and export, storage, marketing and consumption (Republic of Paraguay, 2007a).

3. The law on water resources (Law No. 3,239 of 2007), which establishes the conditions for approving concessions for the use of water and states that access to a minimum quantity of drinking water, enough to satisfy basic needs, is a human right (Republic of Paraguay, 2007b).

4. Law No. 3,009 of 2006, which defines the conditions for the production and independent transport of electricity from conventional and non-conventional energy sources (Republic of Paraguay, 2006).

5. Law No. 5,169 of 2014, which creates the Radiological and Nuclear Regulatory Authority and establishes its scope of application to the nuclear energy area (Republic of Paraguay, 2014).

In addition, the law that approves the statute of the International Renewable Energy Agency (Law No. 5,984 of 2017) establishes in its objectives the implementation and sustainable use of all forms of renewable energy based on the country's priorities and the benefits derived from their use (Republic of Paraguay, 2017a).

Finally, the forestry law (Law No. 422 of 1973), while not explicitly referring to the exploitation of forests for energy purposes, does establish the conditions for the use of forests to produce fuels from raw materials of vegetable origin (Republic of Paraguay, 1973), which are referred to in the laws promoting biofuels (Law No. 2,748 of 2005, Law No. 5,444 of 2015 and Law No. 6,389 of 2019).

Furthermore, the country is currently discussing legislation for the regulation and use of renewable energy resources other than hydropower, opening the opportunity for private developers to implement renewable energy projects (SIL, 2021). In line with this, in July 2021, the first two licences for private power generation were approved in the country, one of them involving co-generation with biomass resources and the other self-generation with solar PV (MOPC, 2021a, 2021b).

Regulatory framework for the power sector

Paraguay lacks a systemic regulatory framework for the electricity sector. Law No. 966 of 1964 created ANDE and grants it the exclusive right to operate electricity supply systems and to market electricity within and outside of the national territory. Other laws regulate the scope of participation of public agents in the sector's value chain: for example, the Itaipú and Yacyretá hydropower plants.

The commercialisation of electricity is carried out through bi-lateral contracts and is not open to free trade. However, Law 3,009 creates a legal framework for independent producers of electricity for self-consumption or export, granting licences to independent power generators (private or public) with a capacity of less than 2 MW, concessionaires for co-generation and self-generation projects, and shared risk contracts for power generation from hydraulic resources in plants larger than 2 MW. This law also sets sales conditions and fees. For example, for transport companies, ANDE proposes the tolls and connection fees to the Executive Branch, with the possibility of an adjustment after evaluating the use and time in which the energy will be transported.

In 2019, in collaboration with the Latin American Energy Organization (OLADE) and the IDB, Paraguay initiated the implementation of the Energy Information System (sieParaguay). The Energy Information System consists of online hardware and software that serves as a co-ordinated platform for the various actors that provide energy information based on common methodologies, units and definitions. This new information system will strengthen the country's capacity to administer, store and process statistical information in relation to the various topics that are required to analyse, monitor and understand the evolution of the energy sector. This will automate access to this type of information with modern technological tools and promote models of knowledge management and energy planning in the country.

In reference to the modelling of the electricity sub-sector, the Telematics Master Plan 2018-2024, published by ANDE, highlights the actions and acquisitions that must be made in order to improve the information technology and communications systems that support the services and systems for the business and operational management of ANDE.

In particular, ANDE is working on the implementation of a SCADA/DMS/OMS distribution system and a Comprehensive Electrical Distribution Management System (SGIDE) that allows the creation of its own model of electrical energy distribution management, adapted to the reality of the company and country. To model the electricity distribution network, the company modernised the operation of the transmission system, with a SCADA system that includes applications for the safe and efficient administration of the national grid. This initiative includes a geographic information system (GIS) that uses both urban and rural digital cartography, on which all the components of the electrical distribution system are represented and modelled.

Paraguay's climate change law identifies the potential development of a national carbon market, as a key strategy to boost the mitigation of emissions in Paraguay and at the same time facilitate achievement of the country's climate pledges, such as those presented in the NDCs. Likewise, the National Development Plan 2030, through the strategy Global Habitat Sustainability, identifies a carbon market as a relevant action to increase the national income from the sale of environmental services.

The promotion of renewable energy integrates the lines of action of the strategic framework. There has been important progress in the drafting of laws, such as the law on the Production and Independent Transportation of Electricity and the submission of a new bill in August 2018 to Promote the Use of Renewable Resources for Energy Purposes that establishes conditions for optimising access to electricity supply, contributing to the reduction of greenhouse gas emissions, and providing incentives for research and development. Another recent initiative, registered in March 2020, is the draft law that Regulates the Production, Promotion, Commercialisation and Use of Non-Hydraulic Renewable Resources for Energy Purposes and establishes the conditions for the fiscal purchase, sale and incentives in the national energy system for non-hydraulic renewable energy sources.

Box 2. **Promoting energy efficiency in Paraguay**

Paraguay created the National Energy Efficiency Committee (CNEE) in 2011. The CNEE aims to develop and execute the National Plan for Rational and Efficient Use of Energy for the Republic of Paraguay (Energy Efficiency Plan). The Committee includes representatives from the MOPC, the Ministry of Education and Culture, ANDE, MADES, PETROPAR, the National Institute of Technology, Standardization and Metrology, the bi-national hydropower plants of itaipu and Yacyretá, the National Council of Science and Technology, the National University of Asunción and the National Forest Institute.

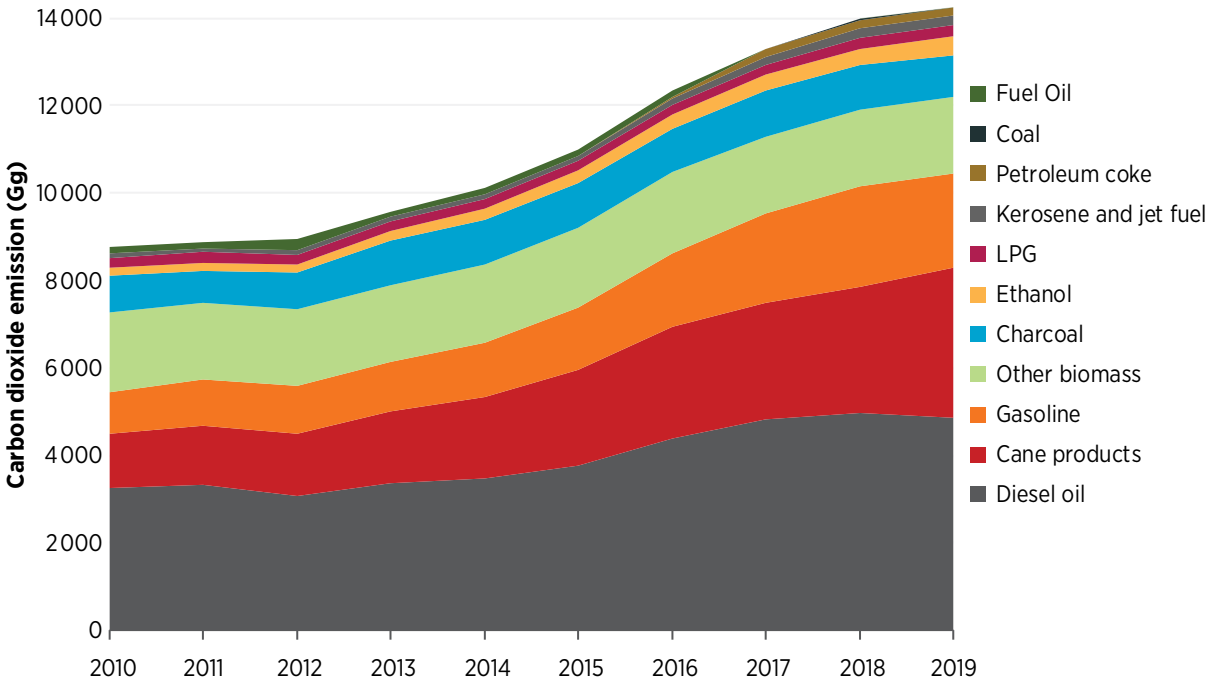
In 2014, the first National Energy Efficiency Plan was created with the objective of providing guidelines for the implementation of measures and strategies in the efficient use of energy resources in different sectors, supporting national sustainable development. The strategic axes of the plan are: 1) policies (decrees, laws, norms and other legal instruments); 2) education, awareness and training, 3) energy efficiency implementation programmes, 4) diagnosis and energy audits and 5) sustainability actions during the process. However, the Plan did not specify quantitative targets due to the lack of data.

In 2015, Paraguay published its National Energy Policy 2016-2040, which includes among its components the improvement of energy efficiency levels in the supply and demand of energy. The energy policy also establishes an Action Plan for Energy Efficiency, including policy instruments to be implemented in the form of plans and programmes with specific time frames. These aspects are discussed in section 2.4 (VMME, 2016).

Other projects, studies and programmes related to energy efficiency include but are not limited to the Energy Efficiency Indicators of the Industrial Sector of the Republic of Paraguay (BIEE), the triangular co-operation "affordable and sustainable energy for Paraguay, implementing the National Energy Policy 2040", guidelines for the implementation of energy efficiency labelling, and education and awareness programmes such as energy efficiency manuals and training programmes, among others.

Currently, a legislative project on energy efficiency is under review by different energy institutions of the country. The document was developed by the VMME (Alternative Energies Directorate) with the support of the IDB.

Figure 13. **Carbon dioxide emissions by source, 2010-2019**



Source: SIEN, 2019

Energy and climate action

In 2015, Paraguay's carbon dioxide emissions totalled 45 841 gigagrams (Gg), around 1% of global emissions. This was up from 40 023 Gg in 2000, representing an average annual increase of 0.97% during the period. On average, the energy sector accounted for 10.3% of national CO_2 emissions in the period 2000-2015 (UNFCCC, 2018).

Between 2010 and 2018, CO_2 emissions from the energy sector (fossil fuels) and biofuels increased from 8 753 Gg to 13 996 Gg, a rise of 59.9%. The consumption of fossil fuels averaged 52% of the total, and biomass[5] averaged 41% (as a result of the degradation of native forests). Figure 13 groups the emissions from the energy sector and biofuels.

Energy and climate change policies are presented together in national strategies and implemented through national committees and task forces. Decision makers face the challenge of crafting tailored policies that allow Paraguay to meet its energy needs while acting responsibly to implement effective mitigation and adaptation initiatives. In the country's NDCs, energy use and climate change are inextricably linked through targets in the energy sector and strategic, long-term energy scenarios integrated with other government policies.

In July 2021, Paraguay presented its updated NDC including adaptation and mitigation actions towards 2030. The NDCs are aligned with the Energy Policy 2016-2040 and contemplate 7 prioritised sectors and a total of 25 objectives by 2030, which include relevant lines of action, gaps and needs. The line of actions are: 1) resilient communities and cities; 2) health and epidemiology; 3) ecosystems and biodiversity; 4) energy; 5) agriculture, livestock, forestry and food security; 6) water resources and 7) transport. The national climate commitments are also aligned with the National Development Plan 2030, which includes the climate change planning process as a strategy at the sectoral and local levels to reduce risks in the national development process.

[5] Cane products, firewood and charcoal

The country's NDC includes three objectives for the energy sector aimed at 1) improving the distribution capacity of electricity services in vulnerable communities, through the following lines of action: increasing the capacity, quality and reliability of electric transmission and distribution systems, strengthening maintenance planning, and fostering education and training of local technicians; 2) conserving or restoring the water basins for hydropower generation; and 3) promoting the use of alternative energy sources other than hydropower, which includes the following lines of action: promoting the use of efficient stoves for families that depend on biomass for cooking, promoting initiatives for distributed generation using solar and wind systems, and using solar thermal energy for water heating (DNCC/MADES, 2021).

Furthermore, the revised NDC present the mitigation component based on the Climate Change Mitigation Plans (PMCC) for 5 sectors: 1) agriculture; 2) land use, land-use change, and forestry (LULUCF); 3) industrial processes and product use (IPPU); 4) waste; and 5) energy and transport.

Mitigation measures for the energy sector incorporate the use of certified forest biomass (as contemplated in the Decree 4056/2015), optimal use of energy through energy efficiency measures, improvement of the quality of fossil fuel used, fostering sustainable construction in cities, projects to promote renewable energies of Itaipú Binacional, promote clean cooking through the efficient stove program, and follow the guidelines from the National Energy Efficiency Plan, National Energy Policy and National Development Plan 2030. For the transport sector, mitigation measures included the substitution of fossil fuel for biofuels, efficient driving for public and freight transport, the substitution of conventional vehicles by electric and hybrid vehicles, and the use of green hydrogen (UNFCCC, 2021).

The National Plan of Adaptation to Climate Change (SEAM, 2016) incorporates further measures on adaptation, such as: analysing energy demand and proposing improvements to the transmission and distribution system; elaborating economic and environmental assessments on clean energy deployment in industries; developing energy performance and resilience standards, including codes on climate variations in new and existing buildings; expanding energy access and deploying smart meters; and strengthening renewable energy transmission and distribution networks to ensure efficient public transport.

The Energy Policy 2016-2040 also integrates measures to mitigate and adapt to climate change impacts. This policy prioritises (among others) the preparation of a Plan for Monitoring and Controlling GHG Emissions in the Energy Sector; a National Policy on Nationally Appropriate Mitigation Actions (NAMAs), Strategy to Accelerate the Development of Energy Projects that Mitigate Climate Change; a Plan for Adaptation to New Meteorological Regimes; and the Design and Implementation of National Adaptation Programs of Action (NAPAs).

Box 3. IRENA's climate action with renewables: Enhancing Nationally Determined Contributions (NDCs)

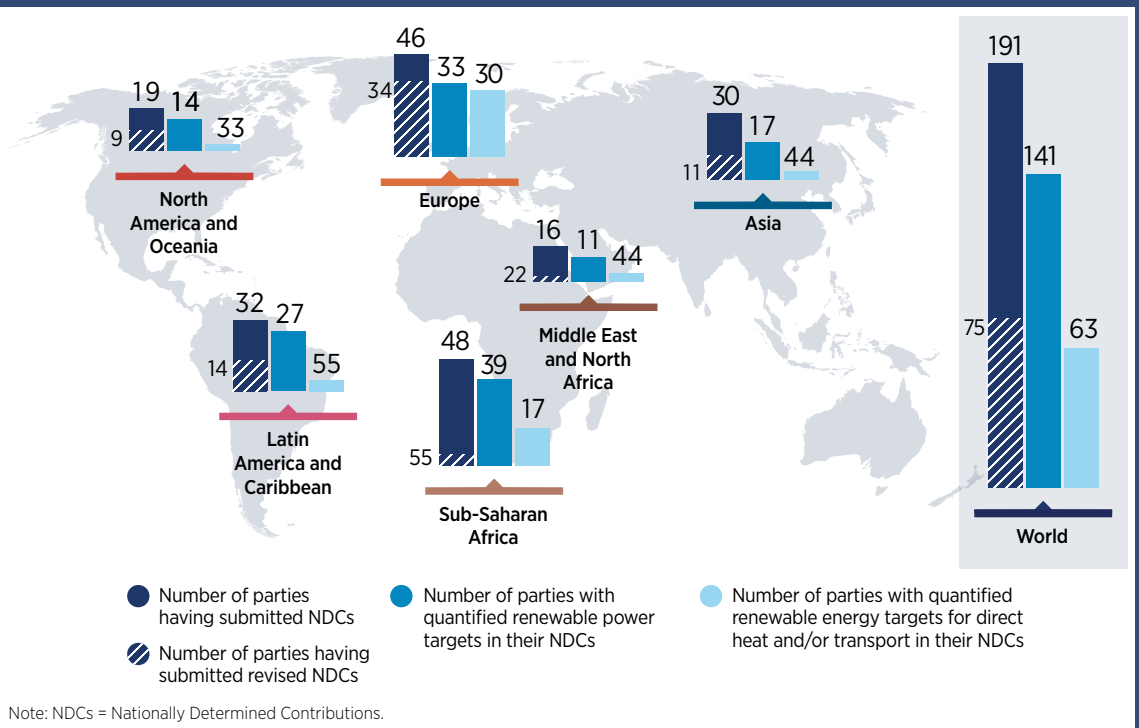
Under the Paris Agreement, Parties are mandated to submit Nationally Determined Contributions every five years explaining their climate targets and contribution to achieving the Agreement. IRENA's World Energy Transitions Outlook analyses the NDCs communicated by countries during the first quarter of 2021. Of the total of 191 Parties, IRENA found that 141 Parties (74%) included quantified renewable energy targets for the power sector, while only 63 Parties (33%) included targets for direct heat and transport (Figure 14).

IRENA, in its role of promoting renewable energy as a key climate solution, has set out to support its Member Countries worldwide in communicating its climate action. The Agency's current engagement on NDCs includes 70 countries with a combined population of more than 1.5 billion and 3.2 billion tonnes of energy-related greenhouse gas emissions per year. IRENA has set up a system of comprehensive and robust mechanisms to assist the NDC revision process and implementation plans, as well as investment frameworks, to close gaps and accelerate the energy transition.

The Agency currently supports 20 countries in Latin America and the Caribbean, including Paraguay, in its NDC enhancement and implementation process through various offerings, including Renewable Readiness Assessment (RRA), renewable energy roadmaps, data and statistics (including monitoring, reporting and verification (MRV) systems), decarbonisation roadmaps, project facilitation, resource and technology assessments; and capacity building activities in areas such as policy and finance, low-carbon technologies and modelling of energy scenarios, among others. These activities aim to enhance countries' renewable energy capacity, resulting in a more robust NDC leading to a just and inclusive energy transition.

Source: IRENA, 2021b, 2021c

Figure 14. **Renewable energy components of NDCs, as of the first quarter of 2021**



Note: NDCs = Nationally Determined Contributions.

Note: NDCs = Nationally Determined Contributions

Source: IRENA, 2021b

Promoting sustainable development

Under the National Development Plan 2030, Paraguay links its development ambitions to the Sustainable Development Goals (SDGs) of the UN's 2030 Agenda for Sustainable Development. The country has in place policies and actions that contribute to at least 13 of the 17 SDGs. Regarding poverty and food security, the higher objectives of the bi-national hydropower entities prioritise public investment programmes, productive development and the fight against poverty with actions that aim to increase rural households' access to electricity and industrial machinery in order to strengthen agricultural value chains. In terms of actions to reduce undernourishment and malnutrition, the National Human Development Report Paraguay 2019-2020 highlights progress in increasing access to efficient fuels for cooking.[6]

The use of wood and coal, which is linked to the conditions of poverty, also has a gender component. The collection and use of these fuels for cooking is exclusively or predominantly a female domestic task (also performed by children). In terms of health and wellbeing, the National Development Plan 2030 establishes the Adequate and Sustainable Habitat Strategy, which aims to improve the energy efficiency of homes, increase access to drinking water and quality electricity, and reduce deaths attributable to indoor air pollution.

To promote equal opportunity, the Energy Policy 2016-2040 integrates a line of work on inclusive energy development with equality of gender criteria and ethnic diversity. It considers the implementation of programmes to provide energy services for social inclusion simultaneously with programmes that will increase equal access to land, water, infrastructure and agricultural technology. The National Energy Efficiency Committee was created to develop and monitor the implementation of the National Energy Efficiency Plan to promote responsible production and consumption. The Plan gives priority to updating the regulatory framework, implementing technological innovation programmes in the main sectors of the economy, promoting a culture of efficient energy use, and monitoring and measuring the Plan's impact.

In terms of environmental issues, Paraguay has a National Climate Change Law that reiterates the country's commitment to implementing its NDC in order to reduce its greenhouse gas emissions 20% by 2030 (Republic of Paraguay, 2017b). In this regard, the National Development Plan 2030 contemplates the implementation of the strategy Valorisation of Environmental Capital to increase renewable energy use by 60% and to reduce fossil fuel use by 20%. The Plan also defines actions to create alliances that facilitate achievement of the SDGs through the strategic axis on Insertion of Paraguay in the World. This axis defines the country's actions to work with strategic partners on energy integration, biodiversity conservation and climate change reduction.

In the energy sector, the strategic framework follows the guidelines of the Energy Policy 2016-2040 and the mandate of the VMME to guarantee energy security, ensure access to high-quality energy, use national energy sources, and consolidate energy integration and sustainable energy use. The VMME prioritises five areas of action: institutional framework, energy policy, institutional management, legal framework and energy integration. The Energy Policy 2016-2040 highlights actions that respond to the energy needs of the population and productive sectors, attending to social and environmental responsibility and energy efficiency and constituting energy as a factor of economic growth. Its main components propose the implementation of actions structured on the basis of institutional framework, energy policy and planning, institutional management and legal framework. Table 7 shows part of the high-priority activities of the VMME and the Energy Policy 2016-2040.

Furthermore, the United Nations Development Programme (UNDP) developed the study Energy and Human Development for Paraguay, highlighting various links between the energy sector and sustainable development in the country. The report emphasises the role of the energy transition in the achievement of a more equal society, by promoting more human development and less inequality. Additionally, the Paraguayan energy transition has the potential to boost employment in the country, especially through the creation of small- and medium-sized enterprises in the energy sector (UNDP, 2020).

[6] The Energy Policy of the Republic of Paraguay 2016-2040 includes a programme to install efficient stoves in three phases: 15 000 stoves (phase 1), 50 000 stoves (phase 2) and 200 000 stoves (phase 3).

Table 7. **Priority activities from the energy strategic framework**

Institutional Framework
Creation of the National System of Energy (SISNAE)
Creation of the National Energy Policy Council (CONAPE)
Creation of the Direction of Energy Regulation (DRE)
Energy Policy and Planning
Defining the Energy Agenda
Indicative Biofuel Supply Infrastructure Development Plan
Public and Private Financing Plan for Energy Efficiency Projects and Technology
Program for the Promotion of Biogas and Thermal Uses of Solar Energy
Certification Plan of Solid Biomass
Plan for Monitoring and Control of GHG Emissions
Program for the Promotion of Renewable Sources for Electricity Generation
Institutional Management
Implementing an Institutional Information Management and Monitoring System
Implementing the Investor Orientation Unit for the Development of Energy Projects
Training Professionals in Electricity Subsector Activities
Promotion of Research for the Development of Bioenergy and Alternative Sources
Legal Framework
Draft Law on the Use of Additional Financial Resources in the Energy Sector
Enactment of a New Legal Framework for the Solid Biomass Subsector
Enactment of the Law on Independent Power Generation
Enactment of the Law on Rational and Efficient Use of Energy
Issuance of Regulations for Electric Mobility and Distributed Generation
Energy Integration
International Energy Marketing Strategy for National Projects
Creation of an Electricity Market Observatory

Source: VMME, 2016

3. Renewable Energy Development

Renewable energy development in Paraguay focuses on the use of hydrologic resources and biomass. Other renewable energy sources were not included in the country's energy balance as of 2019, although small-scale wind and solar projects do exist in isolated areas. Energy crops[7] such as corn, sugar cane and soybeans have maintained sustained growth driven by the demand for liquid biofuels (bioethanol and biodiesel). The country seeks to take advantage of the potential to produce biogas and green hydrogen by implementing the actions defined in the Energy Policy 2016-2040 and the Sustainable Energy Agenda 2019-2023.

Drivers of renewable energy deployment

The Republic of Paraguay is committed to the sustainable development of its energy sector and society. The country is recognised globally for its clean energy matrix, with high shares of renewable energy and electricity generated mainly by hydropower.

Paraguay is not endowed with oil and gas resources, and in recent years it has become increasingly dependent on fossil fuels, used mostly in the transport sector. Additionally, climate change has been affecting the production of electricity from hydrologic resources, with the recent long dry periods in the river basins threatening the energy security of the country. Therefore, Paraguay is aiming to diversify its energy mix through the promotion of other renewable energy resources and the implementation of low carbon-technologies such as green hydrogen.

Renewable energy technologies are an affordable option for the diversification of the Paraguayan energy mix. Power generation from renewable technologies such as solar PV and onshore wind have experienced a significant cost reduction in the past decade. The global weighted-average levelised cost of electricity (LCOE) for solar PV has been reduced 85% in the period between 2010 and 2020, being the renewable energy source with the highest price reduction. In the same period, LCOE for onshore wind fell by 56%. Cost reductions for renewables continued despite the COVID-19 pandemic in 2020, showcasing the resilience of renewable energy technologies. The LCOE for new capacity installation in 2020 decreased compared to 2019, for instance, concentrated solar power (CSP) fell by 16%, onshore wind by 16% and utility-scale solar PV by 7% (IRENA, 2021d). The cost reduction for variable renewable energy technologies has the potential to be competitive in the Paraguayan context, where cost of electricity generation from hydropower is low.

Enhancing energy security by promoting renewable technologies and the electrification of the energy sector are clearly highlighted in the country's Sustainable Energy Agenda 2019-2023, and goes in line with the objectives of the National Energy Policy 2016-2040 of guaranteeing energy security with social and environmental responsibility. Electrification with renewables is an important aspect in achieving a sustainable energy future. IRENA's World Energy Transition Outlook highlights that the global electrification rate will need to reach 90% (include green hydrogen) to achieve the goal of limiting global temperature rise to 1.5 degrees Celsius (°C) (IRENA, 2021b).

[7] This refers to fast-growing crops intended to produce energy or combustible substances.

Paraguay's climate change policy has among its main pillars measures for mitigation of emissions and climate adaptation of systems in the country. Therefore, reducing the use of fossil fuels is an important component of the country's climate action strategy, which is reflected in the revision process of its NDCs. The transport sector is the main user of fossil fuels and, consequently, Paraguay is promoting the transition of the sector through the use of biofuels, implementation of electromobility, and the use of green hydrogen for larger transport.

Progress has included the creation of the Electric Mobility Board in 2018. Led by the Ministry of Information Technologies and Communications (MITIC), the board brings together the main stakeholders to implement a strategy for the energy transition in the transport sector. In 2019, the board presented the Regional Electric Mobility Project submitted to the Green Climate Fund (GCF) to receive support for identifying and addressing main barriers, providing assessments, and financing alternatives to accelerate the adoption of electric mobility technology in the country (STP, 2019).

Paraguay is currently co-chairing, pro tempore, the Steering Committee of the GCF Readiness Project on Advancing a Regional Approach to Electric Mobility in Latin America. The country is also preparing a Green Hydrogen Road Map, following the guidelines of the National Energy Policy and, more specifically, the Sustainable Energy agenda 2019-2023. It consists of three phases: 1) knowledge acquisition, 2) expansion of the project to increase hydrogen generation capacity, and 3) consolidation of hydrogen use in Paraguay. Both initiatives are part of the objective of promoting the energy and technology transition and increasing the country's productivity.

Paraguay's National Energy Policy 2016-2040 recognises the importance of the energy sector for economic growth by increasing the country's productivity and promoting sustainable development. The energy sector is a key contributor to human development (UNDP, 2020) and job creation. For instance, IRENA estimates that the energy transition towards the 1.5°C pathway could generate 43 million jobs worldwide in the renewable energy sector alone by 2050 (IRENA, 2021b). For Latin America and the Caribbean, it is expected that renewable energy alone generates around 3.3 million jobs by 2030, accounting for 55.5% of the total jobs from the energy sector in the region. Bioenergy and solar will have the largest potential for job creation in Latin America and the Caribbean, followed by hydropower and wind. This will have a positive impact on the economic growth of the region, resulting in GDP increment of 0.7% by 2030, compared to the business-as-usual scenario (IRENA, 2020). Paraguay's wider uptake of renewable energy technologies could also signify a positive impact on the country's socio-economic development in line with the National Energy Policy.

The adoption of clean energy technologies beyond the power sector has the potential to address many aspects of the UN 2030 Agenda for Sustainable Development, such as improving the quality of energy access, enhancing food security, including a gender perspective, and improving health services, among others. Clean energy projects can have positive impacts on local communities, enhance the local economy, empower women leaders in society, and contribute to the modernisation of industry and agriculture in the country.

An overview of the drivers for the deployment of renewable energy in the Republic of Paraguay, together with the expected impacts of the implementation of action lines, can be found in Table 8.

Table 8. **Drivers and expected impacts of renewable energy in Paraguay**

Driver	Expected impacts from promoting renewable energy
Enhance energy security	• Diversification of the energy mix through local energy sources • Reduced dependence on (and imports of) oil-based fuels • Increased energy network interconnections • New opportunities to export renewable energy from variable renewable sources, biomass, geothermal, etc. to the power market • Strengthened infrastructure for generation, transport and storage of energy • Increased energy efficiency • Increased share of renewables in final energy consumption • Increased efficiency of land use, helping to mitigate emissions from land-use change and forestry • Mitigation policies that increase the resilience of energy systems
Achieve sustainable development	• Universalisation of access to high-quality and reliable electricity • Industry growth as a result of increased energy supply • Increased private investment for the development of energy infrastructure • Increased trade in goods and services associated with renewable energy • Enhanced food security, with the use of modern renewable energy in the agri-food sector • Improved health and health services through modern renewable energy sources • Improved energy services, mitigating energy poverty in the country • Achievement of the 2030 Agenda for Sustainable Development
Mitigate climate change	• Reduced greenhouse gas emissions, contributing to climate action (NDC/LTS) • Improved air quality in urban and rural areas with the use of clean technologies • Mitigation of the degradation of natural resources • Achievement of targets posed in Climate Commitments

Source: VMME, 2016; STP, 2014a; UNFCCC, 2016

Renewable energy resources

Paraguay is endowed with a high capacity for hydro energy production. Therefore, it is one of the few nations in the world that has an electrical system based almost exclusively on a clean source, hydropower. Because the current installed capacity satisfies the growing electricity demand, interest in using other clean energy resources has remained low. However, the country has an untapped diversity of renewable resources that could mitigate the use of fossil fuels and play a key role in diversifying the energy mix and enhancing energy security. The use of bioenergy, solar and wind has been briefly explored in the country, but other resources such as low-temperature geothermal have not yet been considered and could contribute to the decarbonisation of the industrial and agricultural sectors.

Hydropower

Paraguay has excellent hydropower potential thanks to its hydrographic conditions and watercourses that flow through the basins of the Paraguay and Paraná rivers. In addition to the current installed capacity, the country has an estimated usable hydropower potential of 872.7 MW, which comprises 325.2 MW in the basins of eastern Paraguay (which drain into the Paraná), 378.8 MW of interconnections[8] with Itaipú, and 168 MW in the Paraguay River (Itaipú Binacional, 2011a, 2011b).

[8] These correspond to flow transfers from tributary basins to the Paraná River.

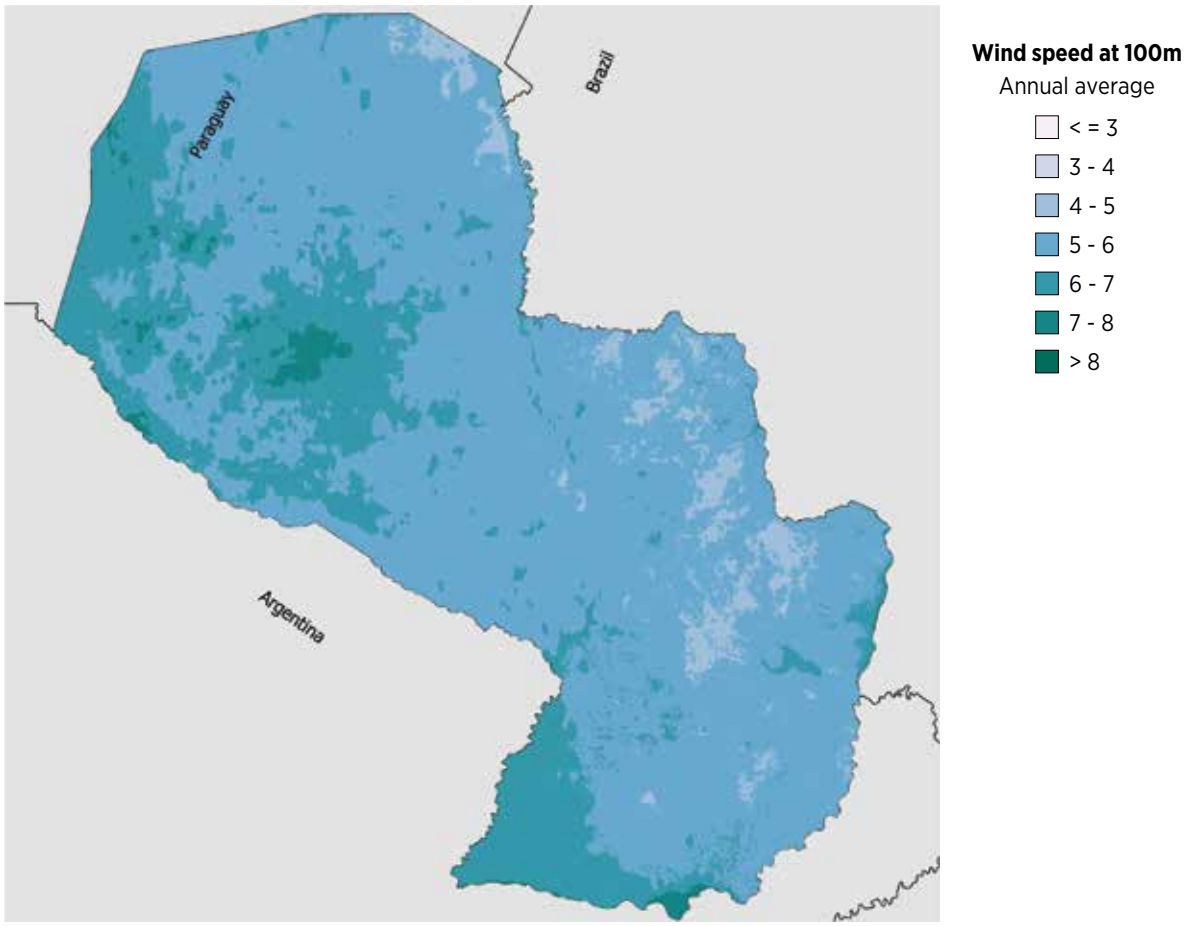
At the regional level, the Ypane and Jejui basins present the greatest potential of the Paraguay River's watershed, each with more than 61 MW. On the Paraná River's slope, the Monday and Ñacunday basins reach their maximum potential, with 39 MW and 61 MW respectively. In the rest of the country's basins, the potential for developing small hydropower has been identified. Other energy uses for the hydraulic potential include water pumping stations, grinding of food and minerals, among others (Itaipú Binacional, 2011a).

Twenty-two sites with favourable technical and economic conditions have been identified. Three of the sites can take advantage of the flows for the installation of two large plants (>50 MW) in Monday and Ñacunday and a medium-sized plant (20 MW to 50 MW) in Ñacunday. Additionally, five sites are in the Ypane basin and three in Jejui, where their exploitation might have a productive use. Of the high-potential areas, 20% could have access to the transmission networks coming from the central eastern region (close to Itaipú), while 22% of the sites in the north of the eastern region could be connected to the 220 kV lines without incurring relevant transport costs.

Wind energy

The wind potential of Paraguay is classified as medium to high, with some of the best locations for wind power generation located in Alto Paraguay and Boquerón. In these areas, wind speeds reach an average of 6.5 metres per second per year at an altitude of 80 metres, as shown in Figure 15.

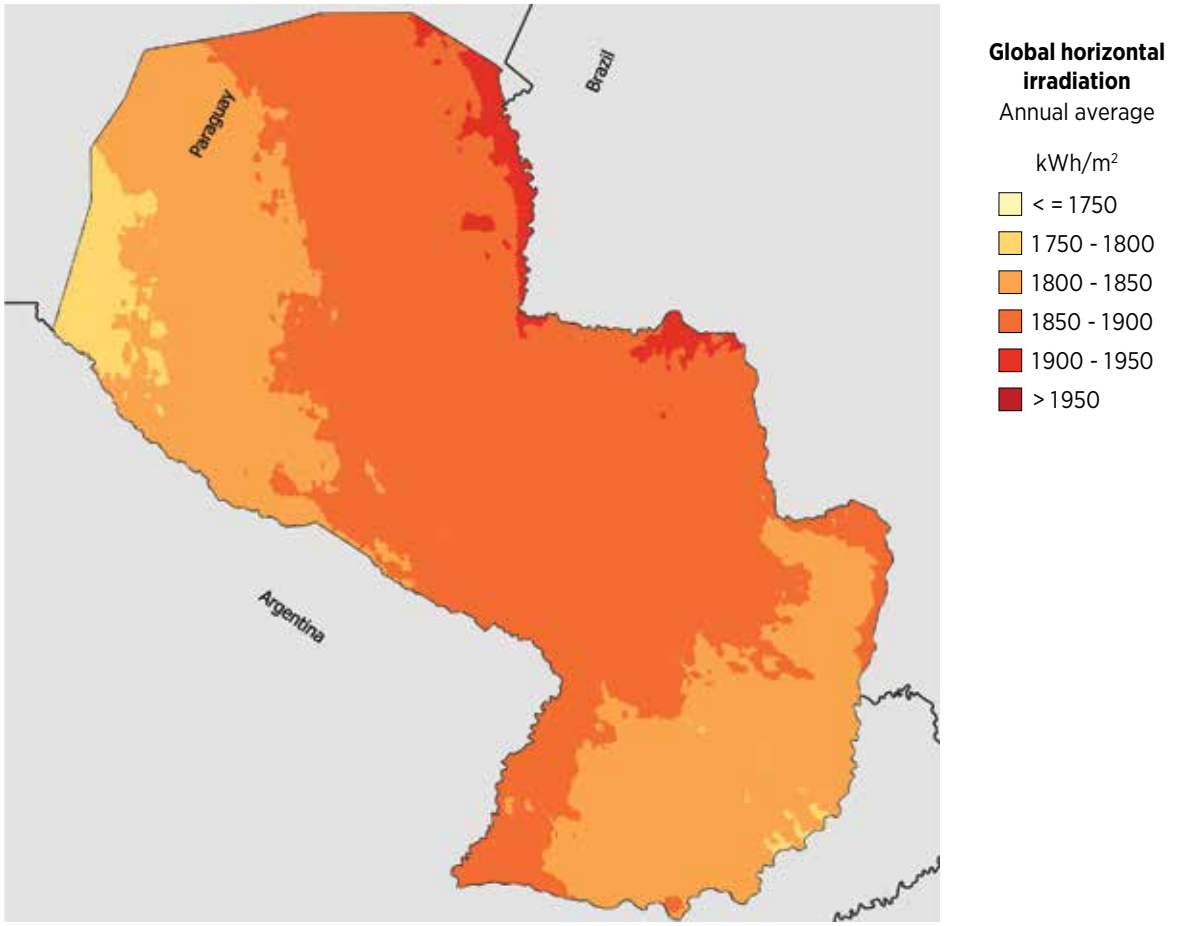
Figure 15. **Onshore wind speed zoning assessment**



Source: IRENA: Global Atlas, Map data: Technical University of Denmark (DTU), 2021, 2021 OpenStreetMap contributors, 2021 United Nations administrative boundaries

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 16. **Solar PV horizontal irradiation assessment**



Source: IRENA: Global Atlas, Map data: World Bank, ESMAP, 2021, 2021 OpenStreetMap contributors, 2021 United Nations administrative boundaries

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.

Solar energy

There is a high potential for the use of solar energy throughout the country. The areas with the highest irradiation index are in Alto Paraguay, Boquerón, Concepción, Amambay, San Pedro, Canindeyú and Alto Paraná, with maximum usage between 1 850 kWh and 2 000 kWh per square metre a year, as shown in Figure 16.

Bioenergy

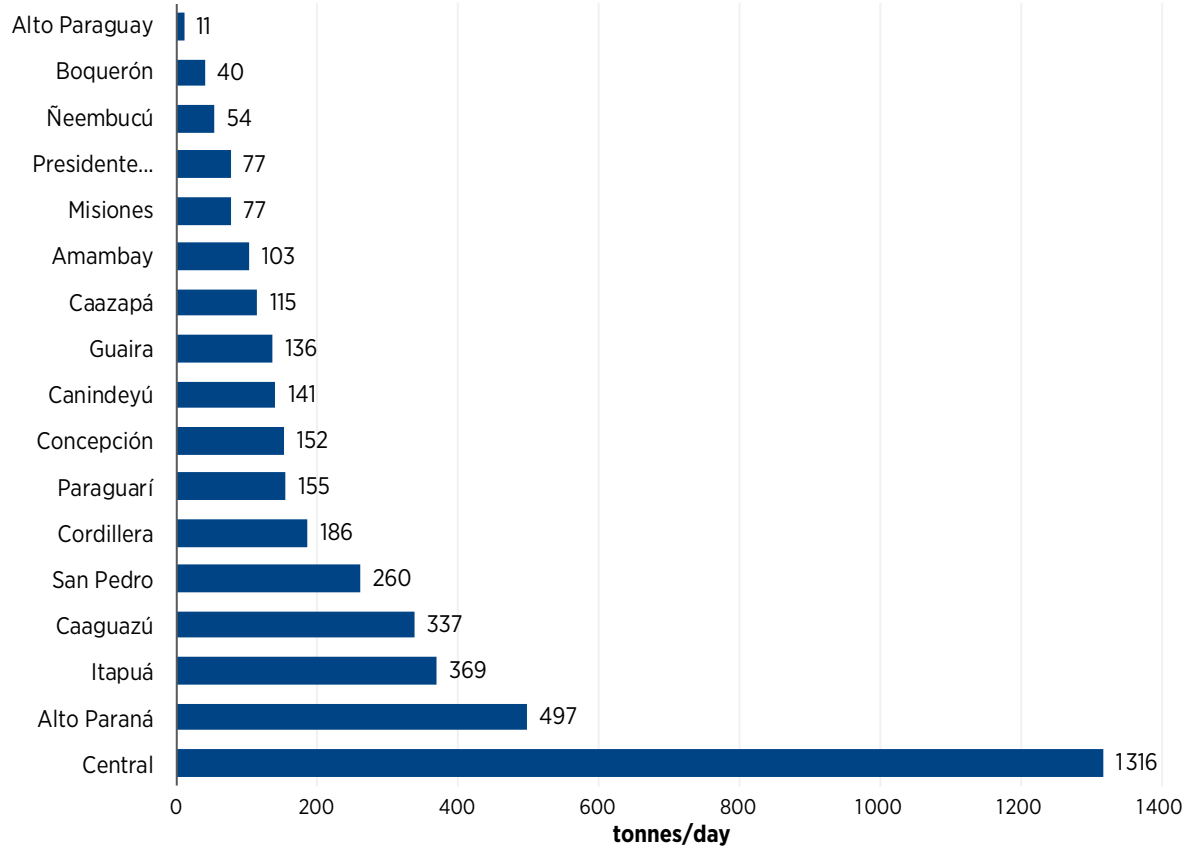
Forest biomass

Paraguay has the potential to utilise forest biomass from native forests, with an estimated productive area[9] of 700 000 hectares in the eastern region and 12.2 million hectares in the western region, which represents a supply of 5.3 million m³ of biomass per year.[10] Of this, at least 3.5 million m³ per year could be used for energy purposes.[11] However, the sustainability of forested areas in the eastern region has been affected by the conversion for agricultural development and by the demand for firewood from the residential and industrial sectors. In recent years, these two sectors together consumed nearly 10 million tonnes of wood per year on average, four times the sustainable supply of forest biomass in this location and resulting in average national forest degradation of 7.6 million tonnes of biomass per year (FAO, 2018).

Biogas

Although Paraguay has experience exploiting biogas, studies quantifying this potential are lacking. Based on available information on organic waste, the country has the potential to take advantage of biogas from landfills in urban areas. Every day, Paraguay generates 4 000 tonnes of organic urban waste with a heat production capacity of 4.6 million kilocalories per year[12] and 584 GWh per year of energy.[13] The largest generation of waste (33%) is concentrated in the Central department, followed by Alto Paraná with 12%. Figure 17 shows the generation of urban organic waste by department.

Figure 17. **Generation of urban organic waste by department**



Source: STP, 2014b

[9] Excludes protected wilderness areas.

[10] Considering an average productivity of 2.5 m³ per hectare per year for the eastern region and 1.3 m³ per hectare per year for the western region.

[11] Considering that 34% and 86% of the wood harvested in the eastern and western regions is destined for energy use, respectively.

[12] Assuming that one kilogram of dry organic waste has a calorific value of 3.154876 x 103 kilocalories.

[13] Assuming that one tonne of waste is capable of generating 400 kW per hour.

Bioethanol

The potential for developing crops for bioethanol production depends on the availability of land for agriculture (FAO, 2018). The Paraguayan territory comprises 55% cultivable areas (22.3 million hectares), a quarter of which are used by the agricultural sector. The National Sugarcane Plan 2019 highlights the potential to develop 20 000 hectares of new crops by 2023 that can be used for energy purposes.

Biodiesel

In 2019, fat production in the country reached 38.3 million kilograms from agricultural activities, enough to produce around 22 million litres of biodiesel.[14] Of this total fat production, however, only an estimated 50% is used for biofuel production. According to records of the National Service for Quality and Animal Health (SENACSA), the production comes from 47 slaughterhouses with sanitary registration, of which nearly three-quarters (74%) are grouped in Central, Itapúa, Paraguarí, Concepción and Alto Paraná.

Geothermal energy

The country has documented the "low" existence of exploitable aquifers as well as very-low-enthalpy geothermal resources for direct-use applications. Systems identified in the Chaco region are the Yrenda, Patiño, Misiones and Caacupé aquifers, which are permeable due to their intergranular porosity (Godoy and Paredes, 1995). However, the high solar irradiation of the country combined with the heat absorption capacity of the subsoil suggests that there is a geothermal potential that could have applications for heat pumps. The country has not yet implemented an official survey of the geothermal potential of aquifers and the thermal favourability of the subsoil for productive or energy uses.

Renewable energy financing

Investment in renewables

The main external financiers of renewable energy and energy efficiency projects in Paraguay are the Inter-American Development Bank (IDB), the Development Bank of Latin America (CAF) and the German development bank KfW. During the 1960s and 1970s, the IDB allocated resources to develop the Acaray and Itaipú hydropower plants (IDB, 1967, 1974). In the period of 2019-2021, the bank approved the following: 1) technical co-operation to support the preparation and implementation of clean energy projects under the Conditional Credit Line for Investment Projects (PR-O004) and the rehabilitation and modernisation programme of the Acaray hydropower plant (PR-L1156), for a total amount of USD 850 000; and 2) a loan for the expansion to a high-voltage transmission system and energy efficiency, with USD 70 million in financing (complemented by the approved loan by JICA in July 2021 of USD 85 million).

In 2017, CAF approved a USD 170 million loan for the Program to Strengthen the Transmission System of the SIN and Rural Electricity Distribution. In 2019, it approved the programme to improve the electricity transmission and distribution system and modernise the management of electricity distribution in Paraguay (ANDE-6) for USD 250 million. Finally, KfW is providing technical assistance to ANDE, including financing of the Environmental and Social Impact Study (EIAS) of the Electricity Transmission Works Package in the Southeast Chaco Region of Paraguay, which will involve an investment of around USD 110 million.

Infrastructure investments to produce biofuels come mainly from the private sector. During the 2010s, twelve bioethanol and eight biodiesel production companies began operations. In 2018, in response to the growing demand for bioethanol, the second alcohol plant belonging to Paraguayan Industry Alcohol S.A. (INPASA) was inaugurated in Guayaibí, which mobilised investments of USD 80 million.

Paraguay's ANDE, through its Generation Master Plan 2021-2040, has committed an action plan with a gross investment of USD 3.6 billion over 20 years, including infrastructure and equipment. This plan presents a synthesis of the technical planning studies carried out with a view to determining the set of necessary works to be performed in the National Interconnected System (SIN) for the generation of

[14] Considering an average final production yield of 60%.

electricity, in order to develop a steady supply and to provide a service of technically acceptable conditions according to the adopted criteria and planning premises. In addition, in 2018, an agreement between the United Nations Development Programme (UNDP) and PETROPAR mobilised an investment plan of USD 7.6 million to make improvements to the Mauricio José Troche bioethanol plant owned by PETROPAR. In a position of support, UNDP monitors the implementation of the investment, provides technical advice and administrative services, and prepares the financial reports (UNDP, 2018).

The Green Climate Fund provides funding for the project Poverty, Reforestation, Energy and Climate Change (PROEZA), implemented in 2019 with an investment of USD 90.3 million (STP, 2017). The programme provides technical and financial support to establish agricultural-forestry systems, plantations and the regeneration of natural forests. The FAO will provide technical and legal assistance in land use, environment and energy issues. The VMME is developing a programme to promote clean and efficient cooking in households under the PROEZA programme, which encompasses the installation of 7 500 efficient stoves. Further GCF initiatives include the following:

1. **FP063 (IDB Project): Promoting private sector investments in energy efficiency in the industrial sector and in Paraguay.** The project involves the financing of energy efficiency investment projects in industrial small and medium-sized enterprises for a total of USD 57.05 million. The objective is to promote energy efficiency in Paraguay's economy by providing medium- and long-term finance for energy efficiency investment projects.

2. **FP121: UN REDD+ Results-based payments in Paraguay for the period 2015-2017.** The project included a budget of USD 588 600. During the project period, the country cut its emissions by 23 million tonnes of CO_2 equivalent through reducing deforestation, forest degradation, enhancement of forest stocks and conservation (REDD+).

3. **FP128: Arbaro Fund – Sustainable Forestry Fund.** The programme grants USD 25 million to Latin American countries investing in sustainable plantation projects in emerging forestry markets, while also bringing adaptation co-benefits. This approach provides low-income countries and rural communities with a way to increase carbon sinks by producing wood more sustainably and conserving natural forests, while helping to reduce illegal logging.

Table 9. **Recent energy-related projects financed in Paraguay**

Financing institution	Year	Project	Amount (USD)	Description
IDB-JICA	2020-2021	PR-L1173	70 million IDB; 85 million JICA	Expansion of the high-voltage transmission system and energy efficiency
Arbaro Fund – GCF	2020	FP128	25 million	Sustainable Forestry Fund
CAF	2019		250 million	Programme to improve the electricity transmission and distribution system and modernise the management of electricity distribution in Paraguay (ANDE-6)
UNDP	2018		7.6 million	Improvements to the Mauricio José Troche bioethanol plant owned by PETROPAR
GCF	2018		90.3 million	Poverty, Reforestation, Energy and Climate Change (PROEZA)
IDB-GCF	2018	FP063	57.05 million	Promoting private sector investments in energy efficiency in the industrial sector and in Paraguay
CAF	2017		170 million	Program to Strengthen the Transmission System of the SIN and Rural Electricity Distribution
KfW-FONPLATA			105.3 million	Electricity Transmission Works Package in the Southeast Chaco Region of Paraguay
REDD+GCF	2015-2017	FP121	588 600	REDD+ Results-based payments in Paraguay

Source: IDB, 2020b, 2020d; CAF, 2019, 2021; GCF, 2018a, 2018b, 2019, 2020; UNDP, 2018; ANDE, 2021a

Planned infrastructure on renewable energy

Through the Generation Master Plan 2021-2040, ANDE has planned the construction of 2 new large hydropower plants and the expansion of Acaray, 19 small hydropower plants, 1 retrofit hydropower plant, a machine house in a dam, 5 solar PV systems, 9 hybrid PV-diesel plants, and 5 battery banks, with a total investment of USD 1878.5 million (Table 10).

Private companies are also assessing investing in solar PV projects. This includes an investment of USD 18 million for the installation of a 20 MW solar power plant (IP Agency, 2021). Its development depends on the approval of legislation, which was still under discussion at the time of writing this report.

The most relevant projected investment in biofuels comes from the Omega Green project. The project involves mobilising around USD 800 million to install a plant with a capacity to produce 3 million litres per day of biodiesel and biokerosene. Its construction will begin in 2021 (MIC, 2019).

Table 10. **Additional renewable capacity by 2025**

	Total cost (USD million)
Solar PV	
5 solar PV plants (100 000 kW_p)	343.5
9 hybrid PV-diesel plants (8 155 kW_p)	27.7
Construction 5 of a 100 MW to 400 MWh lithium-ion battery bank	429.4
Small hydropower plants	
Jeju 1 (3.3 MW), Jeju 2 (3.2 MW) and Jeju 3 (3.1 MW)	505.0
Tembey 1 (13.1 MW), Tembey 2 (13.3 MW) and Tembey 3 (13.2 MW)	
Capiibary 1 (16.1 MW)	
Pirajui 1 (14.1 MW)	
Ñacunday 1 (12.1 MW), Ñacunday 2 (12.3 MW) and Ñacunday 3 (12.2 MW)	
Carapa 1 (6.2 MW), Carapa 2 (6.1 MW)	
Itambey 1 (8.1 MW)	
Ypané 1 (2.5 MW), Ypané 2 (2.1 MW), Ypané 3 (2.2 MW), Ypané 4 (2.3 MW), Ypané 5 (2.4 MW)	
Large hydropower plants	
Paraguay River A (41.0 MW)	144.0
Paraguay River B (54.7 MW)	108.0
Acaray III (35 MW)	85.5
Acaray (machine house in dam on Yguazú River) (41.19 MW)	80.5
Acaray retrofit	154.85
Total	**1 878.5**

Source: ANDE, 2021b

Financing opportunities

Paraguay's Development Finance Agency (AFD) has access to concessional and non-reimbursable resources from the GCF to finance renewable energy and energy efficiency projects. These resources include USD 40 million in loans (20 million from AFD and 20 million from the GCF) and USD 2 million in non-reimbursable funds. The funds can be used for projects at small and medium-sized enterprises that reduce energy costs, increase business profitability and competitiveness, minimise exposure to energy price volatility, and increase the market for energy-efficient goods and services with a low environmental impact (AFD, 2021).

The AFD offers loans to finance reforestation projects for commercial purposes. Companies in the forestry sector can apply for financing through an intermediary financial institution to invest in forestry plans for fast-growing native or exotic species. The loans might finance up to 100% of the project value, with maximum terms of 12 years.

Finally, the Sustainable Finance Program co-finances energy efficiency. Co-ordinated by the Sustainable Finance Bureau, the initiative offers technical and financial support from the French Development Agency (Proparco), KfW and the Dutch Finance and Development Corporation (FMO). The programme has a line of credit of USD 120 million with the Sudameris Bank to grant for projects for machinery renovation.

Paraguay has backed its infrastructure development through the issuance of sovereign bonds while also receiving support from multiple multilateral banks and development funds, such as the Organization of the Petroleum Exporting Countries (OPEC), the GCF, the IDB, the International Bank for Reconstruction and Development (IBRD) of the World Bank (a key project is Strengthening of the Electric Power Sector in Paraguay, 2010), the Financial Fund of the Plata Basin (FONPLATA), the Development Bank of Latin America (CAF), the Spanish Agency for International Development Cooperation (AECID), the Japan International Cooperation Agency (JICA), the Japan Bank for International Cooperation (JBIC), the European Investment Bank (EIB), KfW, the MERCOSUR Structural Convergence Fund, the Korea International Cooperation Agency (KOICA), the United Kingdom Official Credit Institute (ICO) and Banco do Brasil (BB), among others.

In the last decade, Paraguay was able to strengthen its macroeconomic framework based on fiscal rules, inflation reduction targets, low public debt and adequate foreign exchange reserves (World Bank, 2020c). At the beginning of 2020, its favourable investment conditions positioned it among the five countries in Latin America with the lowest risk premium (World Bank, 2020d), thus allowing it to garner greater investor confidence and profitability on projects. Between the first quarters of 2019 and 2020, the balance of loans from financial institutions increased to 7.52%, while the effective interest rate on development loans from financial institutions fell 2.23% by 2020 (BCP, 2020).

Professional and institutional capabilities

Paraguay has universities that offer careers in energy-related fields, covering areas aimed at prospecting, exploration and the sustainable use of energy sources. Post-graduate specialisations and masters and doctoral degrees are offered in energy management, planning and energy technology, energy systems planning (automation and control), and electrical and electronic engineering sciences with an emphasis on power electronics.

The Paraguayan Model of Dual Vocational Training (MoPaDual) is used for capacity building in collaboration with institutions in the energy sector. The programme offers mixed training and was developed with support from the National Service for Professional Promotion (SNPP).[15] In 2018, ANDE managed a Training Course in Electrical Engineering through the MoPaDual that offered degrees as Industrial Electricians and Electrotechnical Technicians with SNPP training and an internship at ANDE (SNPP, 2020).

[15] Made by Law No. 1,253 in 1971.

In addition, the National Council of Science and Technology (CONACYT), through the Program to Support the Development of Science, Technology and Innovation (PROCIT), has been financing projects and scholarships in multi-phase electricity generation to take advantage of the potential of renewable energy. This also supported the development of algorithms to maximise the power of solar energy panels, optimising biodiesel production using local fruits, testing new technologies for biogas production with industrial effluents and studying the wind potential in the Chaco region (CONACYT, 2013).

At the international co-operation level, there are agreements to provide training and education to professionals from ANDE and the VMME.[16] OLADE has implemented Virtual Energy Training Courses (CAPEV) in energy planning since 2008. In 2009, the AECID financed a co-operation programme implemented by the UNDP to support the transfer of knowledge, technology and action on climate change. The initiative provided support in the preparation of the National Appropriate Mitigation Actions (NAMAs) for the reduction of the use of non-renewable biomass. The AECID is continuing this initiative (in collaboration with OLADE) by providing technical assistance in analysing the impact of climate change on Paraguay's energy planning. The analysis includes assessing vulnerabilities and risks and identifying measures to strengthen the infrastructure of the energy sector. In 2015, IRENA provided training in energy planning to harness the potential in renewable energy.

Finally, the IDB–OLADE collaboration Energy Information System for Paraguay (SieParaguay – 2019) seeks to generate the capacity to harmonise the methodology for the elaboration of the national energy balance. Within this initiative, and in collaboration with EUROCLIMA (2020), the VMME prepared the National Balance of Useful Energy (BNEU), which includes strengthening capacity on planning and crafting energy efficiency policies.

[16] Some current agreements include OLADE, IRENA, CIER, ARPEL, FURNAS/ELETROBRAS and Itaipú Binacional.

Heroes Pantheon - Asuncion, Paraguay.
Image credit: Shutterstock

4. Challenges and Recommendations

This section presents the main recommendations for accelerating the deployment of renewable energy in Paraguay, based on the challenges identified during the Renewable Readiness Assessment (RRA) process. The consultative process included a review of the literature, insights from interviews, and outcomes from focus groups and multi-stakeholder roundtable discussions held during workshops, along with subsequent exchanges with selected stakeholders. This section groups the recommendations in six areas and identifies the main challenges for each. Within the six groupings are a total of 15 short- to mid-term actions for an accelerated deployment of renewable energy in Paraguay.

Strengthen institutional structure and governance in energy

The Ministry of Public Works and Communications (MOPC) manages Paraguay's energy sector through the Vice-Ministry of Mines and Energy (VMME), which is responsible for establishing and guiding policy regarding the use and management of the country's natural mineral and energy resources as well as overseeing the electricity sub-sector in close co-ordination with the National Electricity Administration (ANDE). ANDE exercises certain regulatory functions and controls activities in the generation, transmission, and distribution of electricity and street lighting. Its current responsibilities include setting electricity tariffs and approving contracts for the purchase, sale and exchange of energy within and outside of the country.

The current institutional capacity faces constraints to guaranteeing the rapid implementation of the Energy Policy. The VMME and ANDE require additional human resources, capabilities and budget to lead multi-sectoral responsibilities; implement national energy programmes and provide technical assistance in the design of business models, installation, maintenance and certification of renewable energy technologies. Specifically, the VMME needs additional operational, technical and budgetary capacity for the creation of new operational units in charge of policy implementation activities. However, giving the VMME a ministerial rank with its own budget and authority has proved to be challenging; seven bills were submitted to the National Congress in the 2009-2020 period, but none gained approval, even though most of the energy stakeholders have agreed on the need for a centralised institution for the sector.

The existing procedure for awarding concessions imposes additional barriers of entry for energy developers of projects of any size. The National Congress is the sole entity with the power to award concessions for the exploitation of natural resources, resulting in a lengthy due diligence process that is costly for independent producers.

Action 1. Create an energy committee to ensure key energy policy implementation

It is necessary to prioritise enhancing the governance of energy institutions in the country. This can be done by strengthening capacities and increasing the budgets of existing entities or creating specialised agencies to implement strategic pillars of the Energy Policy, such as energy efficiency and renewable energy.

As a short- to medium-term approach, the Government might consider creating an Energy Committee as a transitional measure towards the eventual creation of a leading institution for the energy sector, such as a Ministry of Energy. This energy committee would support the implementation of urgent actions, such as 1) rapid implementation of the Energy Policy and 2) strengthening the Vice-Ministry of Mines and Energy

and transforming energy sector institutions. This committee should have competencies and autonomy, in order to lead these actions and effectively implement development policies and national commitments. Without this guidance, development of the Paraguayan energy sector will be hindered due to the absence of a clear directive and leadership in the sector.

Furthermore, this committee should have a defined structure and include representatives from the key energy institutions in the country as well as members of parliament, legislators, and representatives from judicial institutions and industrial associations. The aim would be to raise awareness of the relevance of the energy sector for the economic development of Paraguay as well as the specific needs that will help foster it. Immediate committee actions might include integrating members of congress on inter-institutional committees, preparing studies on the potential benefits of energy reforms, enhancing inter-institutional co-ordination, and developing a clear action plan to ensure implementation of the national energy policy, among others.

Action 2. Foster an independent regulatory environment

To promote the development and growth of the energy sector, the country needs to establish a strong regulatory environment. The purpose of this would be to prepare further regulation, supervision, and oversight of compliance with legal and regulatory provisions and technical standards on the production, storage, transport, and distribution of liquid fuels, gas, heat and electricity. This regulatory environment, as well as the required framework, could be fostered either by increasing capacity in an existing institution, or by granting these responsibilities to a new institution. In any case, the regulatory body should guarantee adequate and independent regulation of the different aspects of the energy sector. Additionally, the proposed governance arrangement should work closely with the key energy institutions in the country such as the VMME and ANDE, among others, to develop the conditions for policy and regulations in line with the growing energy needs of Paraguay, the national energy plans and climate action strategies.

An independent regulatory environment would also improve the transparency of the sector, eliminate self-regulation along value chains, strengthen leadership to enforce regulation and close regulatory gaps, and impose penalties when necessary. This will also contribute to improving the electricity service to final users and promote the improvement of energy infrastructure in Paraguay, including transmission and distribution lines.

In line with Action 1, an Energy Committee can also contribute to identifying the necessary adaptation of the regulatory framework for the creation of an independent regulatory entity (as part of an existing institution or as a new agency) and define the powers that it will be granted (consultative, arbitrative or punitive).

Action 3. Streamline administrative procedures when granting permits and concessions

Streamlining administrative procedures when granting permits and concessions is an important step to accelerate the deployment of renewable energy projects. The government may modify the process for granting concessions (differentiating its requirements for small, medium, and large-scale projects) and enhance co-ordination among the various government offices involved in issuing permits, to reduce project delays and construction costs.

Creating a “single-window agency” may help to accelerate the due diligence of permits and concessions for renewable energy projects and serve as a third-party office to assist in minor conflict resolution. This entity can be created as an independent legal body, or included under the mandate of an existing institution. An existing regulation entity should ensure that timetables for various permitting processes are clearly defined and that procedures are transparent.

Enhance planning, policy and the regulatory framework for renewable energy

The National Energy Policy 2016-2040 defines key objectives for the development of the country's energy sector, including guaranteeing energy security with social and environmental responsibility; ensuring access to good-quality energy services; using national energy resources; consolidating Paraguay's role in regional energy integration; and creating public awareness of the importance of energy and its sustainable use, among others.

The STP is responsible for long-term planning of the country's strategic sectors, including the electricity sub-sector. The STP partially shares its responsibility for energy planning with the VMME, delegating to the Vice-Ministry the responsibility of preparing energy projections and proposing energy policies. Long-term energy planning might benefit from strengthening the co-ordination of energy institutions to agree on a flowchart that highlights priority actions, estimated budgets and projected timelines. Weaknesses of such co-ordination in long-term planning pose barriers to accelerating the country's readiness to implement the Energy Policy as well as having a clear pathway for development of the energy sector.

The strategic framework for cross-cutting energy areas of the economy is based mainly on the National Development Plan 2030, which also is aligned with the national Sustainable Development Goals (SDGs). The National Development Plan addresses development areas such as poverty, food security, gender inequalities, access to energy in rural households and drinking water, and energy efficiency, among other important aspects promoting the welfare of the Paraguayan population. Also, the National Energy Policy 2016-2040 considers the implementation of programmes to increase equal access to land, infrastructure and agricultural technology. Legal actions to support the Nationally Determined Contribution (NDC) include the National Climate Change Law, which reiterates the country's commitment to reducing its greenhouse gas emissions by 2030.

Paraguay can accelerate its progress in achieving its energy goals by updating strategic and regulatory frameworks. Some energy action plans have unclear targets, goals and budgets for increasing the share of renewables in the energy mix and reducing greenhouse gas emissions. The implementation of actions to meet the targets of the NDCs should contemplate pathways to achieve energy-related goals, such as modernising carbon-based and inefficient technologies used in industry; increasing the share of renewables in national energy consumption; and promoting energy efficiency in buildings, households, industry and the public sector.

Furthermore, the planning of the power sector and cross-cutting energy areas are the responsibility of different institutions, which makes it difficult to have a clear roadmap of development for the energy sector, omitting important aspects such as the role of electrification in end-use sectors; the need to promote technologies to increase flexibility in the power sector; assessing power grid stability with the incorporation of low-carbon technologies, such as electric vehicles and green hydrogen; and the potential contribution of the energy sector to climate action, among others. A clear long-term energy plan can provide an important basis to attract investment by setting clear rules and perspectives in the sector.

Well-co-ordinated energy planning needs to include all the energy institutions and sectors; the provision of clear targets and goals in the medium and long term; and the implementation of new technologies, such as variable renewable energy, electric vehicles, green hydrogen, etc. It also needs to consider the required investment in energy-related infrastructure, such as transmission, distribution and storage.

The creation of new incentives, standards and certifications sometimes is constrained by the direction and capabilities of the institutions interested in promoting them. Scattered direction across energy institutions can make it difficult to create adequate conditions for the adoption of renewable energy. The key activities for enhancing renewable readiness include removing the barriers to entry for new energy agents, creating legal conditions for independent energy producers, and reducing the time and requirements for granting concessions and permits.

Action 4. Map renewable energy potential

Paraguay has a diversity of renewable energy resources that has not yet been clearly assessed, especially for variable renewable energy. Developing resource maps for the potential of solar, wind and geothermal in the country using satellite data can be the first step in the identification of potential zones for the development of renewable energy projects for power generation or other applications. A zoning exercise could also contribute to the planning exercise and serve as a solution to economise in infrastructure expansion, by focusing on specific areas of development.

Action 5. Establish clear renewable energy targets

Defining clear targets and actions for development of the renewable energy sector might help foster commitment and integrate the economic, social, environmental and governance dimensions of sustainable development. The identified targets should cover all end uses beyond power, account for electrification of end uses, and highlight areas of opportunity such as electromobility and green hydrogen initiatives to take advantage of power surpluses for decarbonising the transport and industrial sectors and achieving climate neutrality by mid-century.

Defining renewable energy targets in different sectors would require co-ordinated work among energy, environmental and economic institutions, aiming to capture the effects of achieving such targets and the necessary measures to create a pathway towards the proposed goals. Sectorial renewable energy targets require a well-established set of data as the basis for developing such goals, as well as to monitor progress in their implementation.

Additionally, developing sectorial renewable energy targets needs to consider the policy, regulations and investment required to bring those ambitions to reality. A dedicated Energy Committee (as presented in Action 1) can facilitate the co-ordination of the country institutions, taking a holistic approach that is able to set achievable goals.

Action 6. Enhance long-term energy planning practices for the development of a national energy plan

The planning responsibilities for the energy sector are scattered among different institutions; therefore, it is necessary to co-ordinate them towards execution and evaluation of both the long-term national electricity plan as well as the development of the broader National Energy Policy. An updated National Energy Plan should consider the end-use sectors (transport, industry, buildings) and the power sector, including flexibility options and trends in low-carbon technologies. Additionally, a national energy plan should be aligned with climate action components such as targets as part of the Nationally Determined Contributions (NDCs).

The STP and the VMME in co-ordination with key energy institutions can define long-term planning through the preparation of sectoral plans (agriculture, transport, energy and others related to the SDGs) and long-term energy scenarios, providing guidance for the development of potential implementation roadmaps, assigning clear responsibilities and a framework to monitor actions and their expected impact.

Many countries in Latin America are well advanced in the development of long-term energy planning as well as in the elaboration of long-term energy scenarios, with recognition at the global level. Additionally, most of these countries have successfully implemented renewable energy technologies and other low-carbon technologies, in line with their own climate commitments under the Paris Agreement. Paraguay can use existing regional forums and initiatives in Latin America to access best practices in the development of national energy plans and learn from more experienced countries in the region.

Action 7. Prepare a cross-cutting strategy to align the nexus between the National Energy Policy, the SDGs and climate action

The implications of climate change for a diverse range of issues addressed by the SDGs are worth addressing in a long-term strategy in order to reach national commitments and net zero by 2050. Paraguay has great potential to achieve net zero by 2050 thanks to renewable energy resources and the existing low-carbon power sector. This strategy should be based on the National Energy Policy and on evaluation of the renewable energy contribution to national and local economic growth. It should identify the enabling frameworks that are required to enhance the socio-economic impacts of increasing the adoption of renewable energy in the country, such as job creation, gender equality, development of local industries, attractivity of investments, health, among others. Additionally, the cross-cutting strategy needs to consider the nexus between renewable energy and the SDGs, for instance improving health services, enhancing food security, water availability, securing sustainable energy for all, and women's empowerment, among others.

Furthermore, the cross-cutting strategy needs to assess the potential of renewable energy in achieving the climate commitments of the country, aligning it to the NDC. For instance, Paraguay's terrestrial ecosystems may be profoundly altered through increased land-use change and forestry activities, desertification, invasive species and other climate-related factors. Renewable energy is a direct solution to provide resilient energy infrastructure and mitigate the effects of climate change. Likewise, strategic plans for developing and modernising the agricultural and industrial sectors could facilitate better land use and improve forestry activities. The use of variable renewable energy can help reduce the excessive use of forests as a source of fuelwood for biomass as well as contribute to decreasing the energy intensity of processes used for converting biomass into fuel.

The government should also consider that, while energy-related actions can promote the adoption of efficient and renewable energy, its links to the various aspects reflected in the SDGs provide the sector with a high potential to secure sustainable economic growth in the country. Simultaneously, it can help to mitigate greenhouse gas emissions and serve as a key part of the measures considered in climate adaptation strategies.

Action 8. Create enabling frameworks for the wide adoption of renewable energy technologies

The government may prioritise actions to bring clear legislation and suitable environment for attracting independent energy investors and increasing the diversification of the energy mix. Key actions to implement effective regulations might include reaching agreements through expanding the scope of sustainable biofuels roundtable discussions to other renewable energy applications and gaining consensus with energy producers regarding actions for increasing their participation in energy markets. The government may consider revising regulations that limit power sector returns on investments and constrain the options for negotiating long-term power purchase agreements and removing barriers of entry for experienced international energy developers.

Agreements between the public and private sectors might improve the effectiveness of new laws and facilitate identifying and prioritising adequate incentives, regulations and guarantees to attract new investments within the assessment process.

Introducing energy standards may promote innovation among manufacturers and technology importers. Standards might help regulated technologies become more homogeneous by making them all efficient, safe and low-carbon appliances. Additionally, further work on the certification of the sustainable use of biomass is required, due to the importance of this energy source in the total energy supply of the country.
As a result of the previous assessment and its findings, the VMME will be able to define a roadmap of priority regulations that require the preparation of national standards. The effectiveness of a regulatory framework will benefit from including analyses of the economic, environmental and social impacts of new standards and regulations on renewable energy and energy efficiency. The government can harness the existing co-ordination among the National Institute of Technology, Standardization and Metrology (INTN); the National Council of Science and Technology (CONACYT); the Quality Commission and the National Accreditation Body (ONA); academia; and actors with high technical capacity.

Develop policy instruments and implementing initiatives to foster energy efficiency

The country has built inter-ministerial co-ordination and set guidelines across the economic sector through the National Energy Efficiency Committee (CNEE). The CNEE is responsible for preparing the Energy Efficiency Plan (EEP) and assessing fiscal, financial, and tax measures and energy efficiency criteria (standardisation and labelling, among others). The EEP prioritises updating the regulatory framework, implementing technological innovation programmes, creating awareness and monitoring of the rational use of energy, and measuring impacts. However, the plan might benefit from including specific targets and local diagnostics (such as energy indicators by sector and use). Also, policy makers face difficulties in changing the widespread perception that hydropower plants have sufficient capacity to cover the country's energy demand indefinitely at affordable prices.

Action 9. Strengthen the framework to promote energy efficiency

Adopting a law specific to energy efficiency can provide the conditions to integrate binding policies and targeted initiatives, as well as additional incentives for high-efficiency and renewable energy equipment that might include discounts implemented through government programmes. Action plans can include specific initiatives to promote energy efficiency in buildings, transport, households, industry and the public sector. Working in co-ordination with municipalities and the Ministry of Housing, Urbanism and Habitat might help to enforce sustainable construction standards. Public tenders can also drive the adoption of renewable energy and energy efficiency technologies in the acquisition of goods and services.

Action 10. Raise public awareness on energy conservation and efficiency

Promoting education at various levels can be a key strategy to reduce national energy demand. The country could conduct public awareness campaigns on energy efficiency using lessons learned from mobile education units deployed by Itaipú Binacional. The new policies and strategic framework should help change the ongoing perception that Paraguay has infinite hydropower resources and emphasise that the country needs to be more conscious in its use of electricity resources. Renewable energy needs to be integrated into the daily lives of consumers and prosumers (those who both produce and consume energy), as well as into institutional frameworks, to allow these participants to be part of the overall energy transition.

Policies that allow for full participation in the energy system include, for example, awareness-raising programmes to encourage behavioural change and policies to couple renewable energy technologies with livelihoods (to enhance access). A new policy approach that prioritises diversifying the energy mix and creating awareness of the rational use of energy might unite institutional efforts in the development of variable renewable energy projects and the adoption of energy efficiency measures.

Promote the use of renewable energy beyond the power sector

Paraguay has excellent resources for renewable energy. So far, the country has promoted renewables mainly in the power sector and is missing the opportunity to increase their application in end-use sectors, which could favour energy security, climate action and achievement of the SDGs. The country has a large hydro resource potential, which could be used not only for power generation but also for the installation of water pumping stations, food and mineral grinding. The existing solar potential can energise community centres and isolated productive areas of the country, particularly in Alto Paraguay, Boquerón and Concepción. The wind potential, identified as medium to high quality, is concentrated in the north-western region, specifically in the department of Boquerón.

Paraguay comprises 55% cultivable areas (totalling 22.3 million hectares). The National Sugarcane Plan 2019 highlights the potential to develop 20 000 hectares of new crops by 2023 that can be used for energy purposes. Between 2015 and 2019, bioethanol demand increased 56.7%, reaching a national average

blending level with petrol of 26%, one percentage point above the established goal. The biodiesel market, meanwhile, has not developed as expected due to a lack of competitiveness associated with the extra cost of blending with diesel.

These energy estimates can be strengthened with additional data collection. Most of the available information is based on models, extrapolations and global measurements that can be improved with data gathering in the field.

The implementation of a "cross-cutting strategy considering the nexus of SDGs and climate actions" (Action 7) demands a clear structure to organise horizontal coherence across ministries and vertical coherence across government levels (national, sub-national and local). For the NDCs, institutions need to gain experience and have enough capacity for the design and implementation of carbon markets, carbon pricing mechanisms, and monitoring, reporting and verification (MRV) systems. Further, the country might benefit from adding binding guidelines and policies to support the implementation of variable energy projects (energy efficiency, electric mobility and green hydrogen initiatives) in industry, building codes and public procurement.

Action 11. Develop a roadmap of clean energy technologies for the end-use sectors

The development of a roadmap to assess the potential penetration of clean energy technologies in all the sectors, in line with the NDCs and SDGs, can draw a pathway for the implementation of renewable energy and low-carbon technologies in key sectors such as industry, buildings and transport.

The roadmap should include the evaluation of challenges as well as options to overcome them. Energy efficiency and self-sufficiency, as well as the high costs of initial investments, are the main challenges across sectors, along with the lack of technical skills for installation and maintenance. For instance, the industrial sector should promote the modernisation of processes that use low-efficiency technologies that consume biomass and diesel for heating purposes, replacing them with low-carbon and renewable technologies such as solar thermal and green hydrogen, among others.

In agriculture, the adoption of low-carbon technologies needs to be addressed in terms of trade-offs, while leveraging interactions within the water and food nexus. The implementation of renewable energy technologies and the adoption of electric machinery and vehicles for food production can mitigate the use of fossil fuels in the sector, enhance food security and favour a more technified and controlled land use.

For the transport sector, the roadmap should foster the transition to electric vehicles and at the same time propose actions for the promotion of charging infrastructure. Additionally, it should assess the implementation of biofuels and green hydrogen for specific applications, such as for heavy-duty vehicles, and to implement the Sustainable Energy Agenda to empower new business models based on clean energy solutions for all value chain stakeholders. The evaluation of initiatives to increase the adoption of clean energy technologies can include strengthening the management of carbon emissions for new projects and controlling greenhouse gases originating from industrial production processes; replacing fossil fuels with renewable alternatives; and introducing conventional energy efficiency and conservation technologies.

The elaboration of roadmaps should include a participatory process with different stakeholders in the sectors, aiming to identify short- and medium-term responsibilities for implementation of the ambitions evaluated here. The engagement of municipalities and regional governments can bring an inclusive approach that also benefits local communities and seeks to provide major contributions to local economies. Additionally, the roadmap should include clear targets for the penetration of low-carbon technology in each sector. These targets should be in line with the national Sustainable Energy Agenda, NDCs and LTS, and should highlight their link to the respective SDGs.

When developing strategies for the implementation of low-carbon technologies – such as green hydrogen, solar PV for water irrigation, electric mobility, and biomass at the industrial level – co-ordinated action between the government and industry can contribute to exploring the development of industrial parks

close to the available resources, and at the same time promote the adoption of modern technologies. These plans should include an assessment of the type of technology, potential application and investment required.

Action 12. Strengthen institutional and stakeholder co-ordination beyond the power sector

Additionally, the country can consider identifying target groups within the strategic sectors with the potential to create economies of scale for developing renewable energy applications. The institutional co-ordination should include working with stakeholders with the potential to adopt renewable technologies beyond the power sector and assessing their capacity to invest in low-carbon technologies and design business models to install and deploy renewable energy technologies. The institutional and stakeholder co-ordination should be under periodical revision and adjusted based on the achievement of goals set for each target group.

Paraguay's geographical location can also facilitate its co-operation with neighbouring countries towards the achievement of regional energy integration. The country can leverage existing initiatives focused on the power sector – such as Renewable Energy for Latin America and the Caribbean (RELAC) and the Regional Energy Integration of the Southern Cone (SIESUR) – to expand the scope of collaboration into new areas such as the trade and development of renewable heat and green hydrogen. Furthermore, the government can ask multilateral institutions for technical co-operation to replicate international practices on institutional and stakeholder co-ordination to promote business model innovations and create the conditions for the massive deployment of renewable energy and the adoption of certified low-carbon technologies.

Box 4. **Promoting green hydrogen in Paraguay**

Paraguay is interested in using its renewable energy potential to produce green hydrogen for domestic use as well as potential export to the region. In June 2021, the Government of Paraguay and the IDB developed a roadmap for the use of green hydrogen in the country. The roadmap highlights Paraguay's huge potential to produce green hydrogen at competitive prices of around USD 2.2 per kilogram. The national power system has the capacity to accommodate large production companies manufacturing electrolytic hydrogen, without major drawbacks for the electricity balance. This manufacturing process can also facilitate the co-production of electrolytic oxygen.

The Green Hydrogen Roadmap is aligned to the National Sustainable Energy Agenda 2019-2023, as it proposes green hydrogen as an energy vector that can contribute to development of the country's energy sector. The focus is on the decarbonisation of the transport sector (VMME, 2021), the largest consumer of fossil fuels in Paraguay.

The roadmap is divided into two documents: 1) a conceptual framework, containing the guidelines to promote the development of green hydrogen for sustainable socio-economic growth in Paraguay; and 2) an innovation proposal, with guidelines for a green hydrogen supply and a utilisation demonstration project in the country.

Currently, the Government of Paraguay, through the Vice-Ministry of Mines and Energy with assistance from various international organisations, is developing a Strategy for the Use of Hydrogen in the Transport Sector, including overland and river transport (OLADE, 2020).

Foster investment in renewable energy technologies

In the last decade, Paraguay has strengthened its macroeconomic situation based on fiscal rules, inflation reduction targets, low public debt and adequate foreign exchange reserves (World Bank, 2020c). At the beginning of 2020, its favourable investment conditions positioned it among the five countries in Latin America with the lowest risk premium (World Bank, 2020d), allowing it to garner greater investor confidence.

Despite its favourable investment conditions, Paraguay faces challenges in attracting investments in certain areas of the energy sector. The main constraints for participating in energy markets are price signals for independent power producers, available incentives for project developers and the difficulties of reaching financing closure. Financing mechanisms are scarce, and only one known bank in the country offers green financing mechanisms for non-conventional energy projects. National banks need support in filling the knowledge gap on environmental and social issues related to green credit lines. Finally, the poor financial performance of project developers (mainly in small and medium enterprises) increases the risk perceived by commercial banks. This results in higher financing costs and lower returns on investments.

Action 13. Create incentives for renewable energy and energy efficiency

Current tax and fiscal benefits can be added to a range of goods and services eligible for exemptions. Tax exemptions might include further incentives for developing projects in strategic regions of the country that lack infrastructure and economic development. Additional incentives for massive adoption of certified high-efficiency and renewable energy equipment might include discounts implemented through government programmes. The VMME can lead a task group responsible for reviewing tax and fiscal schemes and can recommend modifications aligned with Energy Policy implementation.

The country can also consider providing technical assistance to study economies of scale for developing renewable energy applications in strategic sectors, such as power, transport and agriculture, supporting the organisation and professionalisation of small and medium-sized enterprises, and creating capacities in commercial banks and borrowers to increase access to financing. The VMME can design and implement programmes to channel additional resources directed to technical assistance to small and medium-sized enterprises for assessing economies of scale and preparing energy audits and feasibility analyses.

Action 14. Develop dedicated financial instruments for renewable energy and energy efficiency

Defining a financing mechanism for renewable energy projects using the experience of the Program to Support the Diversification of the Economy (PADE) might attract the interest of both energy developers and commercial banks. Meanwhile, guarantees have the potential to boost the development of renewable energy in promising areas that require high investments in infrastructure – for example, green hydrogen and energy storage.

The implementation of financing mechanisms might include credit lines backed by sovereign guarantees, while for investor guarantees the Government might consider assessing investors' risks and working with development agencies to structure dedicated mechanisms for targeted sectors. Having a clear roadmap to approach multilateral institutions might help to identify financial and guarantee mechanisms across sectors. For example, Climate Finance Support from the GCF, the Global Environment Facility (GEF), the IDB and the World Bank, among others, could be a key element for financing the implementation of small and medium-scale projects on renewable energy and energy efficiency.

Reinforce the continuous creation of institutional and human capacities

The Paraguayan Model of Dual Vocational Training (MoPaDual) is used for capacity building in collaboration with institutions in the energy sector. The programme offers mixed training and was developed with the support of the National Service for Professional Promotion (SNPP).[17] In 2018, ANDE managed a Training Course in Electrical Engineering through the MoPaDual that offered degrees as industrial electricians and electrotechnical technicians with SNPP training and an internship at ANDE (SNPP, 2020). In addition, CONACYT, through the Program to Support the Development of Science, Technology and Innovation (PROCIT), has been financing projects and scholarships in multi-phase electricity generation to take advantage of the potential of renewable energy.

The country must take actions to fill the imbalance between educational supply and demand for skills in fast-growing energy-related sectors. Public and private entities need to gain additional knowledge and expertise in the design, manufacture, construction, assembly and operation of renewable energy systems and energy efficiency. The energy sector needs to create adequate conditions to spur innovation in the design of new business models and financing mechanisms; knowledge and experience in the installation and maintenance of variable energy systems; and the certification of technologies and processes for the production, transport and consumption of renewable energy; as well as on project development for renewable energy projects

Action 15. Map labour and skill demand and develop training and capacity building programmes

The country can guide its capacity building by mapping current and future technical skills needed in the energy sector (private and public institutions). Mapping the needs in collaboration with academia could serve to align the professional and technical demand of the country in the energy sector, with the existing educational and formation programmes. Participation of the finance sector in the mapping is also key, as a mechanism to create better understanding on the financing of renewable energy projects as well as to improve the financial performance of local renewable project developers.

It is equally important to address priority energy capacities. On the energy and social nexus, the capacity building can prioritise actions to promote the use of sustainable, clean and affordable energy throughout the socio-economic system and especially in vulnerable households, to guarantee good health conditions and greater gender equality. The VMME can prepare a plan to strengthen the capacities of energy institutions. It might consider working with CONACYT to include new trainings in co-ordination with the SNPP, the National System of Labour Training and Education (SINAFOCAL) and energy sector companies.

[17] Created by Law No. 1,253 in 1971.

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