National Renewable Energy Action Plan (NREAP) of São Tomé and Príncipe

Period 2021-2030/2050

In the framework of the vision
"São Tomé and Príncipe 2030: The country we need to build"

Contact

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Validated for approval: January 17, 2022

With technical and financial assistance from the United Nations Industrial Development Organization (UNIDO) and the Global Environment Facility (GEF) under the project "Strategic program to promote renewable energy and energy efficiency investments in the electricity sector."

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With consulting support from:

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ACRONYMS AND ABBREVIATIONS

AFAP	Project Administration Supervision Agency (Agência Fiduciária de Administração de Projectos)
AfDB	African Development Bank (BAD – Banco Africano de Desenvolvimento)
AGER	General Regulatory Authority (Autoridade Geral de Regulação)
ANP	National Petroleum Agency (Agência Nacional do Petróleo)
BAU	Business as Usual
CC-PTSE	Coordination Committee for the Electricity Sector Transformation Program (Comité de Coordenação do Programa de Transformação do Sector Eléctrico)
CP-PTSE	Steering Committee for the Electricity Sector Transformation Program (Comité Piloto do Programa de Transformação do Sector Eléctrico)
CT-PTSE	Technical Committee to support the Electricity Sector Transformation Program (Comité Técnico de apoio ao Programa de Transformação do Sector Eléctrico)
DGA	Directorate General of the Environment (Direcção Geral do Ambiente)
DGRNE	Directorate General of Natural Resources and Energy (Direcção Geral dos Recursos Naturais e Energia)
DL	Decree Law
ECCAS	Economic Community of Central African States (CEEAC – Comunidade Económica dos Estados da África Central)
EE	Energy Efficiency
EIB	European Investment Bank (BEI – Banco Europeu de Investimento)
EMAE	Water and Electricity Company (Empresa de Água e Electricidade)
ENIEG	National Strategy for Gender Equality and Equity (Estratégia Nacional para a Igualdade e Equidade de Género)
GCF	Green Climate Fund
GDP	Gross Domestic Product (PIB – Produto Interno Bruto)
GEF	Global Environment Facility
GHG	Greenhouse Gases (GEE – Gases com Efeito de Estufa)
GHI	Global Horizontal Irradiation

GT-PTSE	Technical Group supporting the Electricity Sector Transformation Program (Grupo Técnico de apoio ao Programa de Transformação do Sector Eléctrico)
INPIEG	National Institute for the Promotion of Gender Equality and Equity (Instituto Nacional para a Promoção da Igualdade e da Equidade de Género)
LCDP	Least Cost Development Plan (PDMC – Plano de Desenvolvimento de Menor Custo)
LCOE	Levelized Cost of Energy
LPG	Liquefied Petroleum Gas (GPL – Gás de Petróleo Liquefeito)
MIRN	Ministry of Infrastructure and Natural Resources (Ministério das Infra-estruturas e Recursos Naturais)
MPFEA	Ministry of Planning, Finance and Blue Economy (Ministério do Planeamento, Finanças e Economia Azul)
NA	Not Available
NAP	National Adaptation Plan (Planeamento Nacional de Adaptação)
NEB	National Energy Balance (BEN – Balanço Energético Nacional)
NEEAP	National Action Plan for Energy Efficiency (Plano de Acção Nacional de Eficiência Energética)
NREAP	National Renewable Energy Action Plan (PANER – Plano de Acção Nacional das Energias Renováveis)
PNES	National Sustainable Energy Platform (Plataforma Nacional de Energia Sustentável)
PNGIRSU	National Plan for Integrated Management of Solid Urban Waste (Plano Nacional de Gestão Integrada de Resíduos Sólidos Urbanos)
PPA	Power Purchase Agreement (CAE – Contrato de Aquisição de Energia)
PPP	Public-Private Partnerships
PV	Photovoltaic (FV – Fotovoltáicas)
RAP	Autonomous Region of Príncipe (Região Autónoma do Príncipe)
RE	Renewable Energies (ER – Energias renováveis)
RJSE	Legal Regime for the Electricity Sector (Regime Jurídico do Sector Eléctrico)
SIDS	Small Island Developing States (PEID – Pequenos Estados Insulares em Desenvolvimento)
SMEs	Small and Medium Enterprises (Pequenas e Medias Empresas - PMEs)
STP	São Tomé and Príncipe
SUW	Solid Urban Waste (RSU – Resíduos Sólidos Urbanos)
UNDP	United Nations Development Programme (PNUD – Programa das Nações Unidas para o Desenvolvimento)

UNEP	United Nations Environment Programme (PNUMA – Programa das Nações Unidas para o Meio Ambiente)
UNIDO	United Nations Industrial Development Organization (ONUDI – Organização das Nações Unidas para o Desenvolvimento Industrial)
WB	World Bank (BM – Banco Mundial)

INTRODUCTION

The sustainable industrial and socio-economic development of São Tomé and Príncipe (STP) is heavily dependent on reforming the energy sector and transitioning from an almost complete reliance on fossil fuels to renewable energy (RE) coupled with energy efficiency (EE). However, introducing RE and EE products and services into the market is hampered by a wide range of demand-side and supply-side barriers, which need to be addressed simultaneously.

To address the existing barriers, the STP Government, with the support of the United Nations Industrial Development Organization (UNIDO), has developed the National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP) under the project: "Strategic program to promote renewable energy and energy efficiency investments in the electricity sector."

These were prepared during 2020 and 2021 under the leadership of the General Directorate of Natural Resources and Energy (DGRNE) of the Ministry of Infrastructure and Natural Resources (MIRN) and by the National Sustainable Energy Platform (PNES). The targets described in the NEEAP and the NREAP were validated by the STP Government through a participatory process led by PNES/DGRNE, involving the exchange of opinions and information, a series of meetings and discussions with PNES/DGRNE, and revisions of the draft plans by PNES/DGRNE and UNIDO. The process was coordinated with the United Nations Development Program (UNDP), the World Bank (WB), the African Development Bank (AfDB) and others.

The NREAP and NEEAP provide the Government with practical guidance on how to make the energy transition a reality by 2030 and 2050. Based on energy modeling using Low Emissions Analysis Platform (LEAP) software, the NREAP and NEEAP propose a low-carbon scenario that will significantly reduce the country's energy costs and greenhouse gas (GHG) emissions. Energy transition is a prerequisite for the achievement of important national, regional and global policy goals.

The main reference documents used in developing the NREAP and the NEEAP are: Vision 2030 "São Tomé and Príncipe 2030: the country we need to build", the Blue Economy Transition Strategy for São Tomé and Príncipe, Agenda 2030 and Agenda 2063: "The Africa We Want", the Nationally Determined Contributions (NDC, 2021), the Third National Communication (TNC) on Climate Change, the National Action Plan for Adaptation to Climate Change (NAPA) and ECCAS/CAEMC regional policies. Implementing the action plans will enable the country to achieve Sustainable Development Goal 7 (SDG-7), which aims for universal access to affordable, reliable, sustainable and modern energy services by 2030.

The NREAP and NEEAP propose a set of targets and measures to be implemented by 2030 and 2050. The well-integrated documents consider urban and rural contexts, electricity and heat aspects, and important cross-sectoral policies (e.g. climate mitigation/adaptation, trade, education, research, buildings, transport, tourism, health, agriculture, fisheries and other sectors of the economy). The NREAP targets complement those established in the NEEAP, while also complementing others for reduction of GHG emissions and for universal access to energy.

The NREAP and NEEAP are tightly interconnected and mutually reinforcing. For example, introducing EE standards and the related reductions in energy demand will have a positive impact on renewable energy penetration in the grid. The NREAP sets specific targets for the RE sector with the main target of significantly increasing the penetration of renewable generation capacity in the STP electricity matrix by 2030. Section 4 describes the specific RE targets in terms of capacity to be installed and expected electricity generation. The RE sources considered in the NREAP include solar photovoltaic energy (utility-scale and microgeneration), construction and rehabilitation of mini-hydropower plants, and the installation of a biomass plant.

In addition, the NREAP and NEEAP also include targets for home cooking applications that aim to gradually replace traditional cooking sources with cleaner and safer ones that have a lower impact on household health and the environment. The aim is to replace traditional stoves with improved high-efficiency ones, to promote the use of liquid fuels for cooking, mainly Liquefied Petroleum Gas (LPG), and, to a lesser extent, to include the use of electricity and solar stoves.

The plans also aim to change the inefficient, fossil fuel based transport system to a more efficient one. This will be achieved with a low-carbon transport strategy and the introduction of EE vehicle standards, as well as the gradual introduction of electric mobility. It is proposed to replace cars, motorcycles and buses that currently burn diesel and gasoline with electric units starting in 2040, when there is expected to be high penetration of RE in the grid. The first demonstration projects could already have been implemented in the tourism sector or on motorcycles.

In addition to goals and targets, the NREAP defines trajectories and identifies all the measures and programs that will have to be implemented in order to achieve the targets. The plan also identifies in the proposed measures the need to develop specific legislation and regulations to introduce incentive mechanisms for the production of RE (financial and access to finance, especially for farmers and productive use applications), institutional strengthening measures (e.g. creation of the RE department in DGRNE), as well as the need for capacity building of technical and professional cadres (including the support and coordination by local and foreign universities). It also emphasized the need for information dissemination and awareness raising among the population, as well as measures for carrying out supplementary studies in order to improve the local availability of information about the RE potential in the country, in addition to defining specific programs in the energy sector (e.g. for the adoption of efficient charcoal production techniques).

The LEAP software was used in the NREAP (and the accompanying NEEAP) as a tool for modeling possible future scenarios for 2030 and 2050. The following two scenarios were modeled:

- The BAU (Business-as-Usual) scenario, which could imply that no mitigation measures are implemented; and
- The mitigation scenario, which considers the implementation of all mitigation measures proposed in the two plans (NREAP and NEEAP).

Various projections were made under the two scenarios, including energy demand by sector and by fuel type. For each of the scenarios, the end result modeled by LEAP was the greenhouse gas (GHG) emissions, such that the difference between the two scenarios will be the estimated reductions in such emissions. In addition to GHG reductions, LEAP also made it possible to calculate the energy savings (from which the reductions come) in terms of electricity or fuel saved per sector, etc. Knowing the estimate of these savings is relevant for the national economy since STP still does not produce fossil fuels and, considering this is all imported at the international price, reduced consumption will have a significant positive impact on government expenditure, enabling savings to be redirected to spending in areas such as health, education and others.

Based on these projections produced by LEAP (for which the baseline data include the estimated year of commissioning of the different RE plants), the country would have RE penetration of 72% in the total installed capacity by 2030, which would be maintained until 2050. STP decided to adopt this figure as the target for RE penetration in the generation matrix (in terms of installed capacity) by 2030 and by 2050 under the NREAP. These targets are more ambitious than in previous plans.

The sources of information for the baseline data that were entered into LEAP and also used to develop the two plans described in Annex VI (Bibliography). The methodology used for this work is described in Annex V.

1 EXECUTIVE SUMMARY

Socio-Economic Challenges and Integrated Energy

São Tomé and Príncipe (STP) is a small country in sub-Saharan Africa, which is part of the Small Island Developing States (SIDS) and, as such, faces specific challenges in relation to its size (1,001 km^2, 219,161 inhabitants), remoteness from major markets, dependence on a small number of economic sectors, direct investment and remittance inflows, lack of resources and a significant trade deficit. The economic sector consists essentially of the production and export of cocoa, which accounts for about 90% of total export revenues.

The largely informal tertiary sector accounts for about 60% of Gross Domestic Product (GDP), employing 60% of the working population, while the primary and secondary sectors each contribute 20% of GDP (USD 418.6 million in 2019). With regard to agricultural production, STP imports about 15% of the food it needs. However, it faces a rural exodus, with the countryside being abandoned, while traditional and subsistence cultural practices prevail. In addition, key sectors of the economy are highly vulnerable to natural, climatic and external economic shocks.

Industry has a limited share in the national economy, contributing 13.3% to the country's GDP, of which 6.3% is attributed to the construction industry. There is no heavy industry in the country and its current capacity and technological development for transforming raw materials into manufactured goods is low, mainly due to the lack of know-how. The private sector is limited to a few small and medium enterprises (SMEs) in areas such as baking, brewing, distillation of spirits from local produce (rum), palm oil, natural juices from local fruits, mineral waters, paints, soap, coconut oil, manufacturing of building materials, bricks, metal locks, wood processing, shipbuilding, energy production, clothing and furniture production. However, despite the small size of local private industry, STP offers significant business potential in the agri-food sector, both for processing and adding value to local products, and for meeting the needs of local consumption.

Currently, STP has one of the highest power generation costs in sub-Saharan Africa. The energy sector continues to be subsidized and tariffs are not cost reflective, so the national utility company, Water and Electricity Company (EMAE), is unable to recover its costs and the country faces challenges resulting from an outdated transmission and distribution system, a power generation mix highly dependent on expensive diesel, and poor management. In addition, grid losses are worryingly high, being about 33% of power generated in 2019, according to EMAE. Grid losses are associated with inefficiencies in the transmission and distribution networks, accompanied by theft and fraud in the use of electricity.

STP does not yet produce fossil fuels and, therefore, all those consumed in the country are imported, making it dependent on imports and international price fluctuations. The electricity supply is characterized by frequent power cuts and load shedding, forcing businesses and providers of essential social services to run on diesel generators.

Access to electricity services has evolved positively and it is estimated that 84% of the population of São Tomé had access to electricity in 2019. STP's energy policy includes a target of achieving a 100% electrification rate by 2030, thereby ensuring that the entire population has access to reliable electricity services. In the case of grid-connected power generation, the installed generation capacity in 2019 was estimated at 29.7 MW, of which only 19.9 MW had guaranteed availability. Only 1.22 MW is hydropower, the remaining capacity being thermoelectric (diesel). In addition to grid-connected generation, the island of São Tomé had three isolated (diesel) power plants in 2019, with a total installed capacity of 544 kW, of which only 178 kW had guaranteed availability. There are also a number of self-producers, not connected to the power grid, which generate locally for their own consumption, consisting mainly of hotels in the tourism sector.

It is important to stress the role of transport in the country's energy demand. Air (commercial and bunker flights), sea and land transport exist in STP. Air transport consumes aviation fuel, while shipping consumes diesel and lubricants. Land transport consumes gasoline, in addition to diesel and lubricants. The land transport sub-sector is considered the second largest consumer of fossil fuels.

The majority of the population does not have access to sustainable cooking services and relies significantly on traditional biomass (firewood) and charcoal. It is estimated that about 72% of the population uses solid fuels for cooking, with firewood used by 45.6% of households, followed by charcoal (26.5%) and oil (25.5%), with liquefied petroleum gas (LPG) used by only 1.5%. In addition to firewood, charcoal is also used for cooking and is produced locally. It is estimated that almost 75%

of the wood consumed in the country is mostly illegally and irrationally exploited without any regulation or inspection.

Sustainable industrial and socio-economic development depends heavily on reforming the energy sector and transitioning from an almost complete dependence on fossil fuels to RE and EE. Such a transition will lead to a significant reduction in fossil fuel import costs and release scarce monetary resources for social and economic development (e.g. education, health care, transport, export diversification, development of Small and Medium Enterprises (SMEs), and climate change adaptation). In addition, it will help the island's main industries and income-generating activities (e.g. water supply, agriculture, food processing, tourism, fishing and the blue economy in general) to become more productive and competitive.

Renewable Energy Potential and Barriers

In the electricity sector, STP has abundant RE availability, which is highly competitive when compared with diesel generation. The potential is striking, especially with regard to solar energy and hydropower. The infrastructure of several hydropower plants exists in the country, which supplied 80% of electricity 40 years ago, but, unfortunately, the plants began to stagnate and degrade in the post-independence era, and thermal plants were installed to compensate this. Some of these hydropower plants could be rehabilitated and used in future projects to be developed. The hydropower potential through exploiting various rivers and streams that flow through the islands is one of STP's greatest energy resources.

The solar potential in the north/northeast coastal area of the island of São Tomé is around 4 kWh/kWp and on the island of Príncipe it is around 3.5 kWh/kWp. So far, solar photovoltaic (PV) energy has been used in STP as an alternative source to supply electricity to telecommunications stations, military signaling, water treatment plants and private initiatives (hotels, the UN building), as well as schools and agricultural cooperatives in rural areas as part of aid projects with funding from international partners.

No full study of the solar potential in the country has yet been conducted, but there have been studies in specific areas or locations on the islands showing that there is sufficient potential to be exploited. With regard to the use of solar thermal energy, there is no clear data regarding its potential in STP. Experiences in other countries indicate that it could be relevant to study the use of solar thermal technologies to heat water and dry agricultural products, such as cocoa beans. The measures proposed in the NREAP include conducting studies to fill these information and data gaps.

The potential of wind power is low and there are only small-scale, privately-owned wind projects. According to data from the National Institute of Meteorology, wind speed normally varies between 2.5 m/s and 6.3 m/s, and has its greatest impact in the southern region of the island of São Tomé. There is no accurate information about the potential for offshore wind power in the coastal area of STP, but it can be seen from the "Global Wind Atlas" that the wind speed at sea in the coastal areas is also low (in the range of 3-4 m/s).

The vegetation of the country is diverse, with varied forest formations and ample plant coverage. Today, the plant biomass is the energy source most widely used by the population for supplying energy to residential buildings. It has been recorded that the use of firewood as the main source of energy at the household and commercial level (small bakery and catering industries) has resulted in deforestation, the expansion of rural communities into protected forest areas, the loss of both flora and fauna biodiversity, and erosion. In addition to firewood, charcoal is also used for cooking and is produced locally.

In the case of ocean energy, further studies need to be conducted in the coastal areas of the country, but on the basis of the *a priori* information available internationally, the potential of the Gulf of Guinea area for tidal and wave energy is not attractive. STP’s location may offer attractive potential for providing Ocean Thermal Energy Conversion (OTEC) services, due to high surface seawater temperatures, steep underwater cliffs and low risk of tropical storms. Puerto Rico is an island territory of similar size to STP with a well-known OTEC resource, of about 38 TWh per year, equivalent to the supply for 3,600,000 households.

However, the country has not yet taken advantage of these potential sources. There has been no significant progress regarding the integration of RE and EE in the last decade. The RE baseline remains limited to micro/mini-hydropower plants from colonial times, of which only one is partially operational, and small solar PV applications for rural households and productive activities. The

baseline with regard to EE is low and largely unknown. Previous international support to the RE and EE sector in STP has been very fragmented and uncoordinated. These efforts have focused only on the electricity sector and existing barriers have not been addressed in a coherent, cross-sectoral manner. The impact of these scattered interventions has been very limited.

In STP, introducing RE and EE products and services into the market is hampered by a wide range of demand-side and supply-side barriers, which need to be addressed simultaneously. These relate to institutional capacity, policy and regulation, knowledge management, skills, and entrepreneurship, as well as access to finance and technology. The introduction of new products and services into the market for RE and EE technologies requires specific "push and pull" actions directed at overcoming barriers on the demand side (consumers of products and services) and the supply side (suppliers of products and services).

The National Renewable Energy and Energy Efficiency Action Plans

To address the existing barriers, the STP Government, with the support of the United Nations Industrial Development Organization (UNIDO), has developed the National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP) under the project: "Strategic program to promote investments in renewable energy and energy efficiency in the electricity sector."

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The NREAP and NEEAP provide the STP Government with practical guidance on how to make the energy transition a reality by 2030 and 2050. Based on energy modeling using Low Emissions Analysis Platform (LEAP) software, the NREAP and NEEAP propose a low-carbon scenario that will significantly reduce the country's energy costs and GHG emissions. Energy transition is a prerequisite for the achievement of important national, regional and global policy goals.

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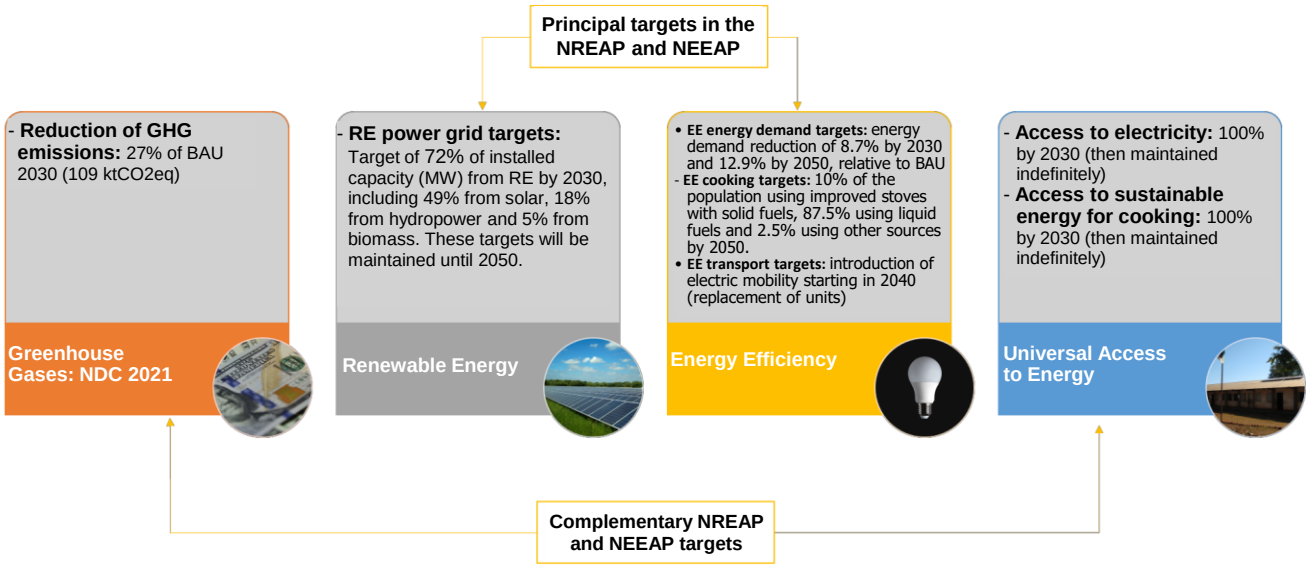
The NREAP and NEEAP propose a set of targets and measures to be implemented by 2030 and 2050. The well-integrated documents consider urban and rural contexts, electricity and heat aspects, and important cross-sectoral policies (e.g. climate mitigation/adaptation, trade, education, research, buildings, transport, tourism, health, agriculture, fisheries and other sectors of the economy). The NREAP targets complement the targets established in the NEEAP, while also complementing those for reduction of GHG emissions and for universal energy access.

The NREAP and NEEAP are tightly interconnected and mutually reinforcing. For example, introducing EE standards and the related reductions in energy demand will have a positive impact on RE penetration in the grid.



The NREAP sets specific targets for the RE sector, with the main target being to significantly increase the penetration of renewable generation capacity in the STP electricity matrix by 2030 and 2050 (grid-connected, as well as off-grid), in line also with what the STP Government has defined in the Nationally Determined Contributions (NDCs) and the Third National Communication (TCN) on Climate Change.

The target of RE achieving 72% of total installed electric capacity by 2030 will be maintained until 2050, and will consist of: (i) rehabilitation/construction of mini-hydropower plants totaling 17.30 MW (15.30 MW grid-connected and 2 MW not grid-connected); (ii) installation of solar PV projects totaling almost 47 MW (42.20 MW grid-connected, some with energy storage, and 4.75 MW isolated with energy storage), and a microgeneration program for 800 households with isolated and roof-top domestic solar PV systems); and (iii) a 4.68 MW biomass cogeneration plant.

These projects will also be complemented by ongoing projects for the rehabilitation of the energy transmission, transformation and distribution infrastructure, and by support projects for strengthening the institutional, policy and regulatory framework, and training and capacity building of the government areas involved in the management of the energy sector, as well as other stakeholders. Smart grid management, energy storage to handle high RE penetration, and digitalization are important elements of these projects.

In addition, the NREAP and NEEAP also include targets for home cooking applications that aim to gradually replace traditional cooking sources with cleaner and safer ones that have a lower impact on household health and the environment. The aim is to replace traditional stoves with improved high-efficiency ones and to promote the use of liquid fuels for cooking, (mainly LPG), and, to a lesser extent, to include the use of electricity and solar stoves. The goal of 100% access to efficient energy for cooking by 2030 complements that of 100% access to electricity services by that same year, thereby ensuring universal energy access by 2030 for the São Tomé population. These goals are directly aligned with the United Nations' SDG-7: "*Ensure access to affordable, reliable, sustainable and modern energy for all*."

The plans also aim to improve the inefficient, fossil fuel-based transport system, transforming it into a more efficient, low-carbon system. This will be achieved with a low-carbon transport strategy and the introduction of EE vehicle standards, as well as the gradual introduction of electric mobility. This work will also include aspects of maritime transport and ports. It is proposed to replace cars, motorcycles and buses that currently run on diesel and gasoline with electric units starting in 2040, when there is expected to be high RE penetration in the grid. The first demonstration projects could already have been implemented in the tourism sector or on motorcycles.

In addition to goals and targets, the NREAP defines trajectories and identifies all the measures and programs that will have to be implemented in order to achieve the targets. The plan also identifies and classifies the measures into several categories, which include the development of specific legislation and regulations to introduce incentive mechanisms for the production of RE (financial and access to finance, especially for farmers and applications in productive uses), institutional strengthening measures (e.g. creation of the RE department in DGRNE), measures to meet the need for capacity building of

technical and professional cadres (including the support and coordination of local and foreign universities), information dissemination and awareness raising among the population, as well as measures for carrying out supplementary studies in order to improve the local availability of information about the RE potential in the country, as well as defining specific programs in the energy sector (e.g. for the adoption of efficient charcoal production techniques), and specific measures for implementing RE projects to increase RE penetration in the electricity matrix. The NREAP contains a set of 55 proposed measures, distributed among the aforementioned categories. Some of these measures are contained in both plans as they relate to EE as well as to RE.

Socio-Economic and Environmental Benefits of the Action Plans

Implementing the NREAP and NEEAP will bring significant economic, social and environmental benefits to STP. The LEAP software was used in the NREAP (and the accompanying NEEAP) as a tool for modeling possible future scenarios for 2030 and 2050. The following two scenarios were modeled:

- The BAU (Business-as-Usual) scenario, which could imply that no mitigation measures are implemented; and
- The mitigation scenario, which considers the implementation of all mitigation measures proposed in the two plans (NREAP and NEEAP).

The economic benefits from implementing the NREAP and NEEAP are significant and will have a positive impact on the country's economy. Using the renewable resources present in STP will reduce dependence on fossil fuels that are currently imported and require a significant portion of the GDP (Gross Domestic Product). The BAU scenario shows that there will be an increase in fossil fuel demand, whereas in the mitigation scenario a portion of this demand will be avoided through the implementation of the RE and EE measures.

In this scenario, it is estimated that there would be an approximate saving of 984,187.8 tons of diesel by 2050, which represents approximately USD 1.16 billion considering diesel price forecasts. The estimated cumulative net benefits far outweigh the projected initial investment costs for the established RE project pipeline, which totals about USD 171 million by 2030. This is particularly true if the projects attract private capital, concessional financing and foreign direct investment.

in 2019 (the base year adopted in the NREAP and NEEAP), expenditure on diesel imports corresponds to 8.4% of STP's GDP[1] (USD 23,627,631). With the implementation of the measures, this percentage is reduced to 0.6% in 2030 (USD 2,529,826) and 0.9% in 2050 (USD 8,447,240.71). The reduction in expenditure on imported fuel will allow funds to be redirected to other areas, such as health and education.

Implementing the NREAP measures will also guarantee universal access to energy services for the entire population, as well as providing opportunities for productive uses, particularly in rural areas. In addition, the development of the RE and EE market will offer local "green employment" opportunities in terms of manufacturing, assembly and maintenance of products. Increased productivity and employment opportunities will be of particular benefit to women and young people in rural areas. Urban industrial and commercial sectors (including the blue economy) will benefit from lower energy costs and energy service reliability.

The most relevant social benefit for the population is the improved access to reliable electricity services, which will directly impact their quality of life. Access to electricity services in rural areas has a positive impact on the provision of health and education services. When health institutions (e.g. hospitals) and education institutions (e.g. rural schools) have access to electricity they can offer better services, for example they can use electrical equipment and have better communication, lighting, internet, etc. Health is also improved by reducing the use of traditional stoves, which will be replaced by improved ones and cleaner fuels or cleaner cooking technologies. At the same time, improved health will reduce the pressure on the health care system and the incidence of respiratory diseases (principally in women and children). Access to electricity services will also positively impact the implementation of certain measures related to improving water and sanitation management, such as implementing technologies to purify water in isolated communities.

[1] *The country's estimated GDP in 2019 was USD 279,700,465 at constant 2010 prices (source: World Bank), in 2030 it is estimated at USD 423,039,635.68 and in 2050 at USD 910,596,621.18*

The overall environmental benefit of implementing the NREAP and NEEAP is to significantly reduce GHG emissions in the power sector and to achieve the 27% emission reduction target set in the NDC (2021) by 2030. As noted earlier, STP is currently a "non-emitting" country for GHG, as the amount of forest and plant cover makes it a natural carbon sink and, therefore, offsets its GHG emissions. Considering the projections made with LEAP in the BAU scenario, this condition could change approximately in 2037. In the mitigation scenario modeled with LEAP, this change would be delayed until, approximately, 2049, thanks to the RE and EE measures proposed in the NREAP and NEEAP.

Another positive impact of the NREAP is the reduction of deforestation associated with the collection of firewood for cooking and charcoal production and, therefore, the plan will contribute to better conservation and management of forest resources. Furthermore, reducing the use of diesel generators and reusing organic waste for energy generation will bring additional environmental benefits. This could reduce the impact of waste burning and discharge of wastewater and agro-industrial effluents into the sea.

2 THE CURRENT STATE OF ENERGY IN THE COUNTRY AND THE POTENTIAL OF RENEWABLE ENERGY

2.1 Context

STP is a state in the Gulf of Guinea consisting of two islands located about 150 km apart from each other and several islets. Its total area is 1,001 km^2 and it is approximately 300 km from continental Africa (Gabon). The country's Exclusive Economic Zone covers 170,000 km² of the sea. Due to its volcanic origin, it is characterized by a very rugged relief, with mountainous areas of volcanic basalt predominating in the interior, with the peak of the island of São Tomé, at 2,024 m, standing out, and plains in the coastal areas. More gradual slopes and a wider coastal zone with larger and more elongated watersheds feature in the northern and eastern region of the island, while the southern region is characterized by plains (CECI Engineering Consultants, 2008). STP's population of 219,161 (World Bank, 2021) is strikingly young, with 62% in the 0-25 age range (STP Government, 2019). The population continues to suffer greatly from the limited and insular internal market, weak purchasing power and poor diversification of the economy. The Family Budget Survey (IOF, 2010) found that 66.2% of the São Toméan population is poor; that poverty predominantly affects female-headed households and that rural populations are most affected, being, therefore, the main cause of the rural exodus (STP Government, 2019). This trend is reflected in the disparities in population concentration between rural and urban areas, with 67% of the population being in urban areas and 33% in rural areas (ALER/ STP Government, 2019).

São Tomé's economy is heavily dependent on Official Development Assistance (ODA), which funded 97.3% of the 2019 State Budget. The economic sector continues to be fragile and not very diversified, and consists mainly of the production and **export of cocoa**, which accounts for about 90% of total export revenues. The largely informal tertiary sector accounts for about 60% of GDP, employing 60% of the working population, while the primary and secondary sectors each contribute 20% of GDP (STP Government, 2019). With regard to agricultural production, STP imports about 15% of the food it needs. However, it faces a rural exodus, with the countryside being abandoned, while traditional and subsistence cultural practices prevail.

STP faces specific challenges to its sustainable development. Its growth and development is often hampered by high transport and communication costs, and expensive public administration and infrastructure, as it is small in size and there are limited or non-existent opportunities to foster economies of scale (STP Government, 2019).

In terms of the share of activities in GDP, the activity with most weight in the STP economy is commerce, representing 25.4% of GDP in 2017 (see Figure 1). In the case of the industrial sector, there is no heavy industry in STP. The private sector is limited to a few small and medium enterprises (SMEs) in areas such as baking, brewing, brick making (blocks), palm oil manufacture, natural juice production with local fruits, manufacture of mineral water, building material, paint, local spirits (rum), soap, coconut oil, metal locks, wood processing, shipbuilding, energy production, clothing and furniture production. The country's current technological capacity to transform raw materials into manufactured goods is low. The low level of technological development for processing local products, as well as the lack of know-how, immediately limits the likelihood of expanding and promoting industry in the country. However, despite the small size of local private industry, STP's economic circumstances offer significant business potential in the agri-food sector, both for processing and adding value to local products, and for meeting the needs of local consumption.

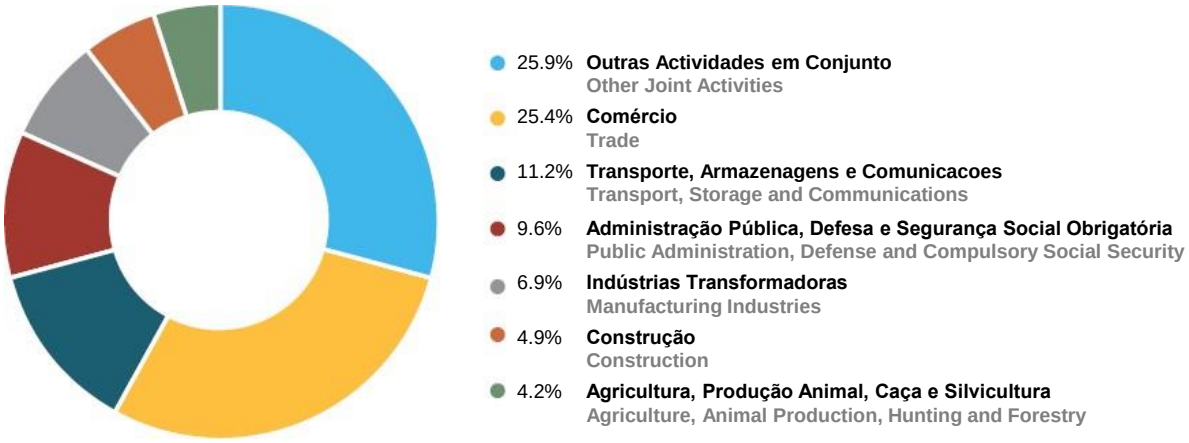


Figure 1: Contribution of the activities in different sectors to GDP in 2017 (ALER/STP Government, 2019)

2.2 The energy sector in STP

The energy matrix of STP is characterized by the high use of biomass (firewood and charcoal) for domestic consumption, and the consumption of ga, predominantly for electricity generation. **Total primary energy consumption in 2019 was 984.9 TJ**, of which 97.9% came from biomass resources (firewood) and 2.1% from water resources (STP Government, 2021).

It is estimated that about 72% of the population uses solid fuels for cooking, with firewood used by 45.6% of households, followed by charcoal (26.5%) and oil (25.5%), with liquefied petroleum gas (LPG) used by only 1.5% (UNDP, 2021). The latest information collected for preparing the GHG Inventory finalized in June 2021 shows that in 2019, 52% of the inhabitants consumed firewood and charcoal (DGRNE, 2021). Unfortunately, forest biomass is not consumed in a sustainable way, and, therefore, from an environmental point of view, this practice poses a threat to the stability of the ecosystem. This is why the NREAP and the NREEP propose measures whose objective is to gradually replace the consumption of solid fuels for cooking with liquid fuels (mainly LPG), in addition to the introduction of improved (more efficient) stoves to replace the traditional three-stone stoves. In addition, the measures aim to introduce other cooking technologies, specifically solar or electric stoves, but in a small percentage and in the long term.

STP does not yet produce fossil fuels and, therefore, all those consumed in the country are imported. STP households and professional energy consumers currently consume fossil fuels such as diesel (for electricity generation), kerosene (for lighting and cooking) and LPG (for cooking). Candles and battery-operated lanterns are also used for lighting in some places. There are oil reserves in the Gulf of Guinea, which are exploited by several countries in the region. Oil production in the area started in the 1970s, mainly in Nigeria (which continues to be the largest exporting producer in the Gulf), Angola and the Republic of Congo. These were later joined by Cameroon, Gabon and Equatorial Guinea. Ghana has also recently gained importance as an oil producer on the west coast of Africa. In the case of STP, there have been some hydrocarbon discoveries (e.g. by Chevron in 2006), mainly in the Joint Development Zone shared between STP and Nigeria (Offshore Magazine, 2006). In 2020, STP and Equatorial Guinea agreed to establish a Special Zone for Joint Exploitation to exploit and develop cross-border oil and gas reserves believed to be in the blocks that border each country's maritime zone (Offshore Energy Today, 2020). Its commercial viability still has to be verified. However, since STP has no oil refinery, the country would have to export crude oil and will continue importing refined products (e.g. diesel).

Although a potential oil resource has been identified nationally, experience to date has shown that its depth makes it unlikely that commercial exploitation will be realized in the near future. Currently, all petroleum products are imported, making the country dependent on imports and international price fluctuations (ALER/STP Government, 2019).

The industrial sector in STP has a limited share in the national economy, contributing 13.3% to the country's Gross Domestic Product (GDP) (USD 418.6 million in 2019), of which 6.3% (STP Government, 2019) is attributed to the construction industry. GHG emissions also arise from the food industry (bakery and artisanal alcoholic beverage production), which generally uses firewood as its main source of energy. **These industries represent only 7% of the number of "large electricity consumers" in the**

customer database of the Water and Electricity Company (EMAE) and less than 4% of total sales within that category (Ricardo Energy and Environment, 2018)**.**

Electricity sale tariffs are "social" in nature, not reflecting the cost of electricity production, and have not been updated since 2007. It is critical, therefore, to implement a new tariff structure to ensure the financial and technical sustainability of EMAE, and for this purpose a tariff study has already been prepared. With regard to electricity purchase tariffs, there is no calculation model with specific criteria for determining prices (ALER/STP Government, 2019).

Furthermore, STP's banking sector is very small, the financial system is very weak, and the State is unable to provide the sovereign guarantees necessary to cover EMAE's risk in the Power Purchase Agreements (PPAs) to be executed, which makes it difficult for private investors to access credit. For this reason, most projects are funded by international institutions and organized by the public sector or Non-Governmental Organizations (NGOs) (ALER/STP Government, 2019).

In terms of education, only limited higher, technical and professional education is offered nationally and does not include specialized courses in the energy sector, with only more general courses being available, which may equip students for further studies in the area of renewable energy. The renewable energy projects that have been implemented have provided training at the local level to the beneficiaries and those responsible for management and maintenance of the projects, which has enabled some local technicians, specifically young people, to be trained. There have been no initiatives in the areas of research, certification and audits. This gap at the level of capacity building of local human resources has been one of the main barriers in the sector, which may be addressed in the training and certification activities planned under the projects of international partners (ALER/STP Government, 2019).

2.2.1 Projections of energy demand in BAU

The BAU is primarily a projection of the expected trend of STP's energy systems given current policies, and consequently the resulting GHG emissions. No new energy or GHG reduction policies are included in the BAU scenario. Methods vary by sector, but are mainly driven by external assumptions regarding population and GDP growth:

- The historical population data and projections to 2050 are taken from the medium variant in the UN population outlook report. The UN's historical data are similar to the country's own census. Household size is derived from population data from the STP Household Budget Survey 2017.
- Historical GDP data are taken from the World Bank's Development Indicators series (NY.GDP.MKTP.KD) measured in USD at the 2010 value. GDP growth estimates through 2025 are taken from the IMF's World Economic Outlook for STP. For the period 2025-2050, we assume slowly declining growth (declining from 4.5% per year in 2025 to 3.7% per year in 2050, reflecting a gradually aging population and, consequently, less rapid growth in the labor force). Value added in each major subsector (industry, services and agriculture) has also been obtained from the World Bank's World Development Indicators. The GDP share of each subsector has been considered constant over the study period.

These key macroeconomic and demographic variables guide the calculation of energy demands in each scenario. The number of households is used as the basis for projecting residential energy demand. The GDP share or value added relating to the major sectors are used as a basis for projecting demand in other sectors. The population and GDP projections are the same in each scenario (BAU and mitigation).

To project energy demands, it is necessary to calculate energy intensities from historical data. To do so, fuel consumption data are taken from STP's National Energy Balance (NEB) and divided by the relevant activity levels to generate energy intensities. Future energy demands are simply the product of both future activity levels and energy intensities. We take a conservative approach by assuming that the energy intensities remain constant, in the most part, in BAU.

For each fuel in each sector, we specify standard emission factors that correspond to the IPCC Tier 1 methodology to calculate the overall emissions of GHGs and air pollutants.

Figure 2 and Figure 3 show the energy demand projections through 2050 in the baseline scenario (BAU), that is, the scenario without mitigation measures being implemented, by fuel type and by sector, respectively. As can be seen, firewood would be the most predominant fuel as it is the most frequently used as an energy source for household cooking and in the commercial/institutional sector. From Figure

2, in the BAU scenario there will also be an increase in the demand for fossil fuels, particularly gasoline and diesel, which are mainly used in the transport sector.

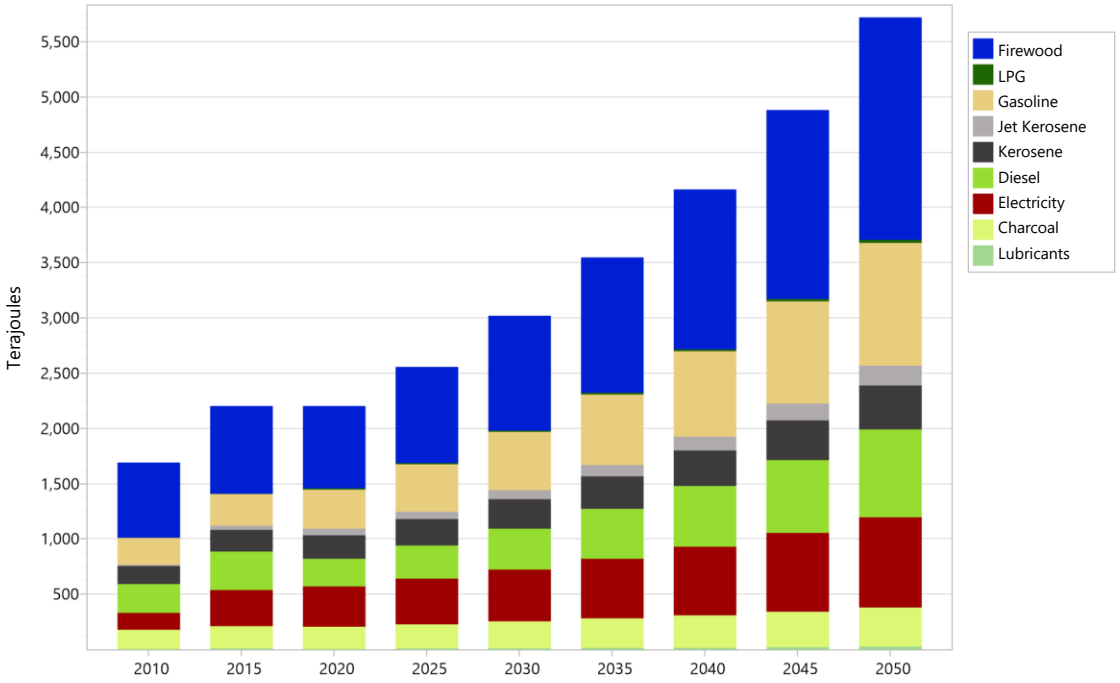


Figure 2: Projection of energy demand in the BAU scenario (2010 - 2050), by fuel type (in TJ)

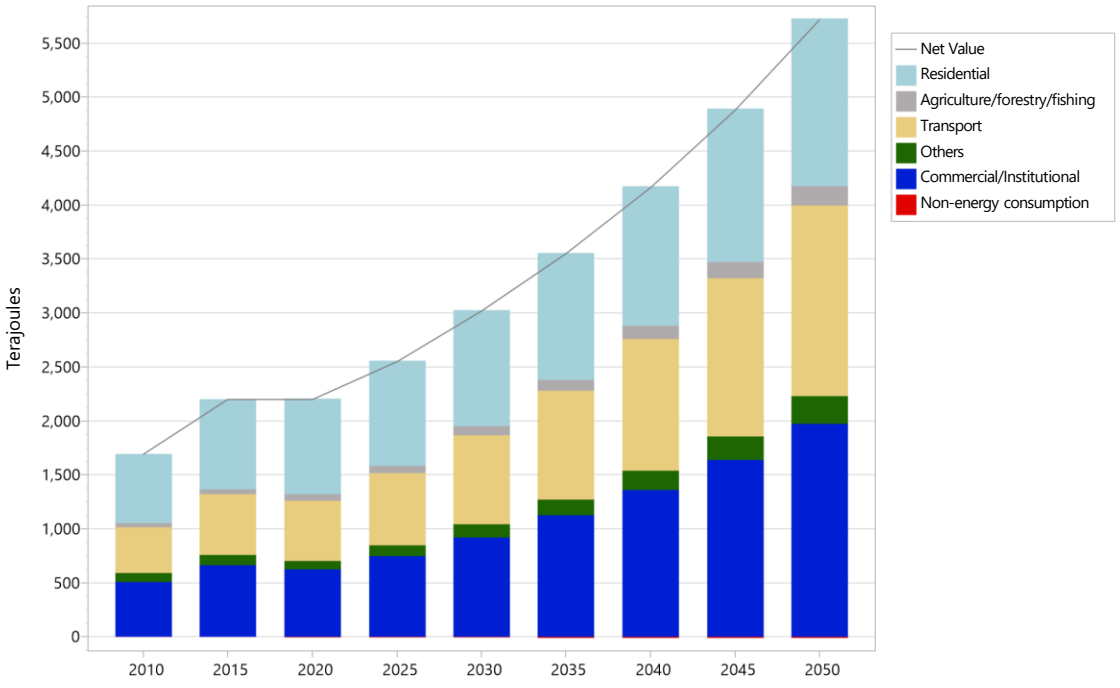


Figure 3: Projection of energy demand in the BAU scenario (2010 - 2050) by sector (in TJ)

The numerical data for the energy demand projections shown in Figure 2 and Figure 3 are given in two tables in Annex I.

Based on the information obtained from the data collection used in the development of the IGEE 2021 report for the energy sector, it is important to highlight the role of transport in the country's energy demand. Air (commercial and bunker flights), sea and land transport exist in STP. Air transport consumes Jet-A1 or aviation fuel (Jet kerosene), while shipping consumes diesel (gasoil) and lubricants.

Land transport consumes gasoline, in addition to diesel (gasoil) and lubricants. According to the IGEE data, the transport sector, in particular the land transport subcategory, is considered the second largest consumer, with 80% of gasoline and 17% of gasoil, as percentages of overall consumption. Under the NREAP, STP aims to shift land transport to more efficient, environmentally friendly and sustainable transport in the long term, proposing not only to develop strategies to decarbonize the transport sector as a whole, but also proposing to replace cars, motorcycles and buses that currently burn diesel or gasoline with electric units from the year 2040. By 2040, it is expected to have already achieved significant renewables penetration in the power grid, which would help support the transport sector's transition to electricity without diesel use increasing significantly.

2.2.2 Electricity subsector

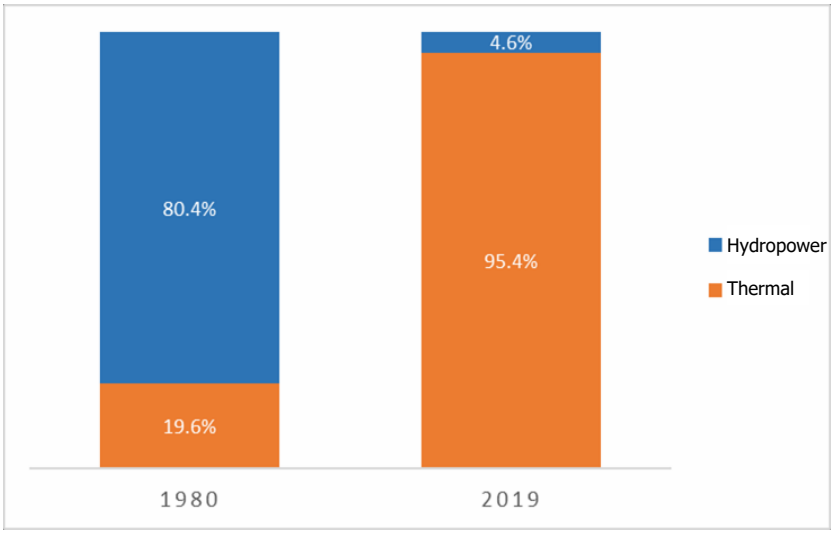


Figure 4: Electricity matrix in 1980 vs. 2019

Electricity production in STP has been increasing over the last 40 years due to increased consumption resulting from the electrification of the country, in line with the growth of the population and São Tomé's economy. Electricity generation has grown sharply since 2009 with the commissioning of new thermal power plants. In 2010, production was 57.9 GWh, while in 2019 it reached 109.1 GWh, an increase of approximately 90% in 9 years. Unfortunately, the hydropower plants that supplied the country's electricity needs in the 1980s began to stagnate and degrade in the post-independence era, and thermal power plants were installed to compensate this (see Figure 4). The following figure shows the increasing electricity demand by sector in BAU (Figure 5), considering the potential evolution of the economy.

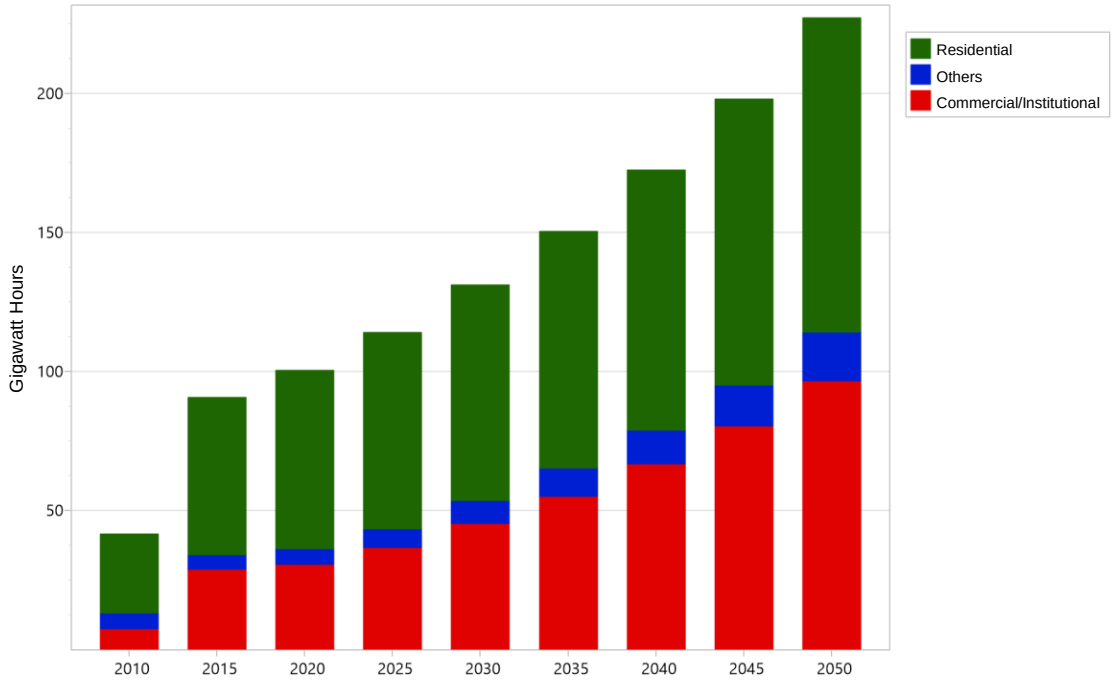


Figure 5: Evolution of final demand for electricity by sector in the BAU scenario (2010-2050) in GWh

STP's electricity matrix is poorly diversified, being predominantly six gasoil-fired power plants, five of which are located on São Tomé and one in RAP, with just one hydropower plant located on São Tomé. The majority of the thermal power plants have been in operation for more than 10 years and have a guaranteed availability well below the total installed capacity, as can be seen in Table 1.

Table 1: Installed capacity of generating plants in STP (EMAE, 2019)

Type	Power Plants	Generator Sets	Year commissioned	Installed power (kW)	Guaranteed output (kW)	Energy Produced (kWh)	Percent. (%)
São Tomé Interconnected Thermal	São Tomé	ABC 3	1996	1,280	675	4,479,850	52.73%
		Caterpillar	2009	1,300	1,000	2,187,000	76.92%
		Deutz 1	2001	1,450	872	6,851,750	60.14%
		Deutz 3	2001	1,450	830	1,835,850	57.24%
		Perkins 1	2015	1,000	584	1,092,775	58.40%
	Subtotal São Tomé			**6,480**	**3,961**	**16,447,225**	**61.13%**
	Sto. Amaro 1	Himsen #2	2010	1,701	1,359	10,543,560	79.89%
		Himsen #3	2010	1,701	1,358	10,831,140	79.84%
		Himsen #4	2010	1,701	1,398	8,758,170	82.19%
		Himsen #5	2010	1,701	1,355	10,285,910	79.66%
	Sto. Amaro 1 subtotal			**6,804**	**5,470**	**40,418,780**	**80.39%**
	Sto. Amaro 2	ABC #1	2016	2,000	1,641	12,834,884	82.05%
		ABC #2	2016	2,000	1,618	11,558,885	80.90%
		ABC #3	2016	2,000	1,624	12,065,227	81.20%
	Sto. Amaro 2 subtotal			**6,000**	**4,883**	**36,458,996**	**81.38%**
	Bobô-Forro 1	Group no. 2	2011	800	499	309,686	62.38%
		Group no. 5	2011	800	174	1,390	21.75%
		Group no. 9	2011	800	598	954,238	74.75%
	Bobô-Forro 1 subtotal			**2,400**	**1,271**	**1,265,314**	**52.96%**
	Bobô-Forro 2	Perkins no. 1	2015	1,636	-	-	0.00%
		Perkins no. 2	2015	1,636	1,300	2,015,000	79.46%
	Bobô-Forro 2 subtotal			**3,272**	**1,300**	**2,015,000**	39.73%
	São Tomé interconnected thermal subtotal			**24,956**	**16,885**	**96,605,315**	**67.66%**
São Tomé Hydro	Contador	Turbine 1	1967	960	547	2,447,000	56.98%
		Turbine 2	1967	960	674	3,386,000	70.21%
	S. Tomé hydropower subtotal			**1,920**	**1,221**	**5,833,000**	**63.59%**
SÂO TOMÉ INTERCONNECTED TOTAL				**26,876**	**18,106**	**102,438,315**	**67.37%**
São Tomé isolated	Porto Alegre	Perkins	2015	328	130	405,600	39.63%
	Ribeira Peixe	Deutz		108	30	91,800	27.78%
	Monte Mario	Perkins		108	18	53,838	16.67%
	S. Tomé isolated subtotal			**544**	**178**	**551,238**	**32.72%**
TOTAL ON SÂO TOMÉ				**27,420**	**18,284**	**102,989,553**	**66.68%**
Príncipe	Thermoelectric	Caterpillar 2	2014	700	450	198,000	64.29%
		Caterpillar 3	2019	700	494	80,000	70.57%
		Caterpillar 4	2014	700	440	1,936,880	62.86%
		Caterpillar 5	2014	700	440	2,944,727	62.86%
	Príncipe thermal subtotal			**2,800**	**1,824**	**5,159,607**	**65.14%**
	TOTAL ON PRÍNCIPE			**2,800.00**	**1,824**	**5,159,607.00**	**65.14%**
GRAND TOTAL ON SÂO TOMÉ AND PRÍNCIPE				**30,220.00**	**20,108**	**108,149,160.00**	**66.54%**

In the case of **grid-connected** power generation, the installed generation capacity in 2019 was estimated at 29.7 MW, of which only 19.9 MW had guaranteed availability, in other words, the useful power, the maximum that the system can provide to customers. **Only 7.5% (1.22 MW) is of hydropower origin and the remaining 92.5% (18.7 MW of installed capacity) is of thermoelectric (diesel) origin**

(EMAE, 2019). This is insufficient to meet peak demand, which was estimated to be 20.8 MW in 2017 (Ricardo Energy & Environment, 2018). In addition to grid-connected generation, the island of São Tomé had three isolated (diesel) power plants in 2019, with a total installed capacity of 544 kW, of which only 178 kW had guaranteed availability. The capacities installed on the two islands are detailed separately in Table 1.

With regard to access to electricity services, it is estimated that **84% of the population of São Tomé has access today (74% on the island of São Tomé and 100% in the Autonomous Region of Príncipe (RAP)** (ALER/STP Government, 2019). STP's energy policy includes the target of achieving an electrification rate of 100% by 2030 (Ricardo Energy & Environment, 2018).

SÃO TOMÉ'S ENERGY POLICY INCLUDES THE TARGET OF ACHIEVING AN ELECTRIFICATION RATE OF 100% BY 2030

STP Government

EMAE's electricity consumers can be grouped into four categories, specifically: 1) residential, 2) small commercial, 3) large commercial and industrial, and 4) the State, institutional consumer and others. Consumption by the large commercial and industrial consumer category, consisting of hotel complexes and processing industries, etc., is almost non-existent (they represented, in 2018, 4% of the total, equivalent to 2.8 GWh), and the growth trend has been practically nil in the last five years. This is due to several factors, specifically the unreliability of the electricity supply, reflected in power failures, the low quality and quantity of electricity supplied, and the lack of transmission infrastructure throughout the territory. Accordingly, the 250 largest electricity consumers existing today often turn to self-production in order to fill these gaps (ALER/STP Government, 2019).

In STP, in addition to grid-connected generators, there are a number of self-producers, not connected to the power grid, which generate electricity for their own consumption on site, consisting mainly of hotels in the tourism sector.

In October 2018, the Project Administration Supervision Agency (AFAP – Agência Fiduciária de Administração de Projectos) published the Least Cost Development Plan (LCDP – Plano de Desenvolvimento de Menor Custo) for STP for the period 2018-2035. Three types of power systems are present in STP: the interconnected system (or main grid), isolated systems (with their own generation plant and a small grid) and off-grid systems. All three types of systems were included in the LCDP analysis, but its primary focus was on the interconnected system. The LCDP was prepared considering the estimated demand forecast for each of the islands. The development policy adopted in preparing the report was that the RE projects in STP should be in the range of 50% of installed capacity by 2030. Table 2 presents the summary of the LCDP proposals regarding generation, transmission, distribution, and isolated systems from 2018 to 2035.

Table 2: LCDP summary for generation, transmission, distribution, and isolated systems (Ricardo Energy & Environment, 2018)

	São Tomé	Príncipe
Additional generation capacity ordered 2018-2035	Thermal: 17.6 MW Hydro: 26.0 MW Solar: 4.0 MW **Total: 47.6 MW**	Thermal: 2.5 MW Hydro: 1.0 MW Solar: 2.0 MW **Total: 5.5 MW**
Proportion of the generation capacity from renewable energy	2025: 49% **2030: 53%** 2035: 49%	2025: 50% **2030: 50%** 2035: 41%
Cumulative generation investment 2018-2035	USDm 154.26	USDm 13.81
Cumulative Other infrastructure costs 2018-2035	USDm 2.40	-
Cumulative transmission investment (connecting new power plants) 2018-2035	USDm 1.53	USDm 0.54
Cumulative transmission investment 2018-2035 (reinforcement and upgrades)[5]	USDm 4.76	USDm 0.32
Cumulative distribution investment 2018-2035	USDm 35.54	USDm 2.90
Cumulative investment in isolated systems 2018-2035	USDm 7.32	-
Total cumulative investment 2018-2035	**USDm 205.80**	**USDm 17.57**

The analysis conducted for the LCDP considered a wide range of power plant technologies and fuel options: thermal (reciprocating engines (onshore), gas turbines (onshore)) and renewable (run-of-river hydro, solar PV (onshore, floating, with battery) and onshore wind). From the results of the Levelized Cost of Energy (LCOE) analysis, the most viable option is hydropower in the case of São Tomé and, therefore, in the LCDP, the share of RE in the matrix was projected to increase from 7.6% in 2018 to 57% in 2028 and to 53% in 2030 (Ricardo Energy & Environment, 2018). In the case of the island of Príncipe, according to the LCDP, the most efficient options are solar energy and hydropower. The results show that on Príncipe, the share of RE in the energy matrix was projected to increase from 0% in 2018 to 50% in 2026 and 50% in 2030 (Ricardo Energy & Environment, 2018). The tables below show the ranking of the generating plants, in accordance with their LCOE, on São Tomé (Table 3) and on Príncipe (Table 4).

Table 3: LCOE ranking of candidate generators on São Tomé (Ricardo Energy & Environment, 2018)

Ranking	ID	Technology	Fuel	Plant	LCOE (USD/MWh)
1	C26	Hydro	Hydro	Agostinho Neto	21
2	C25	Hydro	Hydro	Guegue	33
3	C12	Hydro	Hydro	Santa Luisa	55
4	C24	Hydro	Hydro	Contador Rehabilitation 1c	57
5	C11	Hydro	Hydro	Almeirim	60
6	C13	Hydro	Hydro	Santa Clara	61
7	C7	Solar	Solar	Solar	62
8	C19	Hydro	Hydro	Neves	64
9	C15	Hydro	Hydro	Claudino Faro	65
10	C17	Hydro	Hydro	Dona Eugénia	70
11	C8	Solar	Solar	Solar floating	73
12	C14	Hydro	Hydro	Mato Cana	74
13	C16	Hydro	Hydro	Bombaim	92
14	C3	Thermal	HFO	Reciprocating HFO engine	95
15	C10	Hydro	Hydro	Cruz Grande	109
16	C5	Thermal	NG	Reciprocating NG Engine	110
17	C27	Solar	Solar	Solar-Battery	117
18	C18	Hydro	Hydro	Mateus Sampaio	126
19	C4	Thermal	HFO	HFO Gas Turbine	126
20	C1	Thermal	LFO	Reciprocating LFO Engine	140
21	C6	Thermal	NG	NG Gas Turbine	149
22	C2	Thermal	LFO	LFO Gas Turbine	190
23	C9	Wind	Wind	Wind	206

Table 4: LCOE ranking of candidate generators on Príncipe (Ricardo Energy & Environment, 2018)

Ranking	ID	Technology	Fuel	Plant	LCOE (USD/MWh)
1	C13	Solar	Solar	Solar	62
2	C14	Solar	Solar	Solar	62
3	C15	Solar	Solar	Solar	62
4	C7	Solar	Solar	Solar	69
5	C10	Hydro	Hydro	Papagaio 1	70
6	C16	Solar	Solar	Solar-Batt	72
7	C12	Hydro	Hydro	Bibi 1	109
8	C1	Thermal	LFO	Alternative LFO Engine	140
9	C9	Wind	Wind	Wind	206

In addition to investment in generation systems, it will also be necessary to make additional investment in transmission and distribution to reinforce the existing grid, ensure the stability of the system and secure the supply of electricity to final consumers.

The LCDP report proposes a strategy for electrification of off-grid load centers by combining different electrification solutions: a) extension of the existing transmission system to reach new population centers; b) development of new mini-grids or extension of existing ones; c) isolated solar home systems when none of the above are cost-effective.

2.3 Renewable Energy Potential in STP

It is challenging for STP, as a SIDS, to achieve its development goals in a sustainable way, due to limited resources. In the National Sustainable Development Plan 2020-2024, STP aims to reduce dependence on energy from abroad (which is around 25%), focusing on EE, alternative sources and RE. The country has abundant natural resources to be exploited, with several hydropower plants that could be rehabilitated and used in projects yet to be developed.

The solar potential in the north/northeast coastal area of the island of São Tomé is around 4 kWh/kWp (GHI[2]: 4.35 kWh/m^2/day), as shown in yellow in Figure 6. This area is most suitable for developing solar photovoltaic (PV) plants (see Figure 6), and is also where stand-alone projects can already be found, mainly at the rural level or by private initiatives. The solar potential of Príncipe Island is approximately 3.5 kWh/kWp (GHI: 4.43 kWh/m^2/day), as shown in Figure 7.

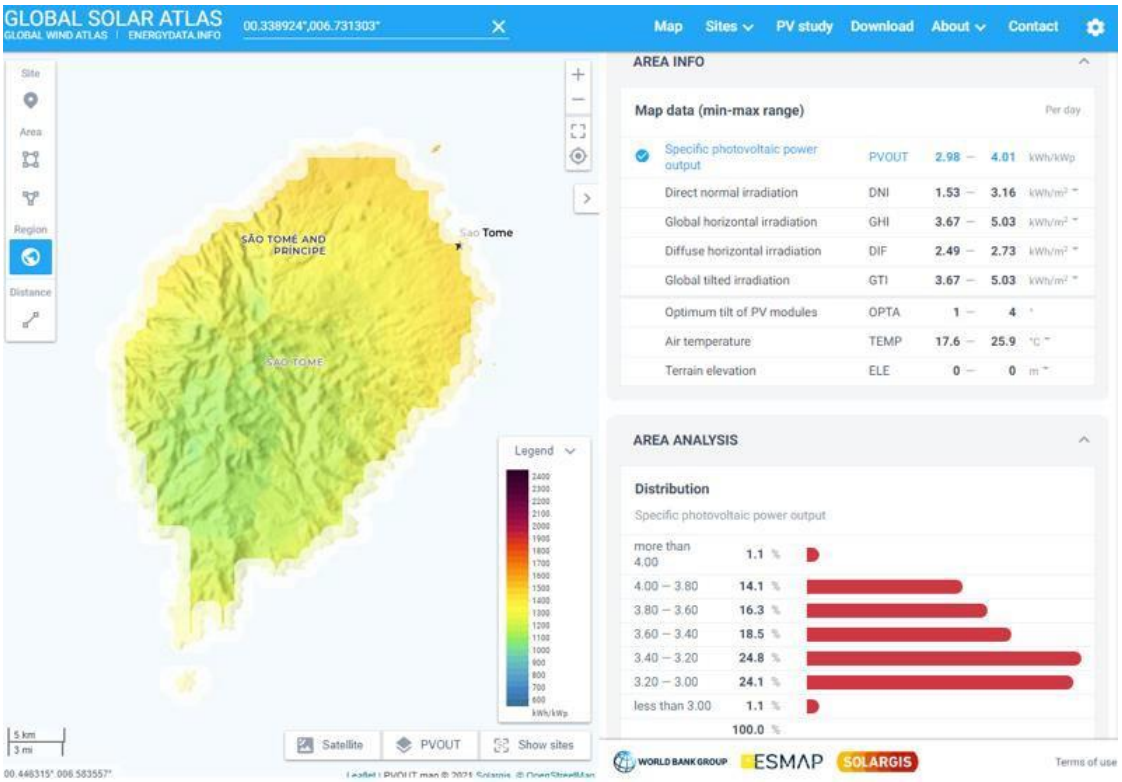


Figure 6: Solar PV potential on São Tomé Island (Global Solar Atlas, 2021)

While there is no specialized study at the national level on solar energy, there is a one on the solar potential in Lobata district, which was prepared in 2011 by the NGO TESE[3] in the framework of the Climate Change Adaptation project. The results of the study highlight 1,760 hours of sunshine throughout the year, dropping to 1,300 hours between 500 and 1,000 meters in altitude, with radiation between 1,800 and 4,350 Wh/m²/day, depending on the exposure location (TESE, 2011). Lobata is one of the areas with the lowest access to electricity services in the country. On RAP, the company HBD, with the support of EDP and in partnership with the regional government, conducted several regional surveys on RE capacity and potential in 2015. The Bombom islet, as an example, had a pyranometer installed that recorded data and estimated annual production at about 1,035 kWh/kWp/year (ALER/STP Government, 2019).

So far, solar PV has been used in STP as an alternative source to supply electricity to telecommunication stations, military signaling, water treatment plants and private initiatives (hotels, the UN building), as well as schools and agricultural cooperatives in rural areas as part of aid projects with funding from international partners, totaling approximately 165 kW (ALER/STP Government, 2019).

[2] *GHI: Global Horizontal Irradiation*

[3] *See website https://tese.org.pt/*

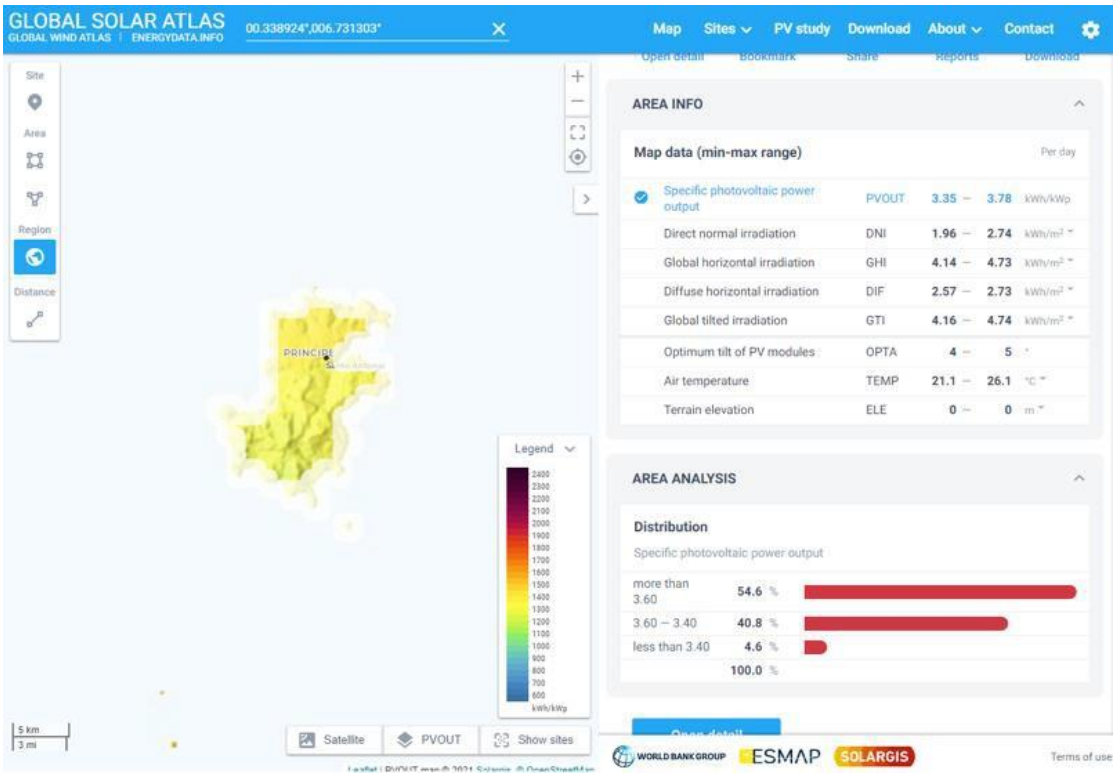


Figure 7: Solar PV Potential on Príncipe Island (Global Solar Atlas, 2021)

The NGO TESE was responsible for the program of solar PV systems in cocoa, pepper, vanilla and coffee agricultural cooperatives to supply electricity to dryers, machine shops, weighing and packing rooms, and offices. The aim of the project was to accelerate the introduction of effective renewable energy solutions for productive rural areas, improving processing and marketing activities, and thereby improving the income of associated households (TESE, 2015). The project has enabled the installation of 48 kW in a total of 11 farming communities and cooperatives. In terms of impact, there has been an increase in the productivity of processing and marketing activities, an improvement in the management of cooperatives by having uninterrupted electricity, and the generation of rural jobs in areas other than agriculture, specifically the installation and maintenance of PV systems, and the running of small businesses charging low consumption appliances (telephones, radios and flashlights) (ALER/STP Government, 2019). This experience demonstrates the benefits that solar PV-based RE initiatives can bring to the agricultural sector and also shows that this type of activity is feasible using the solar energy available in STP. In this context, the NREAP proposes measures for implementing incentives and access to finance to offer local agricultural producers the possibility of obtaining new technologies that are adapted to their needs.

With regard to the potential use of solar PV to address the total or partial lack of access to electricity services, the diagnostic report conducted by WB-ESMAP in 2019 (Brutinel, Wang, Koo, Portale, & Rysankova, 2019)[4], based on the multidimensional energy access survey conducted in 2018, shows that:

- The fraction of households that do not have a connection to the national grid and so use off-grid solutions includes 0.2% that use off-grid solar systems (in 2018);
- Off-grid solutions are more common in rural areas, where mini-grids and (diesel) generators only marginally help fill the gap in electricity access, while solar products have yet to reach the commercial market;
- There is much less willingness to pay for a home solar system than for a connection to the national grid, although that desire does increase as the price drops. While only 12% of respondents would pay full price for a high capacity home solar system, more than double

[4] *São Tomé and Príncipe: Beyond Connections. Energy Access Diagnostic Report Based on the Multi-Tier Framework, 2019 (World Bank-ESMAP)*.

that percentage (27%) would pay one-third of the total price. Respondents also showed interest in more flexible payment options, such as installments.

- The vast majority of households surveyed (84%) show no interest in paying for solar equipment under any price or payment plan, due to affordability issues. Accordingly, the report recommends addressing this difficulty by promoting the use of off-grid solar systems. In addition, the report recommends conducting awareness raising and outreach campaigns, and studying possible finance options. These recommendations were considered when designing the measures proposed in this plan.

In addition to the possibility of installing solar PV systems on land, there are also floating ones. Floating technology is an interesting option for countries where land characteristics are not favorable, such as where irregularities complicate installation, or in countries where space availability is the limiting factor. The disadvantage of floating solar systems is that they are much more expensive and technologically complex, so a more detailed feasibility analysis for them would be required in the case of STP.

With regard to the use of **solar thermal energy**, the most widespread applications in countries with abundant solar resources include the use of solar water heaters, which can be used in the tourism area (hotels and other tourist accommodation), and in the residential area for domestic hot water use. The information about the potential for using solar energy in this context is not very detailed, so one of the proposed measures in the plan is to study its applicability.

In the agricultural sphere, **the drying of cocoa**, which is the basis of São Tomé's economy, is currently performed naturally, in most cases simply by directly drying in sunlight. The exception is the Saotocau company, which uses electricity supplied by the grid to power electric fans connected to boilers in the cocoa bean drying process during the harvest season. The company is the largest agricultural user of electricity in the country and the second largest industrial user after ENCO (ALER/STP Government, 2019). Experiences in Colombia, Mexico, Ecuador and Honduras, and even in the case of Saotocau, show that directly drying in sunlight can be improved through the use of structures that generate a natural "greenhouse effect", while protecting the cocoa beans from rain, animal excrements and particulates, increasing the drying efficiency and the final quality of the beans (see Figure 8). In addition to using solar energy for grain drying, alternatives to reduce post-harvest losses have been reported in other studies, such as using solar PV powered refrigeration technologies in the storage of fresh produce, extending its "shelf life", thereby reducing waste and, consequently, economic losses. Such uses of RE are of particular interest to farmers in off-grid areas or where the electricity service is unstable. One study (Sibanda & Workneh, 2020) aimed to identify the causes of post-harvest losses of fruits and vegetables suffered by smallholder farmers in sub-Saharan Africa and found that increasing access to facilities or services to safeguard the harvest, increases food security, incomes and nutrition at the household level, as more and better produce reaches the consumer. The article highlights the need for more detailed study of the use of solar and wind energy to power desiccation and evaporative cooling units in hot-dry and hot-humid climate areas.

It is also possible to use solar water heaters to heat water that is used later to produce the "greenhouse effect" in the dryer overnight, thereby continuing the drying process. In addition, solar PV equipment can be used to pump water if artificial irrigation is required, resulting in a cocoa production system based entirely on renewable energy, as in the case of the *La Angostura* area in Colombia[5]. In Mexico, studies have been conducted on the drying efficiency of "solar drying tunnels" made of polycarbonate, which use small fans to ensure homogeneous drying (see Figure 9). The study showed good results, especially with regard to reducing the total drying time and improving the final quality of the grain when compared to traditional methods. The study did not indicate the energy source used for the fans, but it would be advisable to study the possibility of powering them with solar PV energy.

[5] *See https://www.youtube.com/watch?v=4PLRuVVOIdk*

Figure 8: Drying directly on the ground (left)[6] and drying in protected structures (right)[7]

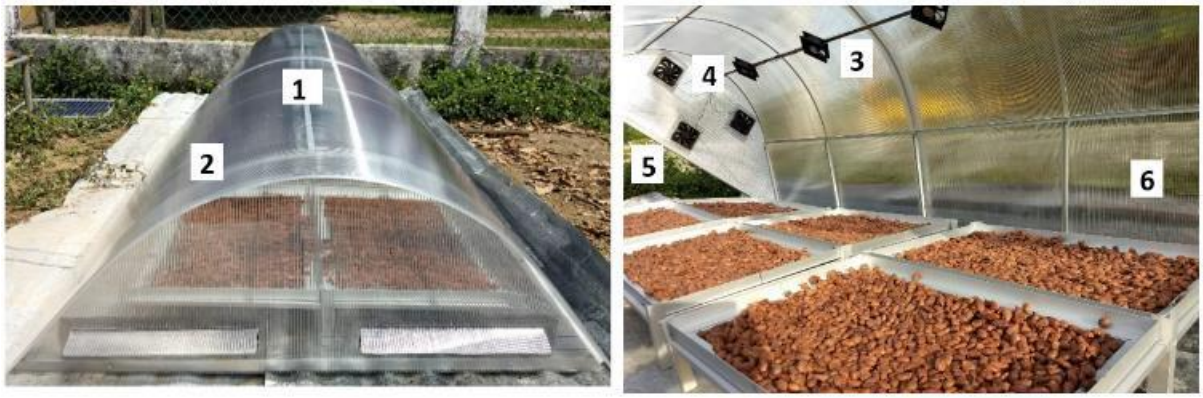


Figure 9: Study of a pilot project for cocoa bean drying using polycarbonate tunnels in Tabasco, Mexico (1. Polycarbonate cover with UV protection; 2. Windows allowing air in; 3. Fans to homogenize the internal heat; 4. Exhaust fans; 5. Tray holder; and 6. Trays) (Cerino & García, 2018)

However, solar thermal energy requires direct sunlight and its productivity could be affected by the fact that there are few cloudless days in the STP climate. More detailed studies of the potential for solar thermal applications would need to be carried out in order to verify its actual feasibility.

Wind has low potential (see Figure 10 and Figure 11), and there are only small-scale, privately-owned wind projects. In terms of wind speed, according to data from the National Institute of Meteorology (INM – Instituto Nacional de Meteorologia), this typically varies between 2.5 m/s and 6.3 m/s, and the southern part of the island of São Tomé is the windiest. There is no precise information about the "offshore" wind energy potential in the coastal area of STP, but it can be seen from these two figures that the wind speed at sea in the coastal areas is also low (in the 3-4 m/s range). Furthermore, the country is volcanic in origin and, therefore, has a predominantly hilly and steep geography, which would make the overland transport of large structural components of wind turbines, such as blades, even more complex. In addition, it is very important to analyze two fundamental issues with regard to offshore wind: the characteristics of the land near the coastal zone (how hilly or flat it is), and the depth of the sea in the coastal zone, because floating wind systems should be considered in the offshore wind option if the sea is deep, which are very costly and more technologically complex. In any case, it will be necessary to further analyze both the technical applicability and competitiveness of these technologies with regard to São Tomé. Accordingly, the measures in this plan include conducting further studies to define the actual feasibility of implementing onshore and offshore wind power in STP. These studies will serve to identify how to solve the technical problems associated with these options, such as the use of hybrid storage systems to neutralize generation intermittency.

[6] *See https://www.youtube.com/watch?v=iz6Lup7q0v0*

[7] *See https://www.youtube.com/watch?v=wY1i4-R2Ikk*

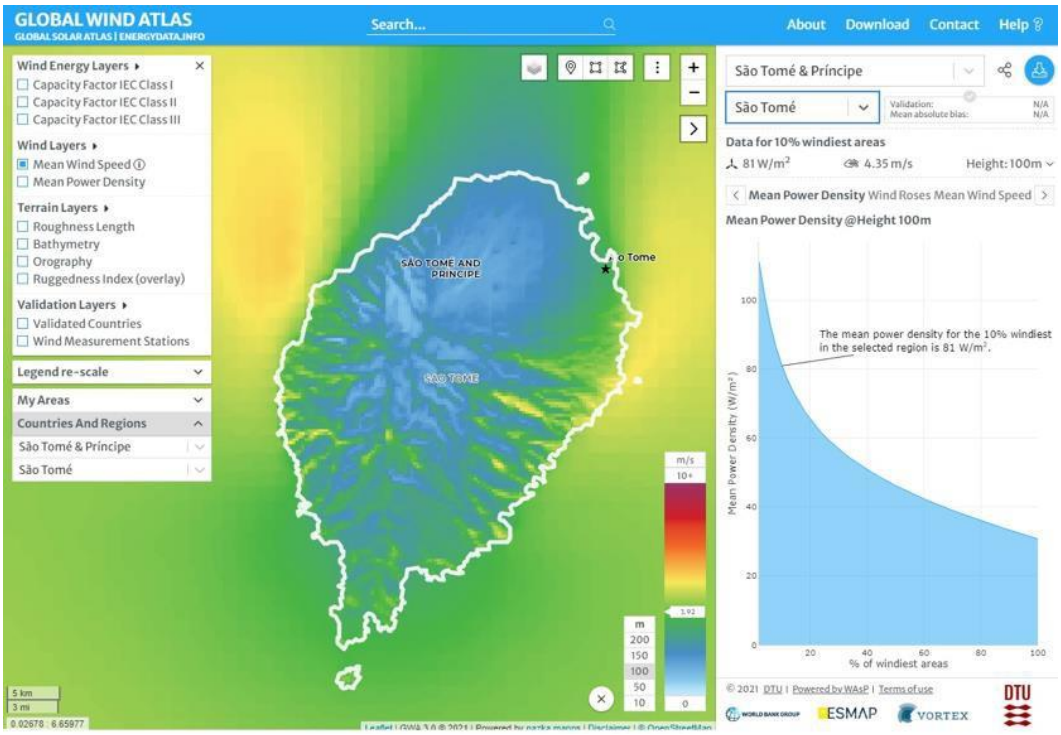


Figure 10: Average wind speed on São Tomé Island (Global Wind Atlas, 2021)

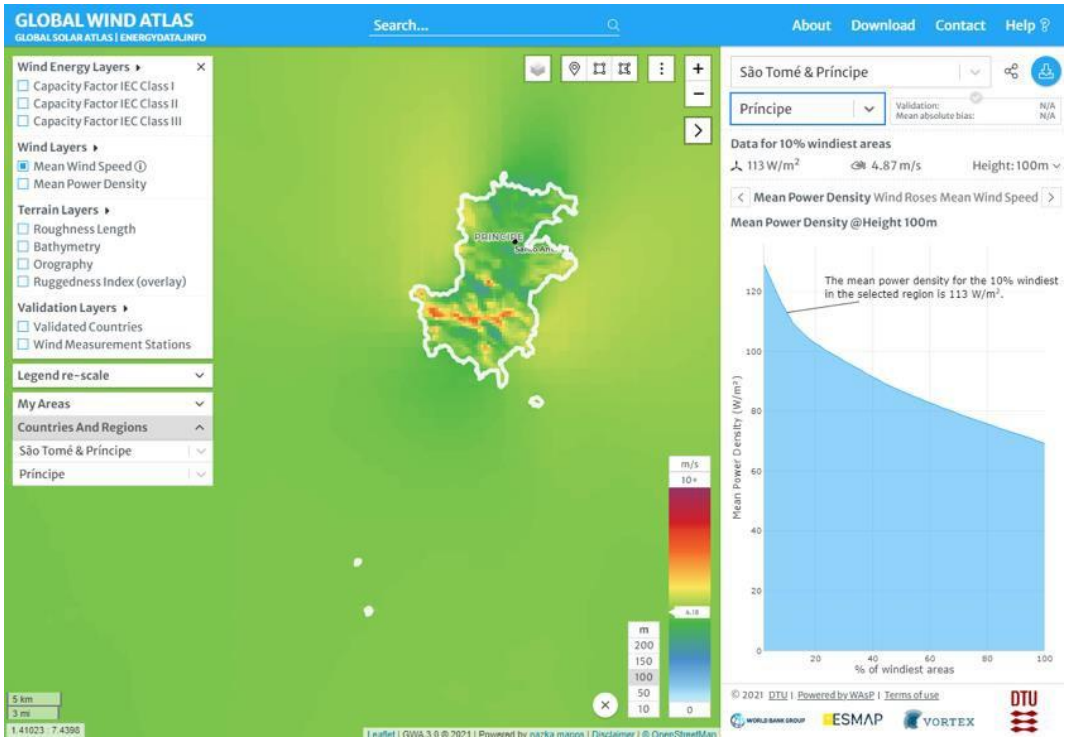


Figure 11: Average wind speed on Príncipe Island (Global Wind Atlas, 2021)

The **vegetation of the country is diverse,** with varied forest formations, which play an important role in economic, ecological and social life. The development of this dense and luxuriant plant cover is favored by the nature of the soils, the climate and the geology. This includes formations with forests and bushes, known as Obô. The most recent Forest Resources Assessment by the Food and Agriculture Organization of the United Nations (FAO, 2010) estimates that the different types of forest cover represent approximately 90% (90,900 ha) of the surface area and are highly heterogeneous:

- 40% of the country is natural forest, called "Obô". The Obô Natural Park covers 29,500 ha and its management plan was validated in 2010 through the European Union-funded Program for the Conservation and Rational Use of Forest Ecosystems in Central Africa (ECOFAC). Pressure is growing on the lowland forests in the buffer zone of the national park as a result of the ever-increasing human intervention for natural resource extraction, although the higher lands are more protected due to difficult access;
- 21% of the country is secondary forest, called "Capoeira". These lands are abandoned cocoa and coffee plantations, and there are no management plans for them. These forests end up being targeted for illegal logging and agricultural conversion, and there are conflicts over land use. Soil degradation due to crop cultivation on these sloping lands is aggravated by the lack of enforcement of anti-erosion measures;
- 29% of the country is shade forest. These are productive lands (cocoa and coffee) under tree cover, and many of them need to be rehabilitated.

With regard to the **potential of biomass,** as it is widely used for energy production (firewood and charcoal), the prospective of using it sustainably is an option that could be explored. The primary energy source in the country is plant biomass, given that most of the population uses firewood, as well as charcoal, for household energy. It has been recorded that the use of firewood as the main source of energy at the household and commercial level (small bakery and catering industries) has resulted in deforestation, the expansion of rural communities into protected forest areas, the loss of both flora and fauna biodiversity, and erosion. In addition, it has been found that using wood to construct houses and fishing canoes has also caused the degradation of this resource.

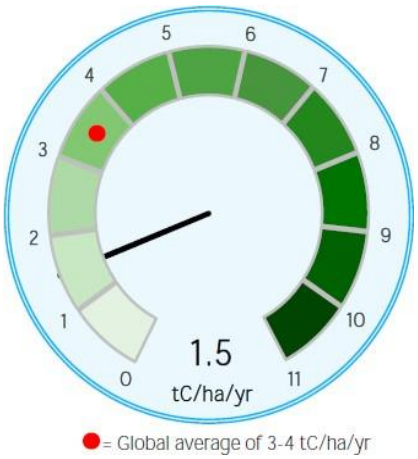


Figure 12: Biomass potential in terms of Net Primary Production (IRENA, 2017)

According to the final report for the National Forestry Development Plan prepared in 2017, 80.1% of the homes on the islands of São Tomé and Príncipe are built with wood. It is estimated that about 75% of the wood consumed in the country is mostly illegally and irrationally harvested, without any regulation or enforcement, contributing to the process of deforestation and forest degradation, which results in increased soil erosion (ALER/STP Government, 2019).

Today, STP is a natural GHG sink precisely because of its unparalleled forest and plant resources, which facilitate carbon capture and sequestration, and thereby contribute to offsetting its GHG emissions, which derive mainly from the burning of fossil fuels. If the country's emissions continue to rise and illegal deforestation is not controlled, the country risks becoming a net emitter of GHG in the short term. Accordingly, the NREAP aims to implement measures related to reducing GHG emissions in the energy sector, as well as to implement measures to reduce deforestation and promote sustainable agriculture in order to maintain its vegetation cover and, therefore, its unique character as a GHG sink.

However, only one biogas production and utilization project is known to have been implemented (ALER/STP Government, 2019). Aside from this, STP is included in the series of profiles IRENA has produced on the potential of RE sources in various countries. With regard to biomass in STP, the profile prepared by IRENA states that in terms of Net Primary Production (in tC/ha/year), STP produces 1.5 tC/ha/year. Net Primary Production is the amount of carbon fixed by plants and accumulated as biomass each year. It is a basic measure of biomass productivity. The global average is 3-4 tC/ha/year (IRENA, 2017).

With regard to **solid urban waste**, at the national level there is still no organized system for its selective collection or differentiated treatment, and there is only one waste processing center. In general, waste is deposited in dumps and burned in the open air in an undifferentiated way, contributing to the emission of pollutant gases, with negative effects on health and the environment. In some rural areas this situation is aggravated by the fact that there is not even an organized collection system and the waste is dumped in nature without any control. In 2018, TESE developed the **National Plan for Integrated Management of Municipal Solid Waste (PNGIRSU – Plano Nacional de Gestão Integrada de Resíduos Sólidos Urbanos) 2018-2023**. The study highlights that most (50.21%) of the waste produced in the country is organic, corresponding to about 15,026 tons/year, and that since 2011 the country has evolved, noting that ecocenters, waste processing centers and composting stations have been constructed, so beginning the selective collection of glass, cans, plastics and batteries. However, serious problems persist, from the low coverage of collection services (38% of the population), health and environmental problems associated with burning, uncontrolled disposal in dumps, lack of legal framework, to the plastic waste left particularly on the beaches. The use of composting and recycling has begun in some more remote locations (Caué, Príncipe Island). Implementing the measures in the PNGIRSU 2011-2016 was problematic, mainly because of lack of funding. The PNGIRSU 2018-2023 focuses on improving waste recovery, with better management, by increasing composting, as well as processing and recycling centers. Composting will replace the use of chemical fertilizers, and the recycled waste (plastic, glass, etc.) can be used in the production of new goods. The study shows that about 70% of the waste, by weight, can be recovered, leaving only 30% requiring technical confinement or final disposal. It will be necessary to replace the existing large dumps where waste is currently deposited without control with controlled landfills to decrease the negative health and environmental impact (STP Government, 2018).

The recovery of organic waste through treatment by anaerobic digesters for the **production of biogas** for domestic use (in the kitchen) on a small scale was tested through the "Bio&Energy" project that ran from December 2014 to December 2016. Its aim was to test the suitability of anaerobic digestion for the treatment of organic waste produced by households in rural communities on the island of São Tomé, where five digesters were installed. In the waste processing center that receives the recyclables, only glass is processed and used in the manufacture of other products. Plastics, batteries and cans have been accumulating and are still waiting to be taken to their final destination (STP Government, 2018). Considering the national characteristics relating to the quantities of waste generated, its composition and its geographical distribution, the PNGIRSU identified the priority options for managing and treating the solid waste generated in the country as: **composting, the elimination of dumps and their replacement by controlled landfills, and recycling** (in addition to strengthening the regulatory framework, raising awareness among the population, training technical staff in integrated waste management, levying fees and attracting funding, among other activities). The PNGIRSU study did not identify activities related to the production of biofuels.

With regard to the use of waste as an energy source for electricity generation, the NREAP has only included one electricity generation investment project, proposed by the company CISAN (contract signed in April 2020), which uses solid waste (urban, industrial and vegetable) to generate 4.68 MWe/h of power (CISAN, 2020).

The **hydropower potential** through exploiting various rivers and streams that flow through the islands is one of STP's greatest energy resources, given the steep terrain and regular and abundant precipitation. The archipelago's rivers and streams have a peculiar morphology, consisting of a radial hydrographic network, with springs in the mountains located in the center of the islands, and more than 200 water courses, with an average length between 5 and 27 km, which feed the different water basins and a large number of aquifers. Most of these rivers originate in the Obô forest to the southwest and south of the islands, with flows highly dependent on the abundant rain. The main rivers on the island of São Tomé are: Ió Grande (the largest in the country), Do Ouro, Contador, Lembá, Quija, Manuel Jorge and Abade. On Príncipe Island the main river is the Papagaio (ALER/STP Government, 2019). See Figure 13. The country's hydropower potential is attractive, as in the 1980s the country operated numerous small-scale hydropower projects or "mini-hydropower plants" (MHPs), generating up to 80% of the electricity at that time. Unfortunately, the MHPs have begun to stagnate and degrade, with an increase in the installation of thermal power plants to compensate this. Recent studies identified 14 projects with an estimated total hydropower potential of 31 MW (ALER/STP Government, 2019), although currently only the Contador plant is active, with an installed capacity of 1.92 MW, but only 1.22 MW is actually available. Given the hydropower potential found in the past and the need to take advantage of the renewable resources available, the NREAP includes projects for rehabilitating several MHPs (Contador, Papagaio, Agostinho Neto and Guegué), as well as constructing new plants on the Iô Grande River and in Bombaim.

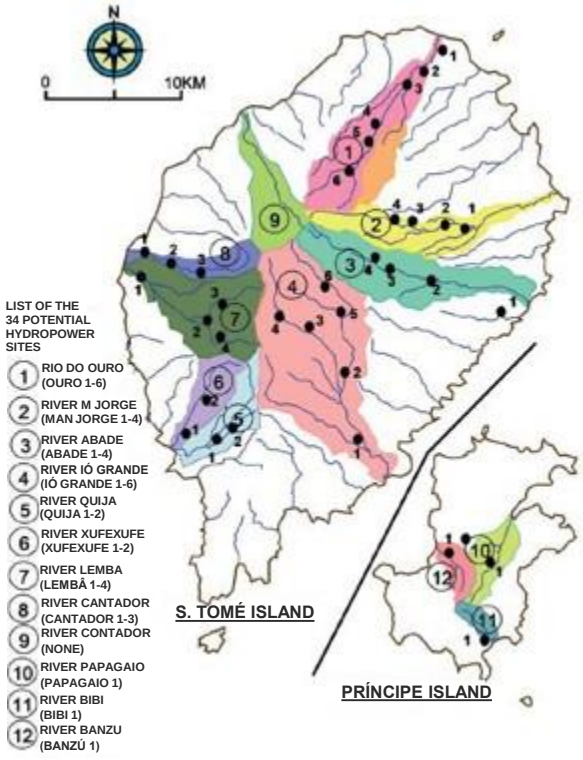


Figure 13: Sites with hydropower potential in STP (ALER/STP Government, 2019)

Ocean energy could be harnessed in several ways:

- Tidal energy (see Figure 14)
- Wave energy (see Figure 15)
- Ocean Thermal Energy Conversion (OTEC)
- Energy from sea currents

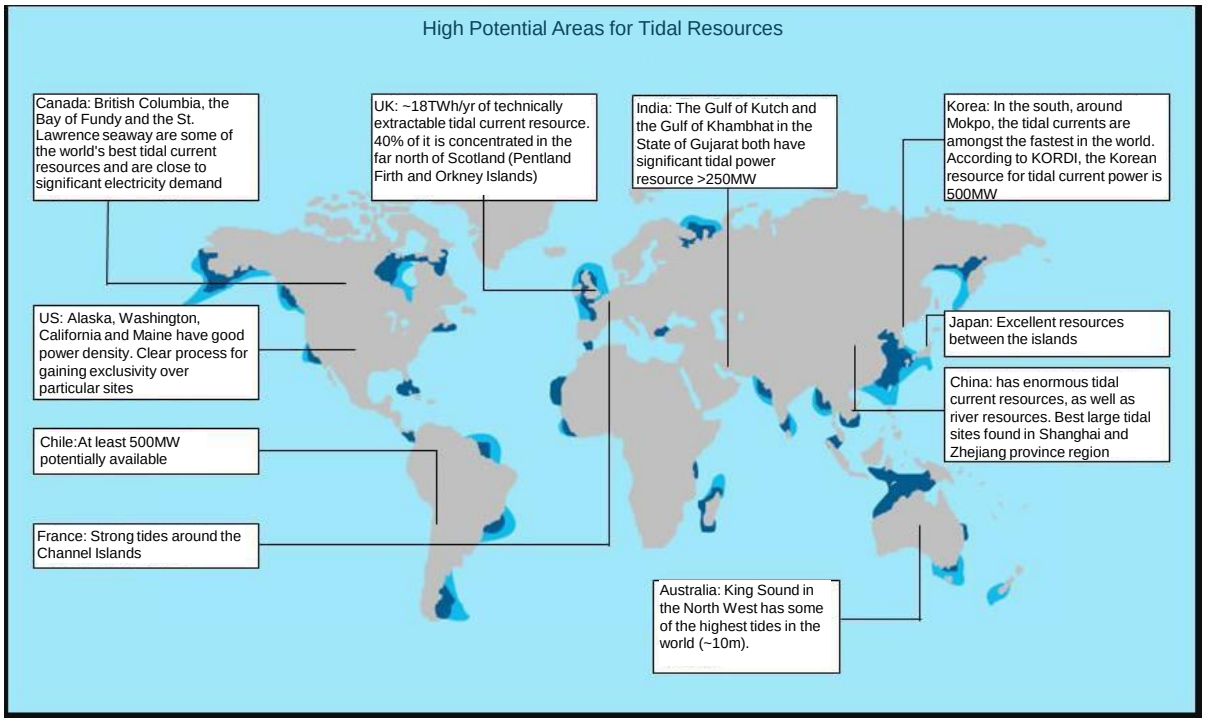
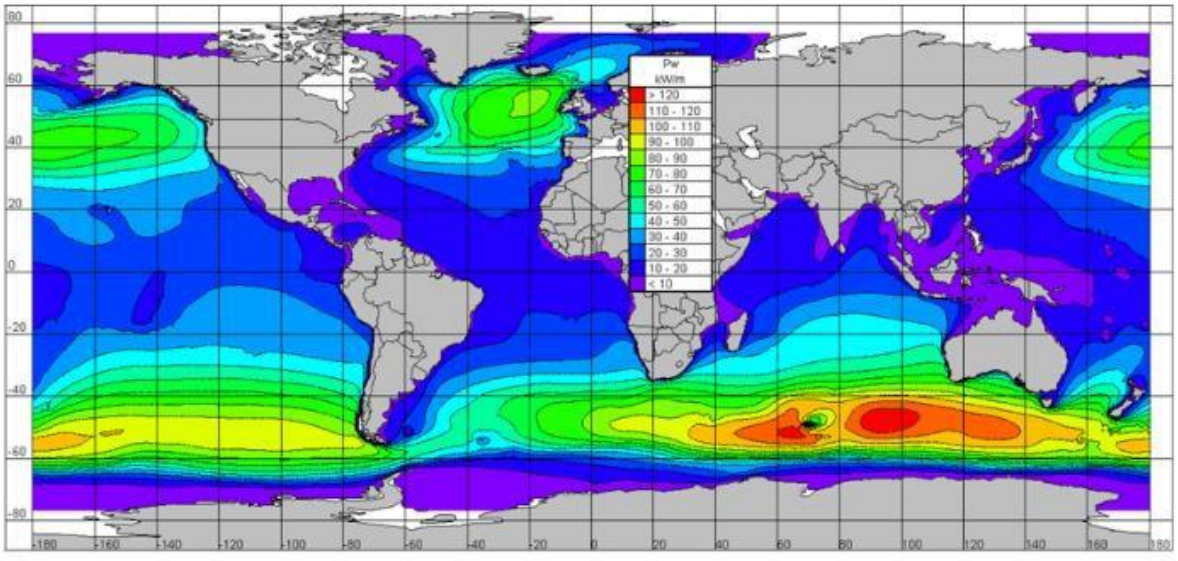


Figure 14: Areas with high tidal energy potential (Opportunity Energy, 2010)



Global distribution of annual mean wave power. (A global wave energy resource assessment made by Andrew M. Cornett. Proceedings of the 18th international offshore and polar engineering conference, Vancouver Canada)

Figure 15: Global distribution of annual mean wave power (Horbjornsson, et al., 2012)

On the basis of Figure 14, *a priori*, the Gulf of Guinea area has no attractive potential in the case of tidal energy. The same is true for wave energy, on the basis of Figure 15.

STP is located in one of the potential areas for Ocean Thermal Energy Conversion (OTEC), due to the high surface seawater temperatures, steep sea cliffs and low risk of tropical storms. One island territory with a well-known OTEC resource and an Exclusive Economic Zone similar in size to that of São Tomé and Príncipe is Puerto Rico. It has an ocean thermal resource of about 38 TWh per year, the equivalent potential to power 3,600,000 homes.

The figure below draws on ocean temperature databases to show the change in ocean temperature with depth for STP[8].

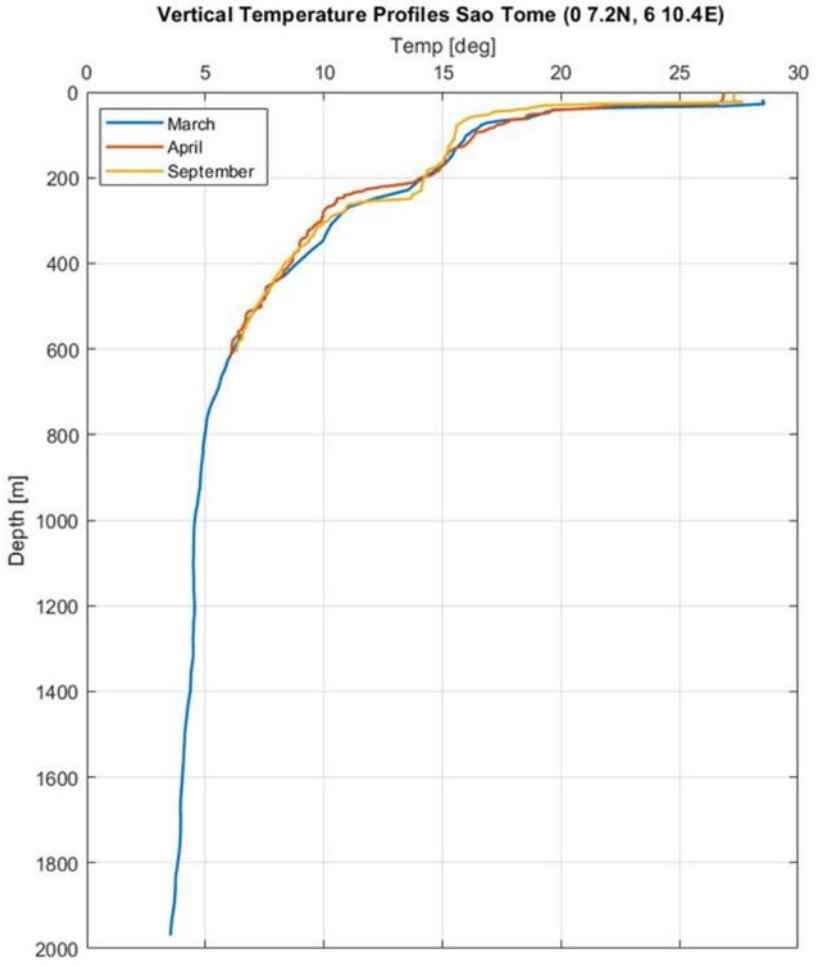


Figure 16: Vertical sea temperature profiles for STP

Within the surface layer, the seawater temperature remains above about 26°C, which varies by 3°C in proportion to seasonal variations. The temperature recorded at 800 meters is 5°C. Therefore, a minimum temperature difference of 21°C is available throughout the year, allowing OTEC to produce energy. The next figure (Figure 17) shows in red the 1,000-meter depth line surrounding the two main islands. São Tomé Island is closest to deep-water access, at about 3 km from the coast to the west and 7 km to the east, while Príncipe is approximately 8 km from the closest deep-water area. An onshore OTEC plant must have access to deep water over a shorter distance to avoid large electricity losses from pumping that water, so offshore OTEC would be the most suitable to consider. Several sites along the coast are relatively close to deep water, providing a number of viable options. The technology is still in its early stages, but could become an interesting option in the next ten years. Currently, there are a small number of demonstration projects (e.g. in Japan and Korea). The benefit lies in the multiple uses that OTEC base load power can offer for various uses related to the green and blue economy. UNIDO and SIDS DOCK[9] in partnership with private developers are currently developing a demonstration project for STP under a joint Global Ocean Energy platform for the SIDS. The project would be a demonstration and requires funding from donations.

[8] *Source: Findings UNIDO/SIDS DOCK partnership on the Ocean Energy Platform*

[9] *SIDS DOCK is an initiative among member countries of the Alliance of Small Island States (AOSIS) to help the SIDS transform their energy sectors and address climate change adaptation.*

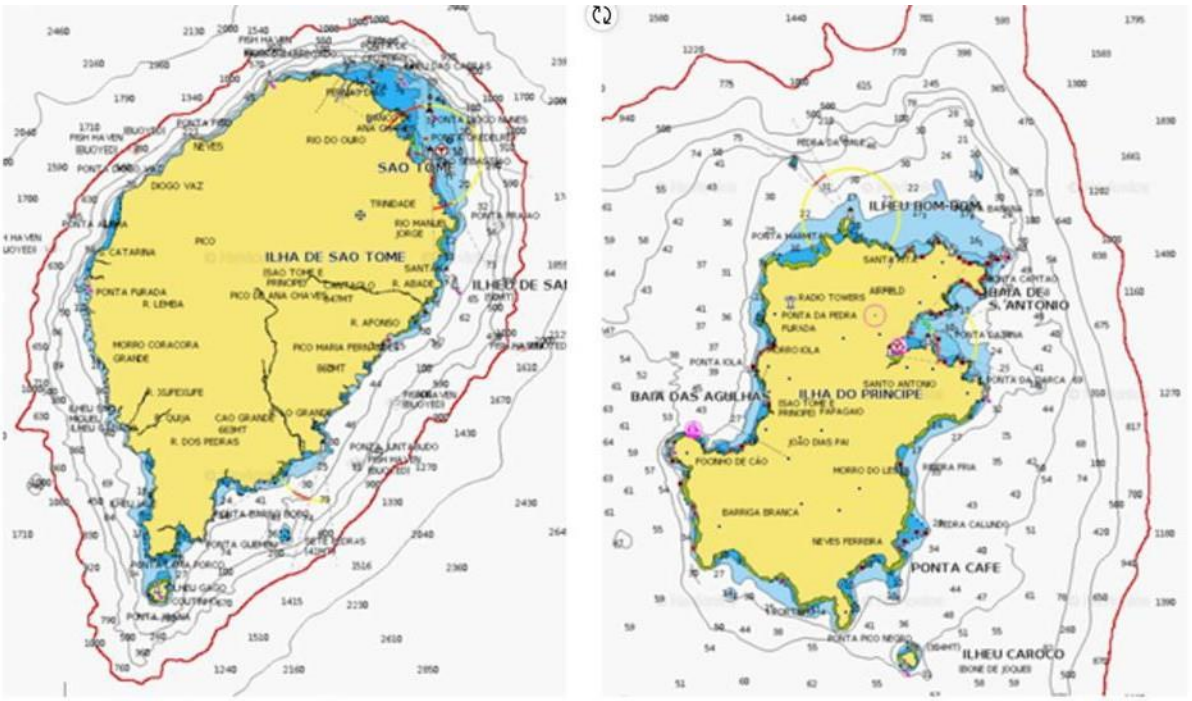
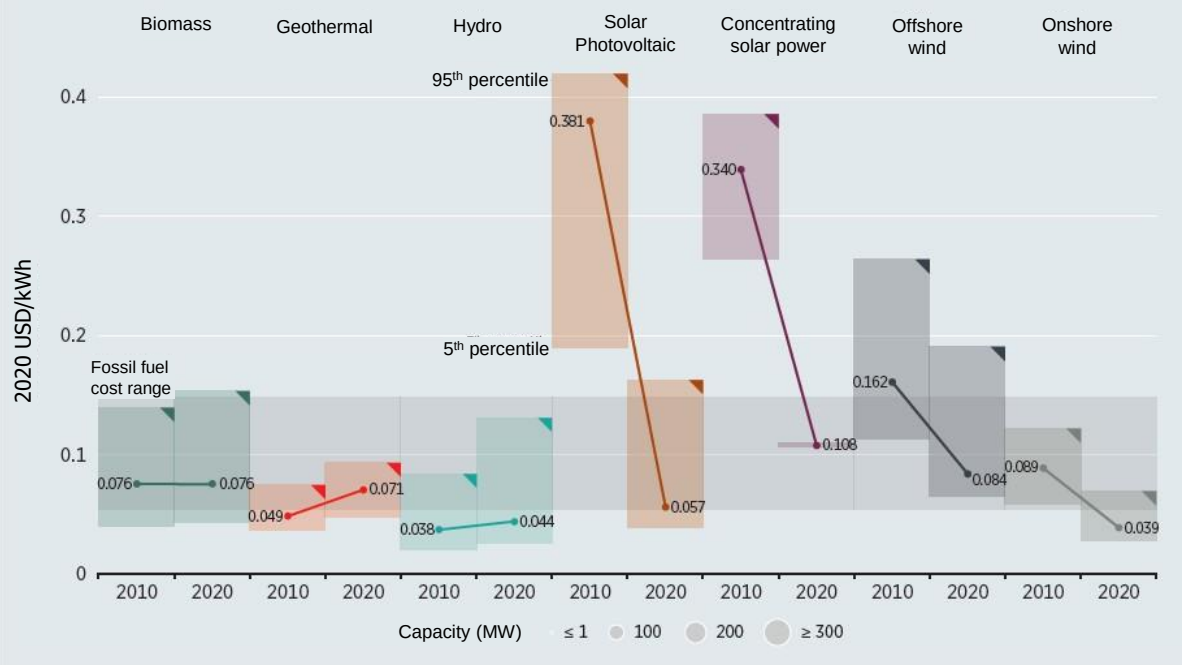


Figure 17: 1,000-meter depth line, in red, surrounding the two main islands

There is no precise information about the potential of **geothermal energy in the country**. Therefore, the NREAP proposed measures include conducting a study of the country's geothermal potential, since it is an energy source that is widely used in some countries of the world, is reliable and offers the possibility of providing "base" power in the system. Figure 18 compares the LCOE of the different renewable technologies between 2010 and 2020. The LCOE for solar PV, as well as concentrated solar and onshore and offshore wind, has clearly and significantly reduced as a result of specific policies being developed and the industrial development of the sector. They are now around the same level as fossil technologies (represented by the light gray band in the figure). Geothermal and hydropower show a slight increase, but they still remain at a competitive level compared to fossil-based generation plants. Biomass suffered some volatility over the 10 years, finally settling at the same LCOE level.

Figure 18: Global LCOE of different newly installed renewable generation plants, 2010-2020 (IRENA, 2021)



Source: IRENA Renewable Cost Database
Note: This data is for the year of commissioning. The thick lines are the global weighted-average LCOE value derived from the individual plants commissioned in each year. The project-level LCOE is calculated with a real weighted average cost of capital (WACC) of 7.5% for OECD countries and China in 2010, declining to 5% in 2020; and 10% in 2010 for the rest of the world, declining to 7.5% in 2020. The single band represents the fossil fuel-fired power generation cost range, while the bands for each technology and year represent the 5th and 95th percentile bands for renewable projects.

3 SUMMARY OF CURRENT NATIONAL RENEWABLE ENERGY POLICIES AND MEASURES

One of the goals of the STP Government is to maximize efforts to ensure adequate power generation and distribution to all sectors to boost the country's socio-economic growth. The government wants to have programs aimed at implementing an energy model based on economic rationality and on sustainability, though, on the one hand, combining the use of energy from endogenous renewable sources (mainly hydropower and solar energy) and, on the other hand, reducing the extra costs that burden energy prices (reducing technical and commercial energy losses and reducing fossil-based generation). This is intended to reduce the dependence on fossil fuels in the country's energy matrix and, simultaneously, to guarantee the security of supply by promoting a balanced energy matrix.

In this sense, and in fulfillment of **Vision 2030 "São Tomé and Príncipe 2030: the country we need to build",** the São Tomé government aims to achieve the following goals, among others:

- Ensure that the energy sector is reformed and measures implemented to guarantee that an energy model with economic rationality is developed, which will ensure that energy costs are sustainable and that the competitiveness of companies and the quality of life of citizens are not compromised;
- Ensure that the entire energy system transitions from an almost complete dependence on fossil fuel imports to renewable energy, through the implementation of the NREAP. After the NREAP has been prepared, the Government aims to use it to strengthen the coordination of RE support programs and the support for innovation and technology transfer.

As a SIDS, STP currently faces the challenge of increasing energy access and energy security for its population, while simultaneously mitigating climate change. STP has one of the highest power generation costs in sub-Saharan Africa. The energy sector continues to be subsidized and tariffs are not cost-reflective, affecting the country's macroeconomic stability. The country is highly dependent on imported gasoil for electricity generation and the associated expenditure in terms of foreign currency has grown in recent years, as shown in Table 5. In 2013, expenditure related to gasoil increased by more than 100% compared to 2009.

Table 5: Imports for electricity generation in thermal power plants (ALER/STP Government, 2019)

Diesel/Lubricant Diesel/Oil	**2009**	**2010**	**2011**	**2012**	**2013**
Diesel (liters) **Diesel (liters)**	11,743,334	9,473,229	13,315,861	18,101,521	19,095,025
Lubricant (liters) **Lubricant (liters)**	51,558	35,761	34,541	46,617	59,428
Custo Total (x 10^3 Dobras) **Total Cost (x 10^3 STD)**	137,176,456	113,291,764	193,367,754	267,024,011	289,494,914
Custo Total (USD) **Total Cost (USD)**	7,838,655	6,473,815	11,049,586	15,258,515	16,542,567

According to the National Energy Balance (NEB) prepared under IGEE 2021, STP imported approximately 30 million liters of gasoil for electricity generation (26,700 tons[10]) in 2019, which cost the country approximately USD 23.6 million.

A cost analysis was conducted estimating the fuel price by 2050. The fuel price forecasts were derived from:

- Commodity price forecasts (including oil price forecasts) published by the WB in October 2021;
- A historical regression of the prices of crude oil and diesel, based on monthly data sets from January 1990 to December 2017, as published by the French Institute of Statistics (INSEE); and
- The base price paid for the purchase of gasoil by EMAE in 2019, according to EMAE's 2019 Financial Report and Balance Sheet.

Table 6 shows the price trend and the projection for diesel imports to STP for electricity generation by 2050. The approximate cost of diesel imports for electricity generation in the BAU scenario from 2019 to 2050 could reach more than USD 1 billion, according to the estimates.

Table 6: Projections for diesel prices and imports to STP by 2050, adapted from (Ricardo Energy & Environment, 2018) and (EMAE, 2019)

Year	2019 (Base Year)	2020	2025	2030	2035	2040	2045	2050
Diesel Price (USD/ton)	884.93	876.20	834.80	793.55	759.97	726.25	690.57	657.00
Projection of the amount of diesel imported in the BAU scenario (ton)	26,700	27,617	31,125	35,725	41,560	48,002	55,242	63,392
Total Cost (million USD)	23.6	24.2	25.9	28.3	31.6	34.9	38.1	41.6

In addition, a wide range of barriers continue to limit the adoption of RE in the energy matrix. These barriers relate to policy and regulation, institutional capacity, knowledge and awareness, qualification and certification, financing, and the local availability of technology and expertise, making it necessary to adopt new strategies in the energy sector and in the RE subsector. The NREAP presents a series of measures and targets based on including RE in the energy matrix to achieve the goal of increasing energy access and energy security while mitigating climate change, taking into account the commitment to reduce GHG emissions by 27% in relation to the baseline scenario (or "BAU - Business As Usual") contained in the NDC updated and published in 2021.

STP HAS COMMITTED IN THE NDC TO A 27% REDUCTION IN GHG EMISSIONS, AND AIMS TO DO SO BY INCREASING THE SHARE OF RE IN THE NATIONAL ELECTRICITY SYSTEM TO 50% BY 2030 (REPRESENTED BY A TOTAL OF 49 MW, ORIGINATING FROM SOLAR (32.4 MW), HYDRO (14 MW) AND BIOMASS (2.5 MW), AND BY INCLUDING EE MEASURES
NDC 2021, STP Government

At the regional level, a meeting of Energy Ministers from ECCAS member states, which includes STP, was recently held (in June 2021), the objective of which was to **validate the roadmap for the promotion of RE in Central Africa and to finalize/validate the study regarding the implementation of a dedicated structure for RE and EE in Central Africa – the Central African Renewable Energy and Energy Efficiency Centre (CEREEAC)**. CEREEAC will be part of the Global Network of Regional Sustainable Energy Centers (GN-SEC) coordinated by UNIDO in partnership with economic communities and will cooperate with centers covering the SIDS (SACREEE, ECREEE, CCREEE and PCREEE) on island issues.

[10] *Considering a diesel density of 0.89 kg/l.*

The document has been adopted by the Member States and includes a series of key actions for the region to take advantage of its RE and EE potential (IRENA, 2021):

- *Assess the cost-effectiveness of renewable energy with the support of international technical partners.*
- *Improve the collection and processing of reliable data on RE by enabling relevant stakeholders to effectively play an active role throughout the policy development process and conduct market and socio-economic analyses related to RE implementation.*
- *Strengthen the technical capacities of relevant national and regional stakeholders to establish realistic RE targets, policies and an enabling environment to lower industry risk and to attract private investment.*
- *Increase private participation and financing of RE projects.*
- *Introduce non-hydro renewable energy into national and regional planning.*
- *Develop skills for developing fundable RE project proposals and implementing them.*
- *Develop a critical mass of professionals capable of installing, operating and maintaining RE systems.*
- *Establish a dedicated regional entity to promote the widespread use of RE in a coordinated and homogeneous manner throughout the region.*

3.1 Institutional framework

Institutionally, the energy sector in STP falls under the responsibility of the **Ministry of Infrastructure and Natural Resources (MIRN – Ministério das Infraestruturas e Recursos Naturais)**, through the **Directorate General of Natural Resources and Energy (DGRNE – Direcção Geral dos Recursos Naturais e Energia)**, and in the Autonomous Region of Príncipe (RAP – Região Autónoma do Príncipe), under the responsibility of the **Regional Secretariat for Environment and Sustainable Development (SRADS – Secretaria Regional de Ambiente e Desenvolvimento Sustentável)**. In addition to the State, its dependent bodies and public companies, local authorities and the RAP play an important role. At the local level, the districts have only regulatory powers in the energy field, although they have a very active and participative role, informally, in the design of public policies and in the regulation of the sector.

With regard to regulation in general, no specific regulator has been assigned to the energy sector, with the electricity sector alone being regulated by the **General Regulation Authority (AGER – Autoridade Geral de Regulação)**, created by Decree Law no. 14/2005. The generation, transmission, distribution and marketing of electricity are performed by **EMAE** in a vertically integrated monopoly. It is the only entity that markets electricity in the country and functions as a Regional Delegation in the RAP.

In addition to the aforementioned institutions, the energy sector also includes the STP **National Oil Agency (ANP – Agência Nacional do Petróleo)**, which is the public body that regulates and promotes the activities of the oil and gas industry in the national territory; and the **Directorate General of the Environment (DGA – Direcção Geral do Ambiente)**, which is linked to the MIRN and is the body through which the Government exercises its environmental policy. The DGA has a broad and transversal competence that necessarily addresses the energy sector.

AFAP is an autonomous body, created in 2004 for Project Administration Supervision, and is under the Ministry of Planning, Finance and Blue Economy (MPFEA – Ministério do Planeamento, Finanças e Economia Azul). In the energy sector, AFAP manages the STP Electricity Sector Rehabilitation Project.

There is also the **Coordination Committee for the Electricity Sector Transformation Program (CC-PTSE – Comité de Coordenação do Programa de Transformação do Sector Eléctrico)** and the **Technical Group supporting the Electricity Sector Transformation Program (GT- PTSE – Grupo Técnico de apoio ao Programa de Transformação do Sector Eléctrico),** which, as the names indicate, support the Government in implementing the Electricity Sector Transformation Program. In addition, the Creating Order for these coordination platforms designated:

- The Steering Committee for the Electricity Sector Transformation Program (CP-PTSE – Comité Piloto do Programa de Transformação do Sector Eléctrico). This committee includes the Ministers of Finance and the Blue Economy and has two ordinary meetings scheduled per year.

- Technical coordination is through regular monthly meetings of the Technical Committee supporting the Electricity Sector Transformation Program (CT-PTSE).

The **National Sustainable Energy Platform (PNES)** was established under the UNIDO/GEF project. The PNES includes representatives from public and private institutions that operate/participate directly and indirectly in the STP energy sector. The PNES, coordinated by MIRN/DGRNE, is scheduled to meet regularly, and to bring together the following institutions: MIRN/DGRNE, MIRN/DGA, AGER, EMAE, AFAP, Industry Directorate, APCI, UNDP, ADB, European Investment Bank (EIB) and National Institute for the Promotion of Equality and Gender Equity (INPIEG – Instituto Nacional para a Promoção da Igualdade e da Equidade de Género).

3.1.1 Gender Equity and Energy

In STP, the National Institute for the Promotion of Gender Equality and Equity (INPIEG), established in 2007, conducts activities to promote women, and gender equality and equity in the country. Its main responsibility is to ensure that the government policy translated into the **National Strategy for Gender Equality and Equity (ENIEG – Estratégia Nacional para a Igualdade e Equidade de Género)** is properly executed and implemented. The ENIEG, developed with technical and financial support from the United Nations Population Fund, was adopted in 2007 and revised in 2013. In addition to the ENIEG, in the normative framework at the national level, the Constitution of the Republic of STP also defends gender equity in the Principle of Equality (Article 15). In the normative framework at the international level, STP signed the African Charter on Human and Peoples' Rights on the Rights of Women in Africa (2003) in February 2010, although it has not ratified it to date. In September 2015, STP participated in the Fourth World Conference on Women in Beijing (ALER/STP Government, 2019).

STP has evolved positively in promoting women's rights, but inequalities still exist and there is room for improvement in promoting gender equality. Specifically, in the energy sector, it is necessary to better integrate gender issues at all levels, including in energy policy-making processes and energy projects. Gender issues have still not been included in most energy-related policies and regulations, in part because of challenges on how to do so. However, as noted in the "National Action and Action for the Beijing Strategy on January 20, 2015", actions such as increasing access to energy and access to water and basic sanitation services, which improve living conditions for all households in general, have a very positive effect on women, as household chores such as the collection of water or biomass are time-consuming and usually performed by them (ALER/STP Government, 2019).

In this sense, the NREAP aims to include the issues of equity and gender equality transversally, as topics of particular interest to be addressed in the majority of the measures proposed in the plan.

3.2 Regulatory and legal framework

There are still few regulations applicable to the energy sector in STP, in keeping with the degree of regulation of other sectors of the economy. Hence, there is no general law on RE, but there are different pieces of legislation focused on the various forms of energy capture or utilization that have a bearing on RE. There is also no overall energy policy that links all dimensions of energy or its connection to cross-cutting issues. In an effort to partially close this gap, STP decided to develop the NREAP and the NEEAP, but these do not replace what a general energy policy could and should contain.

3.2.1 Policies and strategies related to RE and EE

Various policies and strategies have been identified at sectoral, regional and national levels that aim to increase energy access and promote RE, including:

- **2021: Law 4/2021,** the **Great Options Plan (GOP)**, published in February 2021, in which the Government indicates that it aims to accelerate the energy transition in STP, through a progressive migration from thermal energy to RE, and to promote EE in STP. Actions include: increasing energy production and distribution capacity; EE projects; maintenance of generator sets at Santo Amaro 2 Power Plant and of Deutz 3 Caterpillar and ABC 3 generator sets at São Tomé Power Plant; construction of the MV 30 KV grid from Angolares to Porto Alegre (BP); construction and rehabilitation of solar and hydro plants; regulation of the energy efficiency rules, regulation of the inspection process of low quality electrical equipment; and development of energy map studies.

- **2019:** The **Third National Communication (TNC) on Climate Change** 2019 identified mitigation options in the energy sector, consisting of installing systems for harnessing water resources, conducting studies to assess the potential for alternative energy production (wind, solar, biomass), and **developing RE production**, particularly solar energy and hydropower. In addition, technology transfer is needed, as a priority for the RE-related energy sector, as well as the transport, agriculture, forestry and land sectors. In the EE area, the TNC considered as mitigation measures: the replacement of inefficient light bulbs by LED ones (at the domestic and public lighting levels), the reduction of grid losses, and, in the transport sector, the replacement of gasoline and diesel cars by more efficient ones.
- **2019:** The **STP National Sustainable Development Plan 2020-2024 (PNDS – Plano Nacional De Desenvolvimento Sustentável)** published by the STP Government in 2019, focused on four strategic axes of intervention: (i) Deepening the democratic rule of law; (ii) Robust economic growth and accelerated job creation; (iii) Improving the quality of health and social protection; and (iv) Developmental foreign policy. In the energy field, the strategy highlights the need to reverse the current situation with the application of EE measures and the **gradual increase in the use of RE**, with a view to the sustainable and clean electrification of the country (using hydro, solar and wind sources). The operational framework of the PNDS is represented by a matrix with 34 programs distributed among the 4 goals and in the 3 programmatic pillars of the plan, and an additional Management and General Administration Program that is transversal to them (see Annex II).
- **2019**: The **Blue Economy Transition Strategy in STP** was published in October 2019. RE is an integral part of the sectors covered by the "blue economy" concept, and chapter 3.4 of the strategy is dedicated specifically to the RE sector. It presents an overview of the situation and the challenges to RE sector growth, including the lack of a national strategic plan for RE development. The strategy identifies 4 niches for action in RE:

  1) Exploit new RE potential: i) identify its potential; ii) conclude the River Contador project; iii) prepare specifications and carry out public tenders; iv) respond to private investment proposals;

  2) Strengthen sustainability in the RE development process: i) create a regulatory framework for the activity of private energy production (incentives for RE);

  3) Include the people in RE policies: i) create community managed energy systems; ii) create tariff systems for rural and riverside areas; and

  4) Strengthen knowledge for improved Governance: i) evaluate the potential of biomass as a source of energy in the communities; ii) evaluate the impact of the use of firewood and woody charcoal by the population to smoke fish and make food.
- **2017:** The **STP Multisectoral Investment Plan: integrating climate change resilience and disaster risk into coastal zone management** published in 2017 identifies drought as one of several climate risks. In the power sector, drought may compromise hydropower generation. The plan also identifies gaps related to climate change monitoring, which include, in general: (i) the lack of mapping and detailed understanding of climate risks and sector vulnerabilities; (ii) the need for capacity building; (iii) the poor coordination between government agencies and projects implemented by partners/donors; among others.
- **2015:** The **STP 2030 Transformation Agenda** published in 2015 was based on Agenda 2030 from the United Nations and included the provision of a guarantee fund for private **RE investment** initiatives, including hydropower, totaling USD 60 million, with the aim of covering, by 2019, 50% of the country's electricity needs through clean and sustainable energy sources. However, according to current data, this figure is still far short of the target.
- **2006: The National Action Plan for Adaptation to Climate Change (NAPA)** presented in 2006 contained some adaptation solutions for the energy sector, including the construction of hydropower stations, with accessible technologies and knowledge at the national level; the introduction of different **RE** types other than hydropower, such as biomass, solar, wind, etc. thereby reducing the consumption of fossil fuels. On the issue of climate change adaptation, in **June 2020** the Green Climate Fund (GCF) and the United Nations Environment Programme (UNEP) received STP's proposal for the implementation of the program "*Reduce São Tomé and Príncipe's vulnerability to climate change impacts by strengthening the Country's capacity to*

implement an integrated approach to adaptation planning", the expected outcomes of which are: 1. Actors mobilized, institutional framework established and national capacity strengthened to develop and implement the National Adaptation Plan (NAP) in STP; 2. Evidence base for adaptation planning developed through the production of preparatory elements and gathering of background information for the NAP process; 3. NAP priorities operationalized in plans at local and national levels and supported by an iterative planning framework and monitoring process; 4. Access to resources and investments facilitated to implement adaptation priorities in STP (GCF, 2020).

- There are also other policies and strategies in different sectors that include aspects of EE and RE. **STP's National Employment Policy (NEP)** promotes green jobs, which include EE and RE, seeking to significantly reduce environmental risks and resource scarcity, as well as considering the environmental dimension at all stages of production, exchange and consumption systems. The **Guide for Entrepreneurs** includes RE as one of the business sectors in STP with good investment opportunities. **The National Investment Plan for Agriculture and Food Security and Nutrition** promotes the development of RE and EE in STP, including support for the installation of hydro, wind and solar power plants, as well as the use of improved stoves.

3.2.2 Energy sector policies and strategies

In this field, the most developed sector is electric power, given its growing role in the country's economic and social development, which is regulated by the **Electricity Sector Legal Regime (RJSE – Regime Jurídico do Sector Eléctrico)**.

- **2020:** The most recent effort to promote RE is **Decree Law No. 1/2020**, the regulation establishing the **Special and Transitional Regime for the Purchase of Energy from Renewable Sources**. The purpose of this Decree-Law is to allow the **independent production of energy from renewable sources** on an exceptional basis, until the consolidation of a definitive legal framework for the sector (Article 1), and was intended to last for one year from the date of entry into force (i.e. until February 2021).
- **2016: The Tax Benefits and Incentives Code** – Decree-Law 15/2016. The Code establishes a framework of tax benefits and incentives aimed at attracting investment projects. The Code includes a benefit for the introduction of new technologies (Article 18), although the technologies this relates to are not specified. It mentions the existence of exceptional benefits for, among others, ventures involving infrastructure projects of public interest, carried out under a concession regime (Article 32). Projects located in Special Development Zones (ZED – Zonas Especiais de Desenvolvimento) enjoy tax benefits; covering new technologies, among other activities (Article 33 et seq.).
- **2014:** The **RJSE - Decree-Law no. 26/2014** represents the **Basic Law for the Electricity Sector** in STP, defining the State policy for the sector, as well as planning and management, issuance of generation licenses, issuance of concessions and the approval of legal statutes. The RJSE was adopted on the basis of three considerations. The first addressed the need to clarify the regulatory framework to meet the various challenges facing the sector, with emphasis on the need to improve the supply of electricity in the country in order to respond to growing demand, the frequent power cuts resulting from the fragility of the production system, and the weaknesses of the already obsolete grid. Secondly, the definition of a regulatory framework facilitating secure and transparent private investment to supplement the energy supply of the traditional producer, EMAE. Thirdly, without exhausting other factors that may have contributed, the strong political will to strengthen the technical and economic regulatory framework for the sector was also very apparent (ALER/STP Government, 2019). Although the RJSE was approved, the existing organizational model for the market has yet to be adjusted to the one it stipulates, suggesting that it is necessary to strengthen the legal framework, reinforce the capabilities and resources of the different actors, and attract private investment. The RJSE provides the general regulations applicable to the activities of the electricity sector, including the **production of energy through renewable sources** (Article No. 50 et seq.). Production for own consumption and production in isolated locations can be performed without the need for licenses (thereby offering simplified access to the production activity); and access is not restricted to delivery points, except for producers wishing to sell part of the energy produced to the grid (but it must consume 60% or more of what they generate); and there is no limit on the maximum

power to be installed for production for own consumption. This framework (Article No. 52) will enable the combined capacity of small self-producers in the country to become a substantial contribution. In another framework (Article No. 53), an entity can qualify for an authorization to generate up to 150 kVA of electricity in an isolated location, not connected to the national grid, and sell the electricity produced locally, which could be attractive in the case of solar PV and mini-hydropower plants. In addition, the RJSE does not put conditions on the number of authorizations per entity. In summary, STP does not yet have a legal framework of RE incentives, or specific access rules for independent generation under a special regime, but the aforementioned frameworks partially work as incentives for RE generation, even though this is not formally stated in the text.

- The majority of the RJSE regulations have been stipulated and require development through supplementary legislation, in particular in relation to Generation Activity, Grid Access and, in particular, Generation from RE Sources.

3.2.3 Programs and projects of interest for the development of RE

Although STP does not have a specific legal and regulatory framework aimed at fostering the development of RE, it does have a portfolio of activities and programs aimed at achieving that development through RE. The following list includes some of the most significant projects and programs in the energy sector that are in progress in the country, or are being developed and due to start in the near future:

a) **Mini Hydropower Projects Support Programme**, implemented by the African Development Bank, Sustainable Energy fund for Africa (SEFA) - in progress (AfDB, 2018);

b) **Economic Reform and Power Sector Support Program (ERPSSP-I)**, implemented by the African Development Bank - in progress (AfDB, 2019);

c) **Energy Transition and Institutional Support Program (ETISP)**, implemented by the African Development Bank - in progress (AfDB, 2020);

d) **Strategic Program to Promote RE and EE investments in the electricity sector of STP** (UNIDO Energy Project), implemented by UNIDO - in progress (GEF, 2018);

e) **STP Power Sector Recovery Project,** implemented by the World Bank - in progress (WB, 2020);

f) **Project to promote hydropower through an approach that integrates land and forest management in STP (Project ENERGIA)**, implemented by UNDP/GEF- in progress (GEF, 2013)

g) **Project Proposal "Building institutional capacity for a renewable energy and energy efficiency investment program for São Tomé and Príncipe",** submitted to the GCF with support from UNIDO, August 2021.

Detailed background information on STP's energy sector, as well as details of policies, programs, plans and other actors in the EE and RE sector can be found in the *Status Report on RE and EE in STP* published by ALER and in the *Energy Policy and Data Gap Analysis Report* prepared as part of the consultancy undertaken for the development of the NEEAP and NREAP.

4 NATIONAL RENEWABLE ENERGY TARGETS AND INDICATORS, AND COMPLEMENTARY TARGETS

The targets for integrating RE into São Tomé's energy matrix shown in the NREAP complement the targets established in the NEEAP and, and are also complementary to the targets for GHG emissions reduction and universal access to energy, as can be seen in Figure 19.

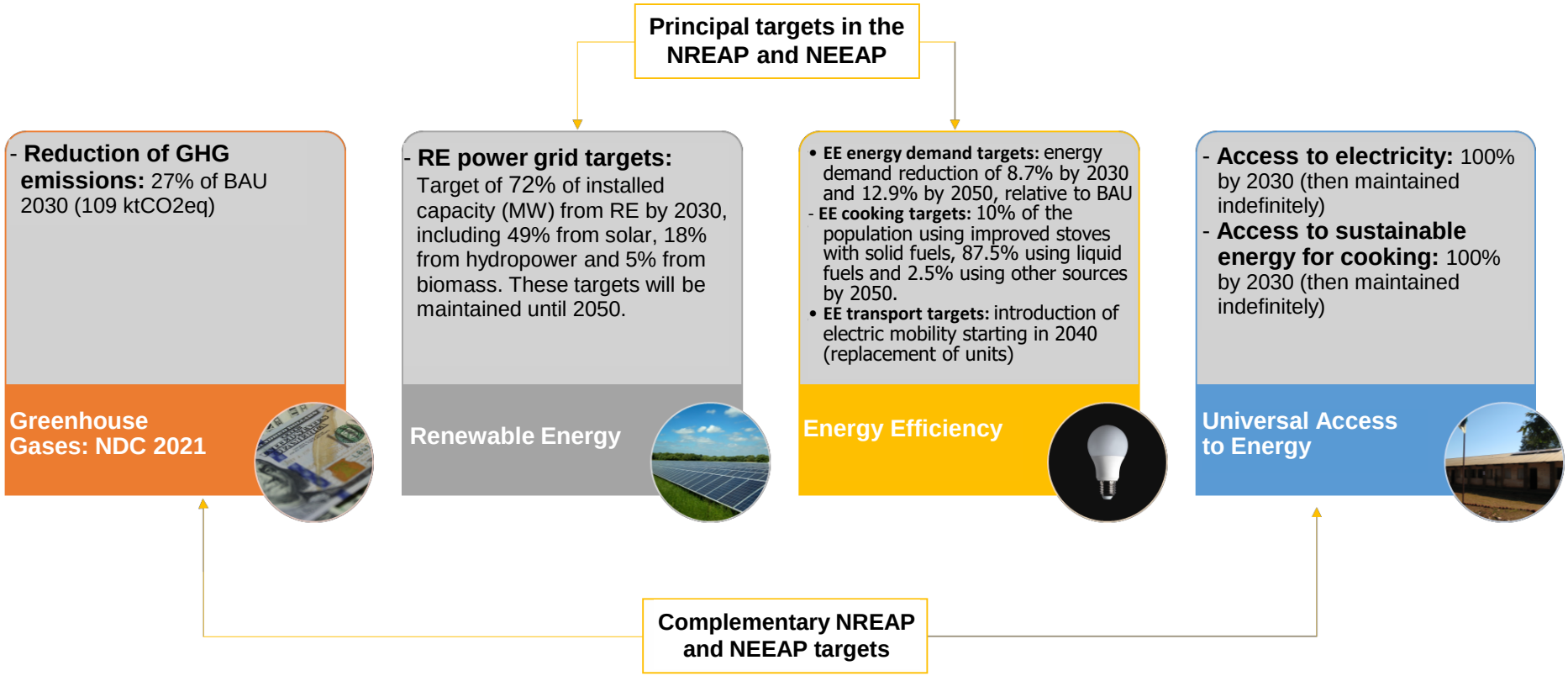


Figure 19: NREAP, NEEAP and complementary targets

The targets described in the NEEAP (and the NREAP) were adopted by the STP Government through a participatory process led by PNES/DGRNE, involving the exchange of opinions and information, a series of meetings and discussions with PNES/DGRNE, and revisions of the draft plans by PNES/DGRNE and UNIDO. The end result of this process was the adoption of the targets and measures contained in the NREAP and the NEEAP.

The NREAP and NEEAP provide the STP Government with practical guidance on how to make the energy transition a reality by 2030 and 2050. Based on energy modeling using LEAP software, the NREAP and NEEAP propose a low-carbon scenario that will significantly reduce the country's energy costs and GHG emissions. Energy transition is a prerequisite for the achievement of important national, regional and global policy goals.

The main reference documents used in developing the NREAP and the NEEAP are: Vision 2030 "São Tomé and Príncipe 2030: the country we need to build", the Blue Economy Transition Strategy for São Tomé and Príncipe, Agenda 2030 and Agenda 2063: "The Africa We Want", the Nationally Determined Contributions (NDC, 2021), the Third National Communication (TNC) on Climate Change, the National Action Plan for Adaptation to Climate Change (NAPA), and ECCAS/CAEMC regional policies. Implementing the action plans will enable the country to achieve Sustainable Development Goal 7 (SDG-7), which aims for universal access to affordable, reliable, sustainable and modern energy services by 2030.

The NREAP and NEEAP propose a set of targets and measures to be implemented by 2030 and 2050. The well-integrated documents consider urban and rural contexts, electricity and heat aspects, and important cross-sectoral policies (e.g. climate mitigation/adaptation, trade, education, research, buildings, transport, tourism, health, agriculture, fisheries and other sectors of the economy).

The NREAP and NEEAP are tightly interconnected and mutually reinforcing. For example, introducing EE standards and the related reductions in energy demand will have a positive impact on RE penetration in the grid. The NREAP targets complement those established in the NEEAP, while also complementing others for reduction of GHG emissions and for universal access to energy.

The NREAP sets specific targets for the RE sector with the main goal of significantly increasing the penetration of renewable generation capacity in the STP electricity matrix by 2030 and 2050. The main target of the NREAP is the introduction of electricity generation plants based on renewable energy sources, both grid-connected and off-grid, stipulated as follows:

- To achieve 72% of installed electricity generation capacity (MW) from renewable sources, consisting of 49% from solar, 18% from hydropower and 5% from biomass. These targets will be maintained until 2050.

The following additions of renewable capacity (grid-connected and off-grid) are considered in the NREAP to achieve the target described above:

- rehabilitation and construction of mini-hydropower plants[11] totaling 17.30 MW (the technology considered is run-of-river), of which 15.30 MW is grid-connected and 2 MW is off-grid;
- installation of several solar PV projects with total capacity of almost 47 MW, of which 42.20 MW will be grid-connected PV plants (some with energy storage) on the island of São Tomé and 4.75 MW will be a grid-connected PV plant on the RAP (with energy storage), and a microgeneration program for 800 households with isolated and roof-top domestic solar PV systems);
- use of the biomass resources available in the country for the installation of a biomass cogeneration plant, with a potential of about 4.68 MW.

More details of the installed capacity by year can be found in Annex III. As already mentioned in the introduction to this document, the targets were adopted by the country in a participatory process, with the exchange of information and opinions during the present year. The measures (specifically the RE and EE projects) were included in the model designed with LEAP to generate the mitigation scenario and the modeling results were adopted as targets, that is, the percentage of renewable capacity integration in the case of the NREAP, and the reduction of energy demand in the case of the NEEAP. The RE projects included in the plan that give rise to the modeling and targets are projects that the country currently has in the pipeline.

[11] *Mini-hydropower plants are defined as having a capacity of up to 30 MW (see definition in Annex IV)*

In addition, the NREAP and NEEAP also include targets for home cooking applications that aim to gradually replace traditional cooking sources with cleaner and safer ones that have a lower impact on household health and the environment. The goal is to replace traditional stoves with improved high-efficiency ones, to promote the use of liquid fuels for cooking (mainly LPG) and, to a lesser extent, to include the use of electricity and solar stoves. The target of 100% access to efficient energy for cooking by 2030 complements the goal of 100% access to electricity services by 2030, thereby ensuring that the population of São Tomé have universal access to energy by 2030. These goals are directly aligned with the United Nations' SDG-7: "*Ensure access to affordable, reliable, sustainable and modern energy for all*."

The plans also aim to improve the inefficient, fossil fuel-based transport system, transforming it into a more efficient, low-carbon system. This will be achieved with a low-carbon transport strategy and the introduction of EE vehicle standards, as well as the gradual introduction of electric mobility. It is proposed to replace cars, motorcycles and buses that currently run on diesel and gasoline with electric units starting in 2040, when there is expected to be high penetration of RE on the grid. The first demonstration projects could already have been implemented in the tourism sector or on motorcycles.

4.1 Summary of Targets

The targets proposed for renewable energy in this action plan are as follows:

Table 7: Summary of RE targets in the STP NREAP

Targets for RE in the electricity sector (including on-grid and off-grid systems)	Base Year	Target Medium Term	Target Long Term
Installed capacity	**2019**	**2030**	**2050**
Available installed RE capacity (MW)	1.22[12]	68.98	68.98
Percentage of total installed capacity from RE (%)	4.2%	72%	72%
Production	**2019**	**2030**	**2050**
Total generation from RE (GWh)	5.8	79.53	162.67
Percentage of total electricity generation from RE (%)	5.3%	86.6%	67.9%
Targets for home cooking applications	**Base Year**	**Target Medium Term**	**Target Long Term**
Use of improved stoves	**2019**	**2030**	**2050**
Percentage of the population using solid fuels (firewood or charcoal) for cooking (%) in improved stoves	NA[13]	62.9%	10.0%
Percentage of the population using liquid fuels for cooking (e.g. LPG, kerosene)	27% (2020)*[14]	36.9%	87.5%
Percentage of the population using other efficient technologies for cooking (electricity, solar)	0.08% (2020)*[15]	0.2%	2.5%
Population with access to clean cooking sources	NA	100%	100%

[12] *This value comes from the Contador hydropower plant, which has an installed capacity of 1.92 MW, but has only 1.22 MW available.*

[13] *NA: Not Available*

[14] *Source:* (UNDP, 2021)

[15] *In the base year (2021) the figure includes only electricity, as the information source did not identify other technologies. In the following years targets include electricity together with other technologies, such as solar energy, for cooking.*

4.2 Renewable Energy Targets

STP consists principally of two (inhabited) islands, specifically the island of São Tomé and the island of Príncipe. The island of São Tomé has 74% access to electricity services and the island of Príncipe 100%, giving the country a total access rate to electricity services of 87%.

As already mentioned in Section 2.2.2, electricity generation has grown sharply since 2009, by approximately 90% in 9 years. This has had a negative impact on the country's economy as it has increased dependence on fossil fuels. In its 2030 vision, STP aims to reduce this dependency and increase the share of RE in the energy matrix to ensure that development is more sustainable.

The introduction of RE in grid-connected electricity generation is mainly focused on projects to increase generation capacity based on **solar power and hydropower** (in the case of hydropower, including rehabilitation of existing infrastructure and new projects). These projects will also be complemented by ongoing projects for the rehabilitation of the energy transmission, transformation and distribution infrastructure, and by support projects for strengthening the institutional, policy and regulatory framework, and training and capacity building of the government areas involved in the management of the energy sector, as well as other stakeholders.

With regard to off-grid systems, STP has been using diesel generators to meet isolated demand and currently there are only three isolated units, which entered into service in 2015: the Porto Alegre generator set (328 kW), the Ribeira Peixe generator set (108 kW) and the Monte Mario generator set (108 kW) (EMAE, 2019).

The majority of the population without access to electricity services lives in remote areas of the island of São Tomé, where electricity can only be supplied through isolated or off-grid systems. As part of Vision 2030, the country's goal is to guarantee **universal access by 2030**, achieving this by providing the remaining 13% of the population still without electricity services with access to isolated RE and/or RE mini-grids or hybrid RE systems.

Critical aspects to consider in the country to ensure the smooth implementation/execution of these new projects are:

a. Political stability;

b. The governance goals and programs that are complementary to the RE-related goals;

c. The continuation of the joint PNES efforts;

d. The proposed actions at the regional level contained in the ER Roadmap for the ECCAS.

All these aspects were considered in defining the targets of achieving at least 72% RE participation in STP's electricity matrix by 2030 and maintaining it until 2050, in terms of installed capacity (meaning that, in principle, no more renewable capacity is planned to be added between 2030 and 2050), and these can be achieved through the implementation of the projects mentioned in Table 8, thereby contributing positively to the sustainable development of the country.

Table 8: Targets for RE proportion for 2030 and 2050

RE Targets	Base Year	Target Medium Term	Target Long Term
Installed capacity	**2019**	**2030**	**2050**
Installed RE capacity (MW), of which:	1.22[16]	68.98	68.98
Capacity of hydropower plants (MW)	*1.22*	*17.30*	*17.30*
Capacity of solar plants (MW)	*0.00*	*46.95*	*46.95*
Capacity of biomass power plants (MW)	*0.00*	*4.68*	*4.68*
Percentage of installed capacity from RE (%)	4.2%	72%	72%

[16] *Currently the renewable proportion connected to the grid is from Contador Hydropower plant (São Tomé Island). Its installed capacity is 1.92 MW but only 1.22 MW is available.*

Percentage of capacity from hydropower plants (%)	*4.2%*	*18%*	*18%*
Percentage of capacity from solar plants (%)	*0.0%*	*49%*	*49%*
Percentage of capacity from biomass power plants (%)	*0.0%*	*5%*	*5%*
Production	**2019**	**2030**	**2050**
Electricity production from RE (GWh)	5.8	79.53	162.67
Production from hydropower plants (GWh)	*5.8*	*37.0*	*51.8*
Production from solar plants (GWh)	*0.0*	*40.0*	*94.9*
Production from biomass power plants (GWh)	*0.0*	*2.6*	*16.0*
Percentage of electricity production from RE (%)	5.3%	86.6%	67.9%
Percentage of capacity from hydropower plants (%)	*5.3%*	*40.3%*	*21.6%*
Percentage of capacity from solar plants (%)	*0.0%*	*43.5%*	*39.6%*
Percentage of capacity from biomass power plants (%)	*0.0%*	*2.8%*	*6.7%*

The following graphs (Figure 20 and Figure 21) show a possible mitigation trajectory with the types of energy sources (RE and fossil) highlighted, in terms of installed capacity (MW) and generation (GWh) in the STP electricity matrix. Note that while the trajectory shows only solar, biomass and hydropower, other renewable energy sources, such as offshore wind and PV, geothermal, or ocean energy can also be considered. The NREAP proposed measures include a series of studies with the objective of further studying the feasibility of implementing projects using these other sources. Accordingly, after 2030 the mix could vary, in reality, as these studies produce results.

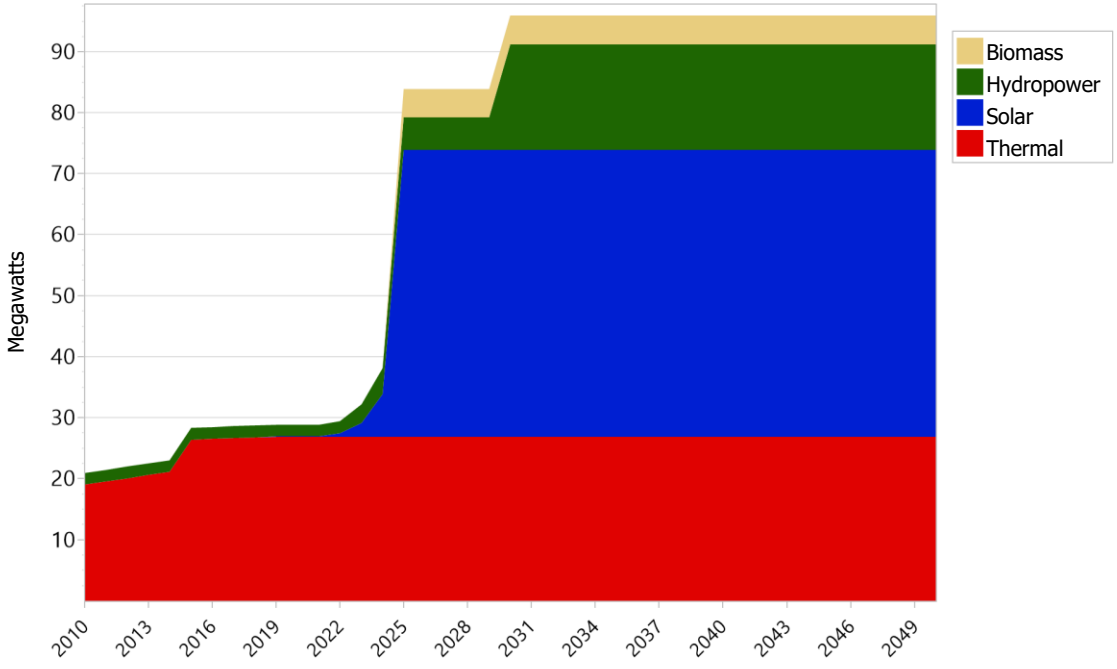


Figure 20: Estimated trajectory of RE installed capacity in the mitigation scenario up to 2050 (in MW)

Figure 20 shows the progressive inclusion of renewable generation capacity in the electricity generation mix. Since it is planned for all RE projects to be operating by 2030, installed capacity increases significantly in that area of the graph and is maintained until 2050. Note that the proportion of solar capacity is large in comparison to the other sources.

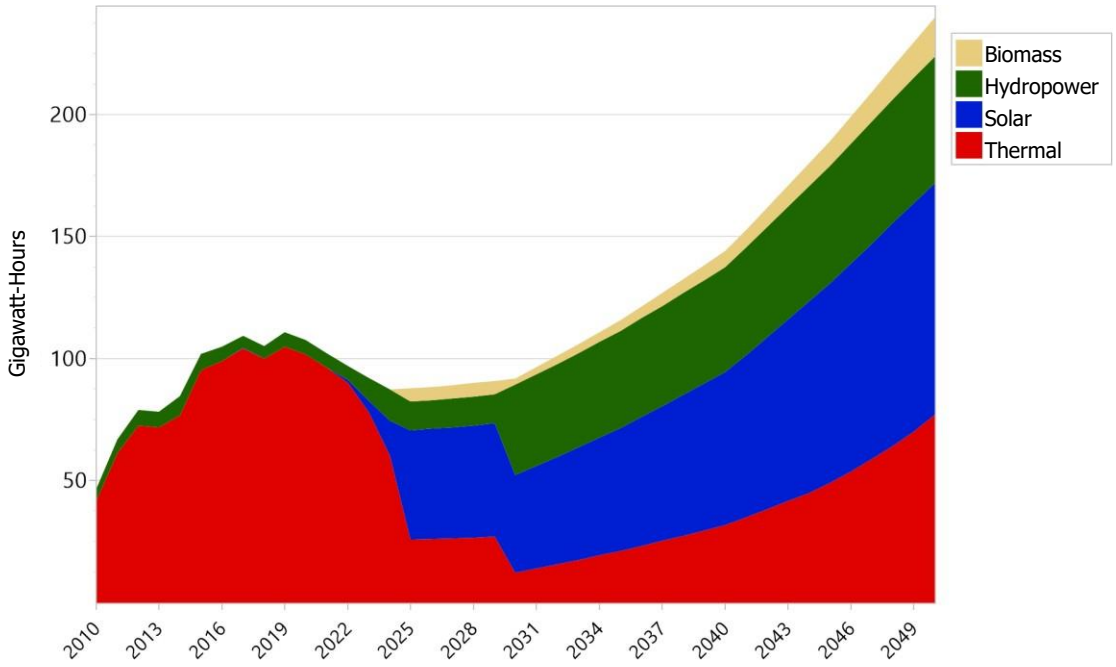


Figure 21: Estimated trajectory of RE generation in the mitigation scenario up to 2050 (in GWh)

Figure 21 shows the estimated trajectory of electricity generation (GWh) by year and the contribution of each source to total generation, with renewable sources predominating strongly over thermal ones.

Annex III provides details of the individual capacities to be installed for each type of renewable technology by year and the electricity generation for each source by year.

4.3 Renewable energy applications in the residential sector

4.3.1 Targets for energy for cooking in the residential sector

The report prepared by UNDP in the period 2020-2021 "Characterization of the charcoal value chain in São Tomé and Príncipe and assessment of economic displacement risks under initiatives related to forest sustainability" offers recent statistical data regarding the use of cleaner cooking sources, and shows that approximately 27% of the STP population uses safe and modern sources for cooking (e.g. oil (kerosene) (25.5%) or gas (LPG) (1.5%)). The rest of the population uses solid fuels.

It is STP's goal to provide the population with access to sustainable energy sources for cooking. In this regard, STP, in the context of the NREAP and NEEAP, aims to achieve universal access to energy by 2030 (see Figure 19), including access to electricity services and to efficient and cleaner sources for cooking. The target of 100% access to clean energy for cooking involves individual targets for each energy source and includes improved stoves (charcoal or firewood) using solid fuels and others using liquid fuels, such as LPG and kerosene, plus a small proportion of solar and electric stoves (see Table 9 for percentages for each source). The target of 100% access to efficient energy for cooking by 2030 complements the goal of 100% access to electricity services by 2030, **thereby ensuring that São Tomé's population has universal access to energy by 2030**. These targets are directly aligned with the seventh United Nations Sustainable Development Goal (SDG-7): "*Ensure access to affordable, reliable, sustainable and modern energy for all*."

This section of the plan should also define the target and associated trajectory for production of **charcoal using efficient technologies** (technologies with a yield greater than 25%). However, in-depth knowledge of the charcoal production sector in the country would be necessary for this, which does not currently exist, so it is not possible to quantify the percentage (%) of charcoal produced using efficient systems in the base year nor to define achievable targets for the country. The study prepared by UNDP on the charcoal value chain mentioned above does not address the technologies or processes used in the country for charcoal manufacturing. An in-depth study of the charcoal production sector is necessary to characterize and define the targets for it. Accordingly, this target appears has NA ("Not Available") alongside it in Table 9.

Table 9: Residential Cooking Energy Targets for 2030 and 2050

Targets for RE and EE applications in cooking	Base Year	Medium-Term Target	Long-Term Target
	2019	**2030**	**2050**
Percentage of population using improved solid fuel stoves (%)	NA	62.9%	10.0%
Number of improved stoves distributed and in use (cumulative)	-	39,600	9,206
Percentage of population using liquid fuels for cooking, and which type	27%	36.9%	87.5%
LPG:	*1.5%*	*15.8%*	*75.0%*
Kerosene:	*25.5%*	*21.1%*	*12.5%*
Percentage of population using electricity, solar energy or other efficient technology for cooking	0.1%	0.2%	2.5%
Total percentage of population with access to more efficient sources for cooking	**27.1%**	**100%**	**100%**
Percentage of charcoal produced by efficient techniques (%)	NA	NA*	100%

Table 9 appears in both the NREAP and the NEEAP (in the latter, as Table 10) because there are measures and targets for applying both RE and EE to cooking: in the case of RE, biomass, but with the use of more efficient stoves, as well as the use of charcoal produced through more efficient techniques; in the case of EE, cleaner fuels and more efficient production techniques.

*it was not possible to set a target for charcoal production by 2030 as there are no records of the current percentage produced through efficient and non-efficient techniques, but STP has stipulated that all charcoal will be produced efficiently by 2050, which is aligned with the target of ensuring 100% access to sustainable and secure energy by 2030 and maintaining it indefinitely.

The figure below (Figure 22) shows the evolution of the introduction and change in cooking technologies through 2030 and 2050, as well as the growth in access to safe, cleaner and more efficient cooking sources. This shows the evolution of the introduction of improved stoves together with fossil fuel stoves to 2030, as well as the growth in the use of liquid fuels (LPG and kerosene), and, after 2030, the progressive decrease in the use of improved stoves and fossil fuel stoves, and the significant increase of LPG, in addition to other cooking sources or technologies, but to a lesser extent.

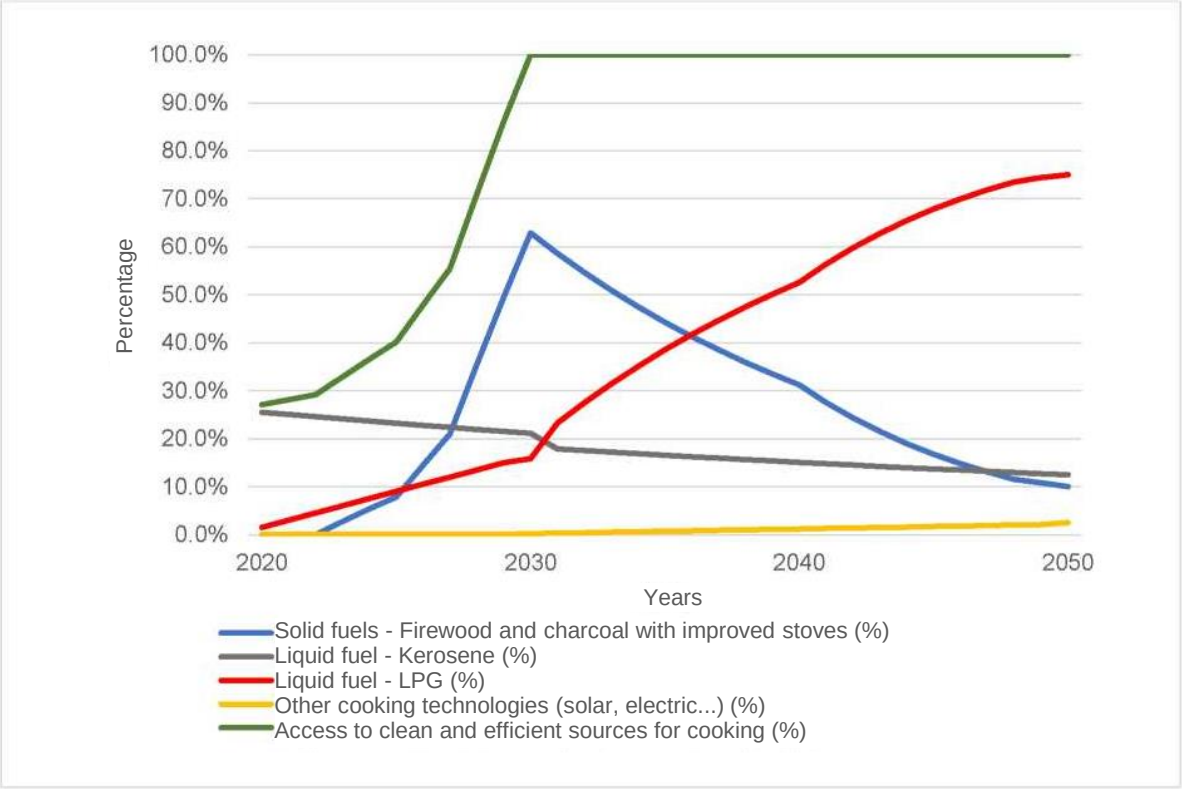


Figure 22: Access to clean and efficient cooking sources (% of population)

4.4 Estimated investment costs for grid-connected RE projects

It is expected that in the coming years the energy sector in STP will diversify, with more companies and professionals entering the market, both in RE production and EE demand management, contributing significantly to the production of national wealth (through, for example, the: creation of new companies, growth of local companies, increased employment supply, creation of qualified jobs and increased foreign investment in the sector). It is important to note that as STP is a SIDS, its integration into the regional market is very significant for the growth of the economy. Within the framework of the Transformation Agenda and Vision 2030, the STP Government aims to transform the country into a maritime and air services hub, offering financial, health, education and tourism services to the Gulf of Guinea. This transformation will be achieved through the realization of a Deepwater transshipment port and a large capacity airport, the development of a free trade zone, and other opportunities (STP Government, 2015).

In this section, only the estimated investment cost for RE is presented in Table 11 (based on the projects in the portfolio to be implemented by 2030 and 2050). The values presented in Table 11 are based on the assumptions given below in Table 10:

Table 10: Estimated investment in grid-connected RE projects per capacity unit

Project		Capacity (MW)	Investment per kW (USD/kW)	Source of investment information
MHPs	Rehabilitation and expansion of the Contador power plant (S. Tomé)	2	6,128	LCDP
	Rehabilitation of the Agostinho Neto power plant (S. Tomé)	1.2	650	LCDP
	Rehabilitation of the Guegué power plant (S. Tomé)	1	650	LCDP
	Rehabilitation of the Papagaio power plant (Príncipe)	1.1	6,768	LCDP

	Construction of hydropower plants on the Iô Grande River and in Bombaim (S. Tomé)	10 (total)	4,987	LCDP
Solar	Construction of the 15 MWp Água Casada Lobata Solar PV Plant, with a 2 MW battery bank (S. Tomé)	15	2,460	LCDP
	Construction of the 15 MWp Água Casada Lobata Solar PV Plant, with a battery bank for backup (S. Tomé)	15	2,460	LCDP
	Construction of the 10 MWp Água Casada Lobata Solar PV Plant (S. Tomé)	10	1,200	LCDP
Hybridization with solar PV	Hybridization of Santo Amaro PV Plant 1st Phase, 0.54 MWp	0.54	1,200	LCDP
	Hybridization of Santo Amaro PV Plant 2nd phase, 1.66 MWp	1.66	1,200	LCDP
Biomass	Construction of the Biomass Plant (S. Tomé) for processing solid urban, vegetable and industrial waste	4.68	2,543	IRENA Power Generation Costs 2020 Report[17]

The renewable potential, the required investment and future market development will be analyzed and quantified when the preliminary studies are carried out. At that time, with baseline data available, targets for market development can then be defined that encompass: (i) investment in other RE technologies that are not yet included in the projects in the portfolio for grid-connected generation (e.g. solar thermal, ocean energy, offshore wind, etc.); (ii) contract volume for local RE production/assembly/installation industries – all investment; (iii) number of registered companies operating in the RE sector; (iv) number of local commercial banks financing RE in the region.

[17] *Source: (IRENA, 2021)*

Table 11: Status of estimated investment in grid-connected RE generation projects in the country[18]

Years		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Total investment in new RE grid-connected power plants per year in USD	Mini-Hydropower Plants	USD 9,961,580	USD 9,961,580	USD 9,961,580	USD 9,701,580	USD 6,475,080	USD 4,987,000	USD 4,987,000	USD 4,987,000	USD 4,987,000	USD 4,987,000	**Total in USD by 2030**
	Solar PV	USD 15,748,000	USD 18,748,000	USD 18,424,000	USD 17,760,000	USD 17,760,000						
	Bioenergy	USD 2,380,248	USD 2,380,248	USD 2,380,248	USD 2,380,248	USD 2,380,248						
Total in USD per year		USD 28,089,828	USD 31,089,828	USD 30,765,828	USD 29,841,828	USD 26,615,328	USD 4,987,000	USD 4,987,000	USD 4,987,000	USD 4,987,000	USD 4,987,000	**USD 171,337,640**

Notes: All the other estimates that could not be presented due to lack of baseline data and/or lack of potential studies were removed from the table.

The preceding table only goes up to the year 2030 (medium term) as grid-connected RE power plants have only been planned up to that year. In addition, investments are considered finalized at the end of each year of the estimated period for implementing the measure.

[18] *This investment is not presented cumulatively, but at the time and in the amount that is expected to be invested in each year of the trajectory. The investment is purely indicative and for the projects that were considered for setting the RE targets in the STP energy matrix.*

5 RENEWABLE ENERGY SECTORAL MEASURES

This chapter of the NREAP shows all of the different measures that could be implemented in the RE sector in order to achieve the main goals described in Figure 19, as well as those considered as complementary.

Subsection 5.1 below presents the measures considered in this NREAP, organized by themes within the energy sector with a focus on RE, specifically:

i. Table 12: Overview of all policies and measures for the energy and electricity sector
ii. Table 13: Projects for grid-connected RE
iii. Table 14: Distributed RE projects (mini-grids, prosumers, microgeneration)
iv. Table 15: Overview of all policies and measures for modern energy for cooking
v. Table 16: Overview of all policies and measures for sustainable agriculture and cattle raising, and reduction of deforestation
vi. Table 17: Overview of all policies and measures for the transport sector

The purpose of these tables is to summarize and provide an overview of all the proposed RE measures and the results to be obtained. A detailed description of each individual measure and additional information can be found in Subsection 5.3.

Finally, Subsection 5.2 provides a general implementation schedule for the measures over the period covered by the plan, that is, until 2050, indicating the order in which the measures will be implemented and which will be implemented simultaneously.

5.1 Summary of the measures

Table 12: Overview of all policies and measures for the energy and electricity sector

TYPE			MEASURE	TARGET GROUP	IN PROGRESS / PLANNED	PERIOD / ENTRY INTO OPERATION
Development of Preliminary Studies and Collection of Information (Political and Technical)	**M**	**1**	Preparation of studies and collection of information regarding technical and economic issues of RE energy planning	Decision makers in the public and private sector	Planned	2021-2025
	M	**2**	Preparation of studies and collection of information regarding the potential of RE and its contribution to mitigation and adaptation	Decision makers in the public and private sector	Planned	2021-2030
	M	**3**	Preparation of studies and collection of information regarding the installation of RE projects	Decision makers in the public and private sector	Planned	2021-2030
Organizational (Institutional) Strengthening	**M**	**4**	Creation and integration of the RE department at DGRNE	Public Sector / Energy Service Companies	Planned	2021-2025
	M	**5**	Preparation of the AGER Restructuring Plans and the EMAE and AGER Personnel Plan	Electricity Sector	Planned	2021-2024
Market Development (Regulatory and Legal)	**M**	**6**	Establish regulations for low voltage electrical installations	Public Sector / Energy Service Companies / Population of São Tomé and Príncipe	In progress (ToRs developed)	2021-2022
	M	**7**	Establish regulations for the quality of materials used in low, medium and high voltage electrical installations	Public Sector / Energy Service Companies / Population of São Tomé and Príncipe	In progress (ToRs being developed)	2021-2022
	M	**8**	Establish regulations for connecting to the grid, as well as model contracts and tariffs.	Public Sector / Energy Service Companies	In progress	2021-2022
	M	**9**	Establish regulations for incorporating solar energy in real estate infrastructure projects (with emphasis on the tourism sector)	Private sector with emphasis on the hotel/tourism sector	Planned	2021-2025
Creation of incentive mechanisms and guarantees (Financial and Fiscal)	**M**	**10**	Creation of incentives and financial mechanisms to attract investments in RE	Energy Service Companies	Planned	2021-2023
	M	**11**	Program for the promotion of RE & EE business, entrepreneurship and innovation models	Private Sector / General Population	Planned	2021-2030

	M	**12**	Creation of guarantees by the State and credible and recognized international institutions.	Private Sector	Planned	2021-2030
	M	**13**	Facilitate access to credit for farmers to install solar systems (10 MWp) and others on their properties for productive use.	STP agriculture and cattle raising sector	Planned	2021-2030
Transparency and Decision Support (Policy and Information)	**M**	**14**	Creation of a centralized information system for (renewable and conventional) energy, water and climate change under the MIRN (DGRNE) and the INM	Political and business decision makers / General population	In progress	2021-2023
	M	**15**	Creation and implementation of a MRV (Monitoring, Recording and Verification) system including RE and EE measures	DGRNE/Policymakers	In progress	2021-2030
	M	**16**	Preparation of a GIS map of the renewable energy potential in the country and identification of priority projects	Political and business decision makers	Planned	2021-2023
RE training, qualification and certification initiatives (for products and services)	**M**	**17**	Creation of a qualification, certification and accreditation training program for installation, operation and maintenance of RE systems	Energy sector professionals	Planned	2021-2023
	M	**18**	Creation, continuous updating and implementation of a program to train experts on the use and application of the results of resource mapping and RE potential	Professionals from MIRN / DGRNE, EMAE, AGER, DGA and other RE-related institutions	Planned	2021-2050
	M	**19**	Continuous capacity building for institutional managers in structuring complete proposals for energy projects and project management for fundraising	Energy sector professionals	Planned	2021-2050
	M	**20**	Strengthening the capacity of the staff of the institutions directly involved in the RE sector with regard to the integration and management of RE systems.	Professionals from MIRN / DGRNE, EMAE, AGER, DGA and other RE-related institutions	Planned	2021-2023
	M	**21**	Continuous actions to support the capacity building of national associations and entrepreneurs in the area of energy	STP RE Associations	In progress	2021-2050
	M	**22**	Development and ongoing implementation of an RE training and capacity building plan for technical staff.	Energy sector professionals	Approved and in progress	2021-2050
	M	**23**	Development of an online training program on sustainable energy solutions for islands, delivered by training institutions and experts in STP	Energy sector professionals	Planned	2021-2023

	M	**24**	Creation and installation of laboratories in the RE area	University and research centers	Planned	2021-2035
	M	**25**	Promotion of technical and technological training for the staff of training centers and universities, on a continuous basis	Universities and professional training centers	Planned	2021-2050
	M	**26**	Establish cooperation agreements with international universities and technological research centers in the RE area	Universities and technology centers	Planned	2021-2050
Information and Awareness Raising Initiatives	**M**	**27**	Implementation of the SEforALL awareness raising campaign in São Tomé and Príncipe, which includes renewable energies and other topics	General population	Planned	2021-2023
	M	**28**	Implementation of the awareness raising campaign and dissemination of information on RE and the benefits of its adoption	Private Sector / General Population	In progress	2021-2050

Table 13: Projects for grid-connected RE

TYPE	MEASURE			TARGET GROUP	IN PROGRESS / PLANNED	PERIOD / ENTRY INTO OPERATION
Infrastructure investment (Political and Economic)	**M**	**29**	Rehabilitation with power increase of the Contador 2 MW mini-hydropower plant	Population of São Tomé	In progress	2020-2024
	M	**30**	Rehabilitation with power increase of the Papagaio 1.1 MW mini-hydropower plant	Population of Príncipe	In progress (Preparation for launching an invitation to tender in the construction sector)	2020-2025
	M	**31**	Rehabilitation of the Agostinho Neto 1.2 MW mini-hydropower plant	Population of São Tomé	In progress (The infrastructure has already been rehabilitated, and is expected to be operational in 2023)	2020-2023
	M	**32**	Rehabilitation of the Guegué mini-hydropower plant with an increase of 1 MW	Population of São Tomé	Planned (the infrastructure already exists and requires rehabilitation, hence expected to be operational in 2024)	2020-2024
	M	**33**	Construction of the 4.68 MW Biomass Power Plant	Population of São Tomé	Planned (CAE signed, awaiting implementation)	2020-2025
	M	**34**	Hybridization of the Santo Amaro photovoltaic plant 1st phase 0.54 MW	Population of São Tomé	In progress	2020-2022
	M	**35**	Hybridization of the Santo Amaro photovoltaic plant 2nd phase 1.66 MW	Population of São Tomé	Planned (awaiting implementation)	2020-2023

	M	**36**	Construction of the 15 MW Água Casada Lobata Solar PV Plant, with a 2 MW battery bank	Population of São Tomé	Planned (CAE signed, awaiting implementation)	2020-2025
	M	**37**	Construction of the 15 MW Água Casada Lobata Solar PV Plant, with a battery bank for backup	Population of São Tomé	Planned (CAE signed, awaiting implementation)	2020-2025
	M	**38**	Construction of the 10 MW Água Casada Lobata Solar PV Plant	Population of São Tomé	Planned (Awaiting CAE signature)	2021-2025
	M	**39**	Construction of hydropower plants on the Iô Grande River and in Bombaim, total of 10 MW	Population of São Tomé	Planned	2020-2030

Table 14: Distributed RE projects (mini-grids, prosumers, microgeneration)

TYPE	MEASURE			TARGET GROUP	IN PROGRESS / PLANNED	PERIOD / ENTRY INTO OPERATION
Infrastructure investment (Political and Economic)	**M**	**40**	Construction of the Solar PV Plant - 4.75 MWp with 3.5 MWh of storage	Population of the RAP	Planned (Awaiting CAE signature)	2021-2024
	M	**41**	Construction of a 2 MW mini-hydropower plant in Claudino Faro	Population of São Tomé	Planned	2021-2030
	M	**42**	Installation of domestic solar PV plant (800 households / 3 kW) (including rooftop PV and RE for industrial prosumers)	Population of São Tomé	Planned	2021-2030

Table 15: Overview of all policies and measures for modern energy for cooking

TYPE	MEASURE			TARGET GROUP	IN PROGRESS / PLANNED	PERIOD / ENTRY INTO OPERATION
Development of Preliminary Studies and Collection of Information (Political and Technical)	**M**	**43**	Study to define the strategy to achieve universal (100%) access to clean and safe cooking sources in STP by 2050	General population	Planned	2021-2023
Development of programs and action plans	**M**	**44**	Implementation of a program to replace 39,600 traditional stoves with improved high-efficiency ones	General population	Planned	2023-2050
	M	**45**	Definition and implementation of a program for the adoption of efficient charcoal production techniques	General population	Planned	2020-2035

Table 16: Overview of all policies and measures for sustainable agriculture and cattle raising, reducing deforestation and using biomass as an energy source

TYPE			MEASURE	TARGET GROUP	IN PROGRESS / PLANNED	PERIOD / ENTRY INTO OPERATION
Improving and strengthening the regulation	**M**	**46**	Establish regulations for the exploitation of forests to prevent excessive and uncontrolled forest exploitation	Policy makers / General population	Planned	2020-2030
Development of programs and action plans	**M**	**47**	National program for reforestation and sustainable management of forest and agroforestry ecosystems and agriculture in general, with emphasis on drought-resilient forestry, reduction of illegal logging, and management of protected areas.	Policy makers / General population	In progress (National Forest Development Plan (PNDF – Plano Nacional de Desenvolvimento Florestal))	2020-2025
	M	**48**	Action plan to use natural fertilizers and reduce the use of nitrogen fertilizers in agriculture and cattle raising	Horticulturists/farmers	Planned	2020-2030
	M	**49**	Program to increase the number of composting centers in agricultural areas to replace the use of fertilizers	Rural Population	Planned	2020-2030
	M	**50**	Program for installing 900 biodigesters for production of biogas from animal waste	General population	Planned	2021-2040
	M	**51**	Action plan for the construction of a landfill with methane capture and flaring system	Population of São Tomé	Planned	2022-2040
	M	**52**	Creation of an action plan to promote the use of waste as an energy source	General population	Planned	2022-2040
Transparency and Decision Support (Policy and Information)	**M**	**53**	Creation of a centralized information system for forests, land use and land use change, forest resources, agriculture and associated climate change, under the DFB and INM	Political and business decision makers / General population	Planned	2020-2025

Table 17: Overview of all policies and measures for the transport sector

TYPE			MEASURE	TARGET GROUP	IN PROGRESS / PLANNED	PERIOD / ENTRY INTO OPERATION
Development of Preliminary Studies and Collection of Information (Political and Technical)	**M**	**54**	Preparation of studies and collection of information regarding the development of a low-carbon public transport system	Decision makers in the public and private sector	Planned	2021-2030
	M	**55**	Preparation of studies and collection of information regarding the potential for biofuel production	Decision makers in the public and private sector	Planned	2021-2030

5.2 Timeline for implementing the measures

Measure		Implementation years																															
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	**2030**	2031	2032	2033	2034	2035	2036	2037	2038	2039	**2040**	2041	2042	2043	2044	2045	2046	2047	2048	2049	**2050**
Overview of all policies and measures for the energy and electricity sector																																	
1	Preparation of studies and collection of information regarding technical and economic issues of RE energy planning																																
2	Preparation of studies and collection of information regarding the potential of RE and its contribution to mitigation and adaptation																																
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4	Creation and integration of the RE department at DGRNE																																
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7	Establish regulations for the quality of materials used in low, medium and high voltage electrical installations																																
8	Establish regulations for connecting to the grid, as well as model tariff contracts																																
9	Establish regulations for incorporating solar energy in real estate infrastructure projects (with emphasis on the tourism sector)																																
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22	Development and ongoing implementation of an RE training and capacity building plan for technical staff.																														
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50	Program for installing 900 biodigesters for production of biogas from animal waste																																
51	Action plan for the construction of a landfill with methane capture and flaring system																																
52	Creation of an action plan to promote the use of waste as an energy source																																
53	Creation of a centralized information system for forests, land use and land use change, forest resources, agriculture and cattle raising, and associated climate change, under the DFB and INM																																
Overview of all policies and measures for the transport sector																																	
54	Preparation of studies and collection of information regarding the development of a low-carbon public transport system																																
55	Preparation of studies and collection of information regarding the potential for biofuel production																																

5.3 Detailed description of the measures

Taking into account the reality and ambition of STP to achieve the proposed targets, the action plan proposes a trajectory based on a series of relevant measures to be implemented. To this end, with the aim of achieving the proposed goals, the detailed description of each measure adopted is presented below, including its priority and expected results/impacts.

5.3.1 Measures concerning the energy and electricity sector

Prior knowledge of renewable alternatives, constraints, benefits and costs, as well as the impacts of adopting future RE measures is crucial to increase RE penetration in STP's energy mix. Accordingly, it will be necessary to develop technical and preparatory studies to facilitate decision making. The most relevant technical studies for STP concerning energy planning and RE potential are presented in the following measures:

No.: RE 1

MEASURE	TECHNICAL STUDIES - RE PLANNING
TYPE OF MEASURE	Studies/preparations
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2025
DESCRIPTION OF THE MEASURE	Detailed studies should be conducted to achieve, respectively, the 2030 and 2050 targets for capacity from renewable sources and to analyze further measures for the integration of RE in STP's energy matrix, in addition to improving grid management, its digitalization and energy delivery, considering the high renewable penetration. To this end, the following analyses should be performed: - Analyze the load curve and technical losses at different points, identifying critical points in the grid; - Final capacity sizing and grid integration (if applicable) of different technology options (including analysis of distributed solar PV deployment) and grid extension needs; - Analysis of grid stability and flexibility, as well as storage needs (e.g. batteries), considering a high penetration of RE, mainly solar - Analysis of possibilities for intelligent grid management and digital integration to increase grid flexibility -Risk analysis and climate change mitigation and Integrated Resource and Resilience Planning - Identification of pilot/demonstration projects to be implemented (considering gender perspectives during the identification process). - Analysis of measures and recommendations for the integration of gender equality and equity in the planning and implementation of the RE (and EE) sector, to be developed in close coordination with INPIEG. The above studies shall complement the "Renewable Energy Investor Guide", which is in the process of approval (September 2021).
TARGET GROUP/SECTOR	Decision makers in the public and private sector
IMPLEMENTING BODY(IES)	RE department (creation planned) at DGRNE, EMAE / INPIEG (in gender-related aspects)
EXPECTED RESULTS / IMPACTS	R1. Analysis and decision support on technical issues for implementing RE with regard to the transmission and distribution network R2. Analysis and decision support on approaches and strategies for progressing the integration of RE into the regional energy strategy R3. Analysis and decision support for national-level RE policy development, as well as policy support mechanisms

No.: RE 2

MEASURE	TECHNICAL STUDIES - RE POTENTIAL AND ITS CONTRIBUTION TO MITIGATION AND ADAPTATION
TYPE OF MEASURE	Studies/preparations
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030

DESCRIPTION OF THE MEASURE	A detailed analysis should be conducted to identify the RE potential in the country, including solar potential (with special attention to solar thermal (heat) applications for water heating and for agricultural and industrial use), wind (onshore and offshore), geothermal, biomass (complementing that obtained in the PNGIRSU) and oceans (OTEC, wave, tidal, etc.). Field measurements should be carried out in order to quantify and classify the potentials at a national level, as well as studies regarding the installation of meteorological stations in all locations with potential (especially in coastal areas for collecting oceanic and atmospheric information). This also includes the potential for distributed generation of small or micro-renewables in rural and urban areas *(net-metering*). The study should consider an analysis of "frontier technologies" and their applicability and potential in STP, including green hydrogen and electric mobility on land (in coordination with measure #54) and sea. The study of potential should be complemented by a study of the effective contribution that this potential and its development could have on GHG emission mitigation, in the context of the NDCs, in addition to the contribution that different technologies could have as climate change adaptation options (to be developed considering the outcome of the GCF/UNEP project "*Reduce São Tomé and Príncipe's vulnerability to climate change impacts by strengthening the Country's capacity to implement an integrated approach to adaptation planning*."
TARGET GROUP/SECTOR	Decision makers in the public and private sector
IMPLEMENTING BODY(IES)	RE Department (creation planned) at DGRNE
EXPECTED RESULTS / IMPACTS	R1. Knowledge of solar, wind, geothermal, biomass and ocean potential R2. Availability of data for more precise calculations R3. Information available for decision making regarding energy planning R4. Analysis and identification of the potential and application of renewable energy in industry (e.g. use of solar thermal / biomass in cocoa production) R5. Contribution of RE technologies and potential in mitigating GHG emissions and adapting to climate change.

No.: RE 3

MEASURE	TECHNICAL STUDIES - RE INSTALLATION PROJECTS
TYPE OF MEASURE	Studies/preparations
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	A study should be conducted for detailed analysis and definition of the installation of a biomass power plant (to complement the one currently considered in the measures) and an onshore wind power plant (3 MW). To this end, the following analyses should be performed: - Analysis of the location of the plants; - Analysis of requirements for extending the transmission and distribution network; - Analysis of static and dynamic grid stability. This measure has to be implemented in coordination with measure #1.
TARGET GROUP/SECTOR	Decision makers in the public and private sector
IMPLEMENTING BODY(IES)	RE Department (creation planned) at DGRNE
EXPECTED RESULTS / IMPACTS	R1. Assessment of the installation of a biomass power plant R2. Assessment of the installation of a 3 MW onshore wind power plant

In this strategy, which is based on creating an adequate RE market, it will be **imperative to create and strengthen the necessary institutions for supervising, monitoring, regulating and tracking the market**, in addition to structuring the institutional frameworks. Accordingly, creating the complete, transparent facilitating institutional mechanism necessarily requires the successful implementation of the following measures:

No.: RE 4

MEASURE	ESTABLISHMENT OF THE RE DEPARTMENT AT DGRNE
TYPE OF MEASURE	Organizational Strengthening
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	5
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2025

DESCRIPTION OF THE MEASURE	This RE strategy requires Coordination, Monitoring & Evaluation components, which could be facilitated by creating and establishing an RE department. This department will have the function of mobilizing, coordinating activities and monitoring the implementation of the RE projects in the field in coordination with the EE department that will be created (see the NEEAP). It will be responsible for monitoring the policy, and the main instrument for intervention and promotion of activities in the sector, including planning, prospecting, monitoring and introduction of new technologies and processes, as well as the strengthening of institutional capacity and human resources. This type of measure will have the electricity sector's institutional guidance manual as a reference, and should be aligned with it. The RE department, in close coordination with the EE department, will be responsible under DGRNE for ensuring the active participation of the latter in RE- and EE-related events, training or other activities promoted by CEREEAC.
TARGET GROUP/SECTOR	Public Sector / Energy Service Companies
IMPLEMENTING BODY(IES)	DGRNE
EXPECTED RESULTS / IMPACTS	R1. Structured institutional framework for RE R2. Guaranteed follow-up of technical, financial, logistical and other operations

No.: RE 5

MEASURE	AGER RESTRUCTURING AND THE EMAE AND AGER PERSONNEL PLAN
TYPE OF MEASURE	Organizational Strengthening
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2024
DESCRIPTION OF THE MEASURE	Institutional gaps in AGER should be identified and the staffing of AGER and EMAE should be planned to ensure the support and facilitation of the RE strategy outlined. To do so, it will be necessary to: - Define and clarify institutional responsibilities; - Increase capacity on grid flexibility and stability, management of smart grids, and digital integration - Increase capacity for integrated resource and resilience planning in the context of expansion planning - Strengthen and empower institutional stakeholders (including gender perspectives in labor inclusion); - Identify and remove institutional barriers to the facilitation, coordination and monitoring of the strategy to be implemented.
TARGET GROUP/SECTOR	Electricity Sector
IMPLEMENTING BODY(IES)	AGER / EMAE
EXPECTED RESULTS / IMPACTS	R1. Structured institutional frameworks R2. Adequate levels of professionals working in the institutions established (including gender perspectives) R3. Institutional barriers eliminated

It is crucial to the development of the RE market to create the legal, regulatory and economic conditions necessary to ensure investor and business confidence. The rules, procedures and market mechanisms, as well as requirements for purchase and sale contracts and tariff setting should be as transparent as possible and known in advance to all stakeholders. The following measures aim to develop the legal, regulatory and economic framework of the RE market:

No.: RE 6

MEASURE	REGULATIONS FOR ELECTRICAL INSTALLATIONS
TYPE OF MEASURE	Market Development (Regulatory and Legal)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	In progress
IMPLEMENTATION PERIOD	2021-2022
DESCRIPTION OF THE MEASURE	A technical regulation for low-voltage electrical installations in STP should be established. To do so, it will be necessary to: - Create safety and quality control standards for the facilities;

	- Create standards for the certification of electricians and certification of low-voltage facilities; - Regulate the institutions / bodies responsible for the safety and quality control of the facilities.
TARGET GROUP/SECTOR	Energy service companies / Population of São Tomé and Príncipe
IMPLEMENTING BODY(IES)	DGRNE / AGER
EXPECTED RESULTS / IMPACTS	R1. The operation and safety of electrical installations ensured R2. The quality of electrical power improved R3. Losses in the distribution network reduced

No.: RE 7

MEASURE	REGULATIONS FOR QUALITY OF MATERIALS IN ELECTRICAL INSTALLATIONS
TYPE OF MEASURE	Market Development (Regulatory and Legal)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	In progress
IMPLEMENTATION PERIOD	2021-2022
DESCRIPTION OF THE MEASURE	A technical regulation should be established for the quality of materials used in low, medium and high-voltage electrical installations in STP. To do so, it will be necessary to: - Create standards for importing or locally manufacturing electrical materials and marketing them in STP; - Create standards for the quality control of the materials used for installations (following national or international standards); - Regulate the institutions / bodies responsible for controlling the quality and safety of the materials used. - Adopt renewable energy product standards and a compliance framework (e.g. solar-thermal, PV)
TARGET GROUP/SECTOR	Energy Service Companies
IMPLEMENTING BODY(IES)	DGRNE / AGER
EXPECTED RESULTS / IMPACTS	R1. The operation and safety of electrical installations ensured R2. The quality of electrical power improved R3. Losses in the distribution network reduced R4. Costs for power grid maintenance reduced R5. Electrical losses in the distribution network reduced

No.: RE 8

MEASURE	REGULATIONS FOR GRID-CONNECTION AND TARIFF CONTRACTS
TYPE OF MEASURE	Market Development (Regulatory and Legal)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	In progress
IMPLEMENTATION PERIOD	2021-2022
DESCRIPTION OF THE MEASURE	A technical regulation should be established for connecting to the grid and model tariff contracts for RE projects, as well as model PPAs. To do so, it will be necessary to: - Create technical parameters such as the power grid code and delivery parameters; - Define the parameters of the commercial relationships between producers and the distributor and between the distributor and the final customers; - Establish regulations for electricity purchase/sale tariffs; - Establish regulations and practical guidelines for distributed renewable energy generation in rural areas (e.g. mini-grids) and urban areas (e.g. net-metering, prosumers) - Define the criteria and requirements for the Electricity Purchase and Sale Contracts, and Electricity Acquisition Contracts. - Develop and implement an auction model for utility-scale RE; - Establish a quality structure and capacity for technical, economic, environmental, financial and legal aspects (in coordination with capacity building initiatives) The specific regulations for RE projects to be developed under this measure should be compatible with the energy regulatory framework that is in the process of being approved and should include: • Regulations for Access and Connection to the Grid • Commercial Relations Regulation

	• A contract for the purchase of electricity from a production facility connected to the national grid • Electricity supply contract • SEN (National Energy Sector) Supervision Manual • Power Purchase Agreement (Self-producer) • Legal Regime for Self-Production of Energy • Distributed renewable energy generation regime (mini-grids, net-metering) • Supervisory Regulations • Regulations for procedures for connecting to the interconnection grid
TARGET GROUP/SECTOR	Energy Service Companies
IMPLEMENTING BODY(IES)	DGRNE / AGER
EXPECTED RESULTS / IMPACTS	R1. Requirements for connecting RE projects to the grid defined R2. Transparent and simplified licensing system for RE projects R3. Model energy contracts prepared and available R4. Tariff structures available and simplified

No.: RE 9

MEASURE	REGULATIONS FOR SOLAR ENERGY APPLICATIONS (WITH EMPHASIS ON THE TOURISM SECTOR)
TYPE OF MEASURE	Market Development (Regulatory and Legal)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2025
DESCRIPTION OF THE MEASURE	Regulations should be established for an energy compensation system for incorporating photovoltaic panels and solar thermal energy in public and private real estate infrastructure projects. Initially, focus will be on the hotel and tourism sector, where electricity consumption is high, but the measure also covers infrastructure for other purposes such as health, education, government buildings, etc. The legal regime for self-production of electricity already exists in STP and it will be necessary to confirm that it can be applied in the specific case of the hotel sector. The viability of solar thermal energy for water heating, for example, has to be verified with preliminary studies (under measure #2), after which its introduction will have to be regulated and encouraged.
TARGET GROUP/SECTOR	Private sector with emphasis on the hotel sector
IMPLEMENTING BODY(IES)	DGRNE / AGER
EXPECTED RESULTS / IMPACTS	R1. Application of energy saving measures and bioclimatic construction to reduce energy demand and promote generation from renewable sources R2. Incentives for the generation of electricity distributed in public buildings

No.: RE 10

MEASURE	CREATION OF INCENTIVES AND FINANCIAL MECHANISMS FOR RE PROJECTS
TYPE OF MEASURE	Market development (incentive mechanisms and guarantees)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2025
DESCRIPTION OF THE MEASURE	Incentives and financial mechanisms should be created to attract investments in RE for large scale projects, as well as for autonomous generation systems. Incentives and mechanisms should be identified and designed in partnership with banking, financial institutions and private investors. The incentive systems will be defined through conducting a study identifying the model(s) to be adopted, which may also include subsidies for interest, guarantees, rates to be applied, etc. The incentive systems should consider the specific financing needs of women. It is necessary to define clear processes and incentive mechanisms for Independent Producers (RE auctions, quota systems and tariff systems).
TARGET GROUP/SECTOR	Energy service companies / Private sector / General population
IMPLEMENTING BODY(IES)	DGRNE / Banks / Investment Funds

EXPECTED RESULTS / IMPACTS	R1. Package of incentives developed and established R2. Increased market guarantees R3. RE Market Growth

No.: RE 11

MEASURE	PROGRAM FOR PROMOTING RE & EE BUSINESS, ENTREPRENEURSHIP AND INNOVATION MODELS
TYPE OF MEASURE	Market development (incentive mechanisms and guarantees)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	5
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	A market analysis should be conducted and the RE & EE business models that best fit the STP context should be identified in order to encourage investment in RE & EE by the local and international private sector. Based on this analysis, a program will be developed to promote entrepreneurship and innovation in the area of RE & EE with a special focus on SMEs. The program should consider gender inclusion through incentives specifically tailored to the needs of women, and foster entrepreneurship and innovation in young people through coordinated work with local universities. International experiences in other countries in the region should be considered as examples.
TARGET GROUP/SECTOR	Private sector (SMEs) / entrepreneurs and local business associations
IMPLEMENTING BODY(IES)	DGRNE / International Partners / Universities
EXPECTED RESULTS / IMPACTS	R1. Innovation-based growth of the RE&EE market R2. Increased entrepreneurship among young people and women R3. Local SME growth and sustainable development of the economy

No.: RE 12

MEASURE	CREATION OF GUARANTEES
TYPE OF MEASURE	Market development (incentive mechanisms and guarantees)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	5
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	Guarantee systems should be created for renewable-based and autonomous generating systems, by the state and by credible and recognized international institutions.
TARGET GROUP/SECTOR	Private Sector
IMPLEMENTING BODY(IES)	DGRNE / Banks / Investment Funds
EXPECTED RESULTS / IMPACTS	R1. Increased investor confidence to enter into Public Private Partnerships (PPP)/CAE

No.: RE 13

MEASURE	FACILITATING ACCESS TO CREDIT IN THE AGRICULTURE AND CATTLE RAISING SECTOR
TYPE OF MEASURE	Market development (incentive mechanisms and guarantees)
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	Access to credit should be facilitated for farmers (with an emphasis on women) to install solar PV systems of up to 10 MWp and/or other types of RE systems on their farms for productive use. Based on the results of the assessment of the potential for solar thermal energy use of measure #2, credit access facilities for rural and productive applications of solar thermal energy (for example, for drying cocoa beans) should also be developed.
TARGET GROUP/SECTOR	STP agriculture and cattle raising sector
IMPLEMENTING BODY(IES)	DGRNE / Banks / Investment Funds

EXPECTED RESULTS / IMPACTS	R1. Increase in electric (and thermal) energy produced R2. Decreased CO_2 emissions R3. Increased income of the rural population

After achieving an adequate institutional framework, an improvement in the competitiveness of RE sources and the removal of bureaucratic and financing barriers, favorable conditions will be created for the RE market to develop freely in STP. To this end, the creation of tools **that ensure transparency and decision support is available will be essential elements to ensure a dynamic and innovative RE market**.

Evaluation and validation of the effectiveness and impact of the measures must be constant and must be accompanied by data collection, organization and analysis. The availability of these data will allow the development of sectoral and thematic studies, which will be useful for learning and decision support. In particular, they will enable energy modeling and planning exercises to be conducted with a more robust information base. The aim of the following measures is to promote transparency and decision support to develop an RE market:

No.: RE 14

MEASURE	CREATION OF A CENTRALIZED INFORMATION SYSTEM
TYPE OF MEASURE	Transparency and decision support
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	In progress
IMPLEMENTATION PERIOD	2021-2023
DESCRIPTION OF THE MEASURE	A centralized system for energy (renewable and conventional), water and climate change information should be created under MIRN / DGRNE and the National Institute of Meteorology (INM), with energy indicators being made available for analysis. Periodic, systematic and exhaustive collection of statistical data on the energy sector will be carried out. Compiled, organized and analyzed data will be made available for consultation, including: - Preparation of a detailed annual energy balance; - Preparation of energy indicators; - Preparation of a prospective analysis. This system will facilitate access to reliable information and enable decision making, together with the MRV system that will also be created. Wherever possible, the system will include the collection of energy indicators that describe women's impact on or relationship with the energy sector, such as the percentage of women with access to clean or more efficient energy for cooking.
TARGET GROUP/SECTOR	Political and business decision makers / General population
IMPLEMENTING BODY(IES)	DGRNE, DGA AND INM
EXPECTED RESULTS / IMPACTS	R1. Energy Information System created and implemented R2. Energy indicators analysis system available

No.: RE 15

MEASURE	MRV SYSTEM CREATION
TYPE OF MEASURE	Transparency and decision support
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	A Monitoring, Recording and Verification (MRV) System for tracking the implementation of the RE measures should be created. The MRV system will be used to evaluate the efficiency and effectiveness of the implementation of the RE measures, and to monitor the actual implementation timescale against the planned implementation schedule. To do so, it will be necessary to: - Define the indicators to be included in the MRV system (including indicators broken down by gender and, if possible, by age, in order to measure the impact of the measures on both children and women); - Ensure access to relevant professionals and decision makers.

TARGET GROUP/SECTOR	DGRNE/Policymakers
IMPLEMENTING BODY(IES)	DGRNE
EXPECTED RESULTS / IMPACTS	R1. MRV system created and implemented R2. Implementation of the national energy policy monitored and evaluated

No.: RE 16

MEASURE	MAPPING RE POTENTIAL
TYPE OF MEASURE	Transparency and decision support
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2023
DESCRIPTION OF THE MEASURE	The GIS mapping of the RE potential in STP should contain the information generated by the studies to be conducted on that potential, including the possible locations for RE projects and the distances to connect them to the transmission or distribution network.
TARGET GROUP/SECTOR	Political and business decision makers
IMPLEMENTING BODY(IES)	DGRNE
EXPECTED RESULTS / IMPACTS	R1. Centralized information on RE potential in STP R2. Facilitation of decision making

The training, qualification and certification of professionals, as well as of services and products, in the electricity and energy sector is a fundamental measure in the strategy to promote RE. The strategy outlined for the energy sector for the next 30 years will require, in the first place, the empowerment and training of human resources in sufficient quantity and quality to meet the challenges faced by that sector. Accordingly, it will be necessary to provide specialized high-level training, associated with research and development activities, as required to maintain constant innovation, with improvements in processes and technologies and, consequently, greater competitiveness. The following capacity building activities are proposed here:

No.: RE 17

MEASURE	CREATION OF A SPECIALIZED TRAINING PROGRAM
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2023
DESCRIPTION OF THE MEASURE	It is intended to organize a training program for professionals in the RE field, providing qualification, certification and accreditation for the installation, operation and maintenance of RE systems, through collaboration with national and international universities or training centers, covering the following aspects: - Renewable Energy Technologies (with a focus on solar PV and thermal energy, small-scale hydropower and bioenergy); - Power Grids; - Installation of RE systems; - Operation of RE systems; - Automation of RE systems; - Monitoring and Communication (smart grids, mini grids); - Maintenance of RE systems. The training courses should include theoretical and practical classes, and provide certification for professionals who demonstrate good academic and practical performance. The courses should implement measures to promote women's participation in them and thereby increase the percentage of (young) women professionals in the energy field.
TARGET GROUP/SECTOR	Energy sector professionals
IMPLEMENTING BODY(IES)	DGRNE / Universities / Training Centers / Research Institute
EXPECTED RESULTS / IMPACTS	R1. Capacity building for professionals in the local RE market, with a focus on female participation

	R2. Availability of information and expertise R3. Opportunity for constant updating for energy professionals R4. Female participation encouraged and thereby the training of women in the energy field.

No.: RE 18

MEASURE	CREATION OF A TRAINING PROGRAM
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2050
DESCRIPTION OF THE MEASURE	It is intended to promote a training program for professionals involved in STP energy planning, on the use and application of the results of GIS mapping of RE resources and potential, through collaboration with national and international universities or training centers, covering the following aspects: - Identification of the potential per available resource; - Identification of the location with the greatest potential for installation of RE projects; - Evaluation of costs for grid connection. The training should include theoretical and practical classes. The training should implement measures to promote women's participation in it and thereby increase the percentage of trained women in the energy field
TARGET GROUP/SECTOR	Professionals from MIRN / DGRNE, DGA, EMAE, AGER and other RE-related institutions
IMPLEMENTING BODY(IES)	DGRNE / Universities / Training Centers
EXPECTED RESULTS / IMPACTS	R1. Capacity building for RE professionals to efficiently develop plans for expanding the generation, transmission, distribution and trading system R2. Female participation encouraged and thereby the training of women in the energy field.

No.: RE 19

MEASURE	CAPACITY BUILDING ACTIVITIES - STRUCTURING OF PROPOSALS
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2050
DESCRIPTION OF THE MEASURE	Short training courses will be developed and provided for institutional managers in structuring complete proposals for RE projects and project management for fundraising, covering the following aspects: - Technical analysis of RE projects; - Financial analysis of RE projects; - Fundraising sources; - Templates for budget spreadsheets; - Project management: Prospecting, Initiation, Planning, Execution, Control and Closure. The training should include theoretical and practical classes. The training should implement measures to promote women's participation in it and thereby increase the percentage of trained women in the energy field.
TARGET GROUP/SECTOR	Energy sector professionals
IMPLEMENTING BODY(IES)	DGRNE / Universities / Training Centers
EXPECTED RESULTS / IMPACTS	R1. Capacity building for institutional managers in the RE sector R2. Female participation encouraged and thereby the training of women in the energy field.

No.: RE 20

MEASURE	CAPACITY BUILDING ACTIVITIES - RE INTEGRATION AND MANAGEMENT
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned

IMPLEMENTATION PERIOD	2021-2023
DESCRIPTION OF THE MEASURE	Short training courses will be developed and provided to strengthen the capacity of the staff of institutions directly involved in the RE sector for integrating and managing RE systems, covering the following aspects: - RE integration in the power system (with a focus on grid stability and control of frequency and voltage in the context of high RE penetration, energy storage options, power system digitalization, and energy delivery optimization); - Decision Analysis for Sustainability; - RE systems management; - Energy technologies, management and sustainable development. The training should include theoretical and practical classes. The training should implement measures to promote women's participation in it and thereby increase the percentage of trained women in the energy field. This could be achieved by implementing a Sustainable Energy Training Program for Women.
TARGET GROUP/SECTOR	Professionals from MIRN / DGRNE, DGA, EMAE, AGER and other RE-related institutions
IMPLEMENTING BODY(IES)	DGRNE / Universities / Training Centers
EXPECTED RESULTS / IMPACTS	R1. Training of technicians at MIRN / DGRNE, DGA, EMAE, AGER and other institutions R2. Capacity building for professionals from the sector's institutions on integration and management of grid-connected or grid-isolated RE systems R3. Female participation encouraged and thereby the training of women in the energy field.

No.: RE 21

MEASURE	SUPPORT ACTIVITIES FOR CAPACITY BUILDING OF ASSOCIATIONS AND ENTREPRENEURS
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	In progress
IMPLEMENTATION PERIOD	2021-2050
DESCRIPTION OF THE MEASURE	Short-term capacity building courses will be developed and provided to build the capacity in STP of RE associations and entrepreneurs in the energy sector, with a focus on female entrepreneurs or activities specially designed for them, covering the following aspects: - RE potential in STP - RE legal framework and regulation; - Incentives and financing mechanisms for RE projects - Perspectives on the RE landscape and benefits of implementing RE.
TARGET GROUP/SECTOR	RE Associations in STP / Entrepreneurs in the energy sector (with a focus on female entrepreneurs)
IMPLEMENTING BODY(IES)	DGRNE / Universities / Training Centers
EXPECTED RESULTS / IMPACTS	R1. Increased participation of national RE associations in the development of the sector R2. Increased entrepreneurship and innovation in the RE area R3. Growth of the local RE market

No.: RE 22

MEASURE	PREPARATION OF A TRAINING / CAPACITY BUILDING PLAN FOR TECHNICAL STAFF
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Approved and in progress
IMPLEMENTATION PERIOD	2021-2050
DESCRIPTION OF THE MEASURE	A training / capacity building plan will be developed for technical staff of RE-related institutions, covering the following aspects: - Energy and Climate Change; - RE technologies; - Applications in STP. The plan should consider measures to promote women's participation and thereby increase the percentage of trained women in the energy field.
TARGET GROUP/SECTOR	Actors in the energy sector
IMPLEMENTING BODY(IES)	DGRNE / Universities / Training Centers

EXPECTED RESULTS / IMPACTS	R1. Appropriate technical updating of national professionals on specific RE issues R2. Female participation encouraged and thereby the training of women in the energy field.

No.: RE 23

MEASURE	DEVELOPMENT OF AN ONLINE TRAINING PROGRAM
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2023
DESCRIPTION OF THE MEASURE	An online training program on sustainable energy solutions for islands focusing on industry professionals will be developed, covering the following aspects: - Isolated RE systems; - Installation of isolated systems; - Management and maintenance of isolated systems. The program should consider measures to promote women's participation and thereby increase the percentage of trained women in the energy field.
TARGET GROUP/SECTOR	Energy sector professionals
IMPLEMENTING BODY(IES)	DGRNE / Universities / Training Centers
EXPECTED RESULTS / IMPACTS	R1. Training of professionals in the area of grid-connected and isolated RE. R2. Female participation encouraged and thereby the training of women in the energy field.

No.: RE 24

MEASURE	CREATION AND INSTALLATION OF RE LABORATORIES
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2035
DESCRIPTION OF THE MEASURE	It is intended to organize the creation and installation of laboratories relating to different aspects of energy and its relationship with society, the economy and development (including gender perspectives), through collaboration with national and international universities or training centers. To make the research institutes attractive hubs for energy research, they will be equipped with laboratory equipment, enabling them to create new knowledge, and social, economic and technological innovations. The laboratories and projects to be developed will be associated with research under development in the country, and consequently with master's and doctorate courses in STP universities. The selection of projects should take into account gender perspectives and encourage the participation of female students. In addition, the creation of specialized RE (and EE) laboratories should take into account the possibility of including evaluation and certification services for products and services in order to guarantee their quality.
TARGET GROUP/SECTOR	Researchers, students and professionals in the energy and related fields
IMPLEMENTING BODY(IES)	Universities / Research Institutes
EXPECTED RESULTS / IMPACTS	R1. Availability of laboratories for technical training and practical application to RE-related systems R2. Availability of information, knowledge and expertise to enable innovative solutions adapted to the country's conditions R3. Research and innovation promoted R4. Female participation in research and innovation promoted

No.: RE 25

MEASURE	TRAINING OF THE STAFF AT UNIVERSITIES AND TRAINING CENTERS
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3

IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2050
DESCRIPTION OF THE MEASURE	It is intended to promote the capacity building of university and training center staff (with a focus on training female staff) so that new trained professionals have access to quality, up-to-date information, through collaboration with national and international universities or training centers. Staff at universities and training centers should have access to courses and initiatives developed specifically for training them on all aspects of RE development. The aim is to strengthen institutions so that they can offer certified training courses in line with international and regional standards.
TARGET GROUP/SECTOR	Universities and professional training centers
IMPLEMENTING BODY(IES)	National and international universities / research institutes
EXPECTED RESULTS / IMPACTS	R1. Increased capacity of specialized RE professionals providing a range of vocational training courses (with a focus on capacity building for female professionals)

No.: RE 26

MEASURE	ESTABLISH COOPERATION AGREEMENTS
TYPE OF MEASURE	Training, qualification and certification initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2050
DESCRIPTION OF THE MEASURE	It is intended to establish cooperation agreements in the RE area with universities, technological research centers and regional centers focused on RE and EE, to foster the transfer of technology and knowledge between institutions. Cooperation agreements should be established with national and international universities and research/investigation centers, with the support of DGRNE. Special attention will be given to establishing cooperation and collaboration agreements with CEREEAC for the development of "Train-the-Trainers" programs, as well as, through GN-SEC, with other centers in the region and the international network focused on the SIDS (CCREEE, PCREE, SACREEE and ECREEE). Gender equity and equality issues will be considered when selecting program participants.
TARGET GROUP/SECTOR	Universities, technological centers or centers with a focus on RE and EE
IMPLEMENTING BODY(IES)	Universities / national and international research institutes / DGRNE / GN-SEC
EXPECTED RESULTS / IMPACTS	R1. Significant increase in international cooperation and exchange initiatives in the RE area R2. Technology and knowledge transfer encouraged at regional and international level R3. Increase in local capacities in RE

Creating a permanent communication channel with the RE market and consumers/users to raise awareness of the importance of this energy source and its benefits is an integral and fundamental part of this strategy. To this end, it **is necessary to prepare awareness raising campaigns, beginning by introducing concepts relating to RE processes and uses in various media channels**, principally the Internet. The following measures are proposed for preparing information and awareness raising initiatives:

No.: RE 27

MEASURE	SEforALL AWARENESS RAISING CAMPAIGN
TYPE OF MEASURE	Information and Awareness Raising Initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	Associated with the promotion of the RE market, information about the importance of the rational use of energy resources and the adoption of RE will be disseminated through the SEforALL campaign. This campaign will be targeted at families, businesses and consumers in general. The campaign should provide information about the positive impacts of universal access to energy on women and children through specific gender-focused activities.

TARGET GROUP/SECTOR	General population
IMPLEMENTING BODY(IES)	STP Government
EXPECTED RESULTS / IMPACTS	R1. Dissemination of information about the importance of the rational use of energy resources and adoption of RE R2. Public awareness of RE benefits (especially among women and children)

No.: RE 28

MEASURE	RE AWARENESS RAISING AND INFORMATION DISSEMINATION CAMPAIGN
TYPE OF MEASURE	Information and Awareness Raising Initiatives
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2050
DESCRIPTION OF THE MEASURE	A general campaign to raise awareness and disseminate information regarding the benefits of adopting and implementing RE projects will be carried out through different media and by conducting events and activities involving communities and actors in the energy sector. It is important for the disseminated information to include the benefits of RE use for women. Special events focused on gender and energy issues should be considered as a fundamental part of the campaign. The Internet makes it possible to provide content adapted to all needs and purposes. Accordingly, information and successful RE projects should be publicized on energy sector portals and in the general media to raise awareness about the benefits of this energy source (including gender benefits) and its potential applications.
TARGET GROUP/SECTOR	Private Sector / General Population
IMPLEMENTING BODY(IES)	DGRNE
EXPECTED RESULTS / IMPACTS	R1. Dissemination of information about RE R2. Public awareness of RE benefits (including gender benefits)

The **construction and rehabilitation of grid-connected and isolated energy infrastructure is a key part of achieving the targets proposed in this plan**. The exploitation of existing renewable resources, and consequently the promotion of a true energy economy, and solid energy expansion and transition, are addressed in this plan through the following measures:

No.: RE 29 - 39

MEASURE	GRID-CONNECTED RE PROJECTS		
TYPE OF MEASURE	Infrastructure Investment		
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	5		
TARGET GROUP/SECTOR	Population of STP		
IMPLEMENTING BODY(IES)	DGRNE / International Organizations		
EXPECTED RESULTS / IMPACTS	R1. Increase in electric energy produced R2. Decreased fuel imports and CO_2 emissions R3. Increase in RE in the energy matrix R4. Improvement in the quality of electric power made available to the population R5. Jobs for young people (and women) R6. Social welfare		
DESCRIPTION OF THE MEASURE	IN PROGRESS OR PLANNED	LOCATION	IMPLEMENTATION PERIOD
29) Rehabilitation with power increase of the Contador 2 MW hydropower plant	In progress	São Tomé	2020-2024
30) Rehabilitation with power increase of the Papagaio 1.1 MW mini-hydropower plant	In progress	RAP	2020-2025
31) Rehabilitation of the Agostinho Neto 1.2 MW mini-hydropower plant	In progress	São Tomé	2020-2023

32) Rehabilitation of the Guegué mini-hydropower plant with a 1 MW capacity increase	Planned	São Tomé	2020-2024
33) Construction of the 4.68 MW Biomass Power Plant	Planned	São Tomé	2020-2025
34) Hybridization of the Santo Amaro photovoltaic plant 1st phase 0.54 MW	In progress	São Tomé	2020-2022
35) Hybridization of the Santo Amaro photovoltaic plant 2nd phase 1.66 MW	Planned	São Tomé	2020-2023
36) Construction of the 15 MW Água Casada Lobata Solar PV Plant, with a 2 MW battery bank	Planned	São Tomé	2020-2025
37) Construction of the 15 MW Água Casada Lobata Solar PV Plant, with a battery bank for backup	Planned	São Tomé	2020-2025
38) Construction of the 10 MW Água Casada Lobata Solar PV Plant	Planned	São Tomé	2021-2025
39) Construction of hydropower plants on the Iô Grande River and in Bombaim 10 MW total	Planned	São Tomé	2020-2030

No.: RE 40 - 42

MEASURE	DISTRIBUTED RE PROJECTS (mini-grids, prosumers, microgeneration)		
TYPE OF MEASURE	Infrastructure Investment		
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	5		
TARGET GROUP/SECTOR	Population of STP		
IMPLEMENTING BODY(IES)	DGRNE / International Organizations		
EXPECTED RESULTS / IMPACTS	R1. Access to electricity services (through off-grid systems, such as renewable or hybrid mini-grids and solar home systems) R2. Electric power available to the population 24/7 R3. Income generation through innovative and inclusive business models R4. Jobs for young people (and women) R6. Social welfare		
DESCRIPTION OF THE MEASURE	IN PROGRESS OR PLANNED	LOCATION	IMPLEMENTATION PERIOD
40) Construction of the Solar PV Plant - 4.75 MWp with 3.5 MWh of storage	Planned	RAP	2021-2024
41) Construction of a 2 MW mini-hydropower plant in Claudino Faro	Planned	São Tomé	2021-2030
42) Solar PV domestic installation (800 households / 3 kW) (includes grid-connected and isolated (rooftop PV) systems and RE for industrial prosumers)	Planned	São Tomé	2021-2030

5.3.2 Modern energy measures for cooking

It is essential to analyze cooking alternatives and define a possible strategy to achieve universal access to clean and safe cooking sources in STP by 2050. Accordingly, it will be necessary to develop technical and preparatory studies to facilitate decision making. The most relevant technical studies for STP concerning clean and safe cooking are presented in the following measure:

No.: RE 43

MEASURE	TECHNICAL STUDIES - UNIVERSAL ACCESS TO CLEAN AND SAFE COOKING
TYPE OF MEASURE	Studies/preparations
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	4
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2023
DESCRIPTION OF THE MEASURE	A detailed study should be conducted to define the strategy to achieve universal (100%) access to clean and safe cooking sources in STP by 2030 and the strategy to maintain it in subsequent years (particularly considering the increased use of liquid fuels). To this end, the following analyses should be performed: - Analysis of cooking technologies and their sources, as well as their availability and the funding requirements to achieve the targets; - Analysis of the applicability of these technologies in the context of STP; - Definition of measures to develop the market in order to promote the adoption of safe and clean cooking sources; - Analysis of impact and reduction in CO_2 emissions. - Analysis of the gender impact of adopting the measures and targets contained in the plans - Design of measures and recommendations for promoting entrepreneurship and innovation in the local production of improved stoves and other more efficient forms of cooking (e.g. solar and charcoal stoves - see measure #45) - Analysis of successful business models in sub-Saharan Africa for promoting more efficient cooking and their applicability in the STP context
TARGET GROUP/SECTOR	General population
IMPLEMENTING BODY(IES)	DGRNE
EXPECTED RESULTS / IMPACTS	R1. Information for decision making concerning the different fuels and technologies used in cooking

On the basis of the studies conducted and the definition of the strategy to be followed to achieve 100% access to more efficient, cleaner and safer energy sources for cooking for the population, **programs and action plans should be developed for implementing the measures that are essential to ensure the effective fulfillment of the stipulated targets**. The following measures aim to promote the development of a clean cooking market in STP:

No.: RE 44

MEASURE	PROGRAM FOR REPLACING TRADITIONAL STOVES
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2023-2050
DESCRIPTION OF THE MEASURE	A program should be prepared in STP to replace 39,600 traditional stoves with improved high-efficiency ones, with the aim of achieving universal access to clean and safe energy sources for cooking by 2030, in line with the NDC. To this end, the following analyses should be performed: - Definition of the distribution strategy; - Definition of the locations for the distribution; - Analysis of the impact and reduction of CO_2 and other pollutant emissions, as well as the impact on family health, with an emphasis on women and children. - Funding requirements
TARGET GROUP/SECTOR	General population (special focus on women)
IMPLEMENTING BODY(IES)	DGRNE
EXPECTED RESULTS / IMPACTS	R1. Decreased CO_2 emissions from biomass R2. Decreased indoor air pollution (positive health impact) R3. Reduced deforestation R4. Decreased household expenditure on cooking fuels

No.: RE 45

MEASURE	PROGRAM FOR EFFICIENT CHARCOAL PRODUCTION
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2020-2035
DESCRIPTION OF THE MEASURE	A program should be developed for the adoption of efficient charcoal production techniques to increase the economic efficiency and environmental quality of the process. To this end, the following analyses should be performed: - Technologies used in the process for its production; - Value chain analysis based on the UNDP report produced in 2021; - Identification of tree species that combine fast growth with good calorific value for use in charcoal production with other wood and non-wood products; - Analysis of Impact and CO_2 emission reduction.
TARGET GROUP/SECTOR	General population
IMPLEMENTING BODY(IES)	DGRNE
EXPECTED RESULTS / IMPACTS	R1. Decreased CO_2 emissions R2. Rational use of energy resources R3. R3. Reduced deforestation R4. Increased cooking efficiency due to better charcoal quality

5.3.3 Measures related to sustainable agriculture and cattle raising, sustainable waste management and reducing deforestation

The creation of the legal and regulatory conditions necessary to reduce deforestation should be aligned with measures relating to the energy/electricity sector, as well as others regarding clean cooking. Regulations should be as transparent as possible and brought to the attention of all stakeholders in advance. The following measure aims to develop the legal and regulatory framework regarding deforestation in STP:

No.: RE 46

MEASURE	REGULATION OF FOREST EXPLOITATION
TYPE OF MEASURE	Improving and strengthening the regulation
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2020-2030
DESCRIPTION OF THE MEASURE	Regulations for the exploitation of forests should be established to avoid excessive and uncontrolled forest exploitation. The regulation should: - Consolidate knowledge about the state of forest resources; - Strengthen the forestry taxation and inspection system; - Define the role of the actors (State / Private sector / Communities / Civil society / Technical and financial partners).
TARGET GROUP/SECTOR	Policy makers / General population
IMPLEMENTING BODY(IES)	DGRNE / Directorate for Forests and Biodiversity / Obô Natural Park in São Tomé (PNOST – Parque Natural Obô de São Tomé) / Regional Directorate for the Environment and Nature Conservation
EXPECTED RESULTS / IMPACTS	R1. 15% reduction in illegal and uncontrolled forest exploitation

The creation of programs and action plans to promote sustainable farming and cattle raising, ensure sustainable waste management and reduce deforestation will support the achievement of the targets for RE penetration in STP's energy mix, as well as clean cooking targets. Accordingly, for sound energy expansion and transition, the following measures should be included:

No.: RE 47

MEASURE	SUSTAINABLE FOREST MANAGEMENT PROGRAM
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	In progress (National Forest Development Plan (PNDF – Plano Nacional de Desenvolvimento Florestal))
IMPLEMENTATION PERIOD	2020-2025
DESCRIPTION OF THE MEASURE	A national program should be created for reforestation and sustainable management of forest and agroforestry ecosystems, and agriculture in general, including: - Drought resilient forestry; - Reduction of illegal logging; - Management of protected areas.
TARGET GROUP/SECTOR	Policy makers / General population
IMPLEMENTING BODY(IES)	DGRNE / Directorate for Forests and Biodiversity / Directorate for Agriculture and Rural Development, and Regional Directorate for Agriculture, Fisheries and Cattle Raising
EXPECTED RESULTS / IMPACTS	R1. Decrease in illegal and uncontrolled exploitation of forests and unsustainable agricultural activities R2. Conservation of vegetation that acts as a natural carbon sink and thereby mitigates CO_2 emissions

No.: RE 48

MEASURE	ACTION PLAN FOR THE USE OF NATURAL FERTILIZERS
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2020-2030
DESCRIPTION OF THE MEASURE	An action plan should be created to reduce the use of nitrogen fertilizers in agriculture, including: • Analysis of the efficiency of the use of nitrogen; • Sustainable farming techniques, such as crop rotation and composting centers; • Partnerships with national and international research institutes of reference in the subject.
TARGET GROUP/SECTOR	Horticulturists/Farmers
IMPLEMENTING BODY(IES)	DGRNE / MAPDR /DGA
EXPECTED RESULTS / IMPACTS	R1. Reduced waste burning R2. Decreased GHG emissions R3. Development of more efficient agricultural practices R4. Changed behavior and greater willingness to use organic fertilizers R5. Reduction of ground and surface water pollution R6. Food and nutrition security

No.: RE 49

MEASURE	PROGRAM TO PROMOTE COMPOSTING CENTERS
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2020-2030
DESCRIPTION OF THE MEASURE	A program should be created to increase the number of composting centers in agricultural areas to replace the use of fertilizers, including: • Composting techniques; • Awareness campaigns for the population about the importance of composting.
TARGET GROUP/SECTOR	Rural Population
IMPLEMENTING BODY(IES)	DGRNE / MAPDR/DGA
EXPECTED RESULTS / IMPACTS	R1. Reduced use of nitrogen fertilizers in agriculture R2. Decreased CO_2 emissions R3. Development of more efficient agricultural practices

No.: RE 50

MEASURE	BIODIGESTION PROMOTION PROGRAM
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2040
DESCRIPTION OF THE MEASURE	A program should be created to install 900 biodigesters to produce biogas from animal waste, including: - Manual for the use of biodigesters; - Identification of sites for the installation of the biodigesters; - Training in the operation and maintenance of the biodigesters.
TARGET GROUP/SECTOR	General population
IMPLEMENTING BODY(IES)	DGRNE/DGA

EXPECTED RESULTS / IMPACTS	R1. Decreased CO_2 emissions R2. Use of waste as an alternative energy source

No.: RE 51

MEASURE	ACTION PLAN FOR THE CONSTRUCTION OF A CONTROLLED LANDFILL
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2022-2040
DESCRIPTION OF THE MEASURE	An action plan should be created for the construction of a controlled landfill with a methane gas capture and flaring system, in accordance with the results obtained from the analysis carried out under the PGIRSU: - Identification of the location and size of the landfill; - Separation at source and waste collection routes for the non-recyclable and non-compostable fraction; - Feasibility analysis of biogas capture and burning (without which emissions would not be mitigated) - Identification of national and international funding options;
TARGET GROUP/SECTOR	Population of São Tomé
IMPLEMENTING BODY(IES)	DGRNE/DGA/ Local and Regional Government
EXPECTED RESULTS / IMPACTS	R1. Decreased CO_2 emissions whenever it is possible to capture and burn the biogas and other pollutant gases R2. Decreased groundwater contamination R3. Improved integral management of Solid Urban Waste (SUW)

No.: RE 52

MEASURE	ACTION PLAN TO PROMOTE THE USE OF WASTE AS AN ENERGY SOURCE
TYPE OF MEASURE	Development of programs and action plans
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2022-2040
DESCRIPTION OF THE MEASURE	An action plan should be created for waste-to-energy (liquid and solid biomass) for biogas production, including: - Evaluation of the potential for biogas production; - Technology transfer for biogas production; - Market and value chain analysis of biogas in STP; - Training courses on biogas production for professionals, with special focus on women.
TARGET GROUP/SECTOR	Political and business decision makers / Energy sector professionals
IMPLEMENTING BODY(IES)	DGRNE/DGA/ Local and Regional Government
EXPECTED RESULTS / IMPACTS	R1. Reduced final waste disposal in open air dumps R2. Decreased CO_2 emissions (whenever there is capture and burning of biogas) R3. Development of more efficient agricultural practices R4. Reduction in the negative impact that uncontrolled disposal has on health and the environment in general.

There should be continuous monitoring, evaluation and validation of the effectiveness and impact of these measures, accompanied by the collection, organization and analysis of relevant data. **The data and its analysis should be entered into and maintained in a centralized system, enabling the development of sectoral and thematic studies, which will be useful for learning and decision support.** The following measure aims to promote transparency and decision support in the promotion of sustainable agriculture and cattle raising, sustainable waste management and reduced deforestation:

No.: RE 53

MEASURE	CREATION OF A CENTRALIZED INFORMATION SYSTEM
TYPE OF MEASURE	Transparency and decision support
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2020-2025
DESCRIPTION OF THE MEASURE	A centralized information system for forest management should be created under the DFB and INM. There will be periodic, systematic and exhaustive collection of statistical data that will be compiled, organized and analyzed and then made available for consultation, including on: - Forest use and deforestation; - Land use, change in land use, and forest resources; - Impact of agriculture and cattle raising activities on forests; - Associated climate change and its impact. This system will facilitate access to reliable information and support decision making.
TARGET GROUP/SECTOR	Political and business decision makers / General population
IMPLEMENTING BODY(IES)	DGRNE/INM/DGA/ DFB
EXPECTED RESULTS / IMPACTS	R1. System containing information on forests, agriculture and cattle raising, and climate change created and implemented R2. System for analyzing indicators of land use, agriculture and cattle raising activities, and climate change

5.3.4 Measures concerning the transport sector

The preparation of studies regarding the development of the low-carbon transport system and definition of a possible strategy are also important for increasing the penetration of RE in STP's energy matrix. Accordingly, it will be necessary to develop technical and preparatory studies to facilitate decision making. The most significant technical studies for STP regarding low-carbon transport are presented in the following measures:

No.: RE 54

MEASURE	TECHNICAL STUDIES - LOW-CARBON TRANSPORT
TYPE OF MEASURE	Studies/preparations
PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	The low-carbon transport study developed under the NREAP will provide the basis for preparing studies and collecting information regarding the development of the low-carbon transport system, including: • Strict fuel economy and emission regulations; • Accrediting urban planning processes • Increasing the supply of low-carbon public transport. • Baseline assessments for Vehicle Energy Efficiency Standards • Inclusion of electric mobility and its impact on electricity demand • Analysis of the possibilities of local production of biofuels (e.g. biodiesel) for use in transport (see measure #55)
TARGET GROUP/SECTOR	Decision makers in the public and private sector
IMPLEMENTING BODY(IES)	DGRNE/DTT
EXPECTED RESULTS / IMPACTS	R1. Information available for decision making R2. Targets and goals relating to the development of a low-carbon transport system in STP defined

No.: RE 55

MEASURE	TECHNICAL STUDIES - BIOFUEL PRODUCTION POTENTIAL
TYPE OF MEASURE	Studies/preparations

PRIORITY (FROM 1 (LOW) to 5 (HIGH))	3
IN PROGRESS OR PLANNED	Planned
IMPLEMENTATION PERIOD	2021-2030
DESCRIPTION OF THE MEASURE	Preparation of studies and collection of information regarding the potential for biofuel production, including: - Analysis of the production potential at the local level (plant species, areas suitable for production, complementation with agricultural activity and availability of space and land, production technologies, etc.); - Capacity to meet the demand of the transport and other sectors; - Analysis of the impact of fossil fuels on imports and the possibility of producing mixtures with them (e.g. biodiesel).
TARGET GROUP/SECTOR	Decision makers in the public and private sector
IMPLEMENTING BODY(IES)	DGRNE/DTT/ENCO
EXPECTED RESULTS / IMPACTS	R1. Analysis of the existing potential and definition of targets for the use of these fuels in STP R2. Analysis of the impact on the balance of trade for importing fuels for use in existing power generators R3. Information for decision making. R4. Definition of the targets and goals for the country relating to biofuels.

6 POTENTIAL BENEFITS OF IMPLEMENTING THE NREAP

6.1 Economic

The economic benefits of implementing the NREAP are significant and will have a positive impact on the country's economy. Using the renewable resources present in STP will reduce dependence on fossil fuels that are currently imported and require a significant portion of the GDP. The BAU scenario shows that there will be an increase in fossil fuel demand, whereas in the mitigation scenario a portion of this demand will be avoided through the implementation of the RE and EE measures. In the mitigation scenario, it is estimated that there will be an approximate saving of 984,187.8 tons of diesel by 2050, which represents approximately USD 1.16 billion considering forecasts for the diesel price, given in Table 6.

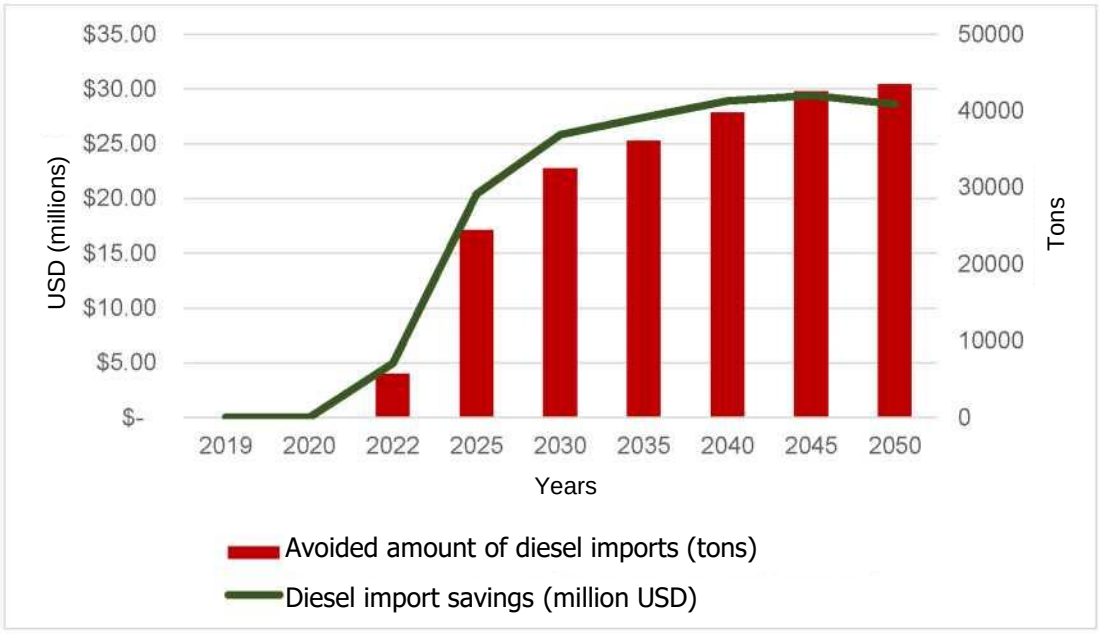

Figure 23: Quantity of diesel imports avoided in the mitigation scenario and the associated savings

The estimated cumulative net benefits far outweigh the projected initial investment costs for the established pipeline of RE projects, which will total about USD 171 million by 2030. This is particularly true if the projects attract private capital, concessional financing and foreign direct investment.

At the same time, the reduction in expenditure on imported fuel will allow funds to be redirected to other areas, such as health and education. in 2019 (the base year adopted in the NREAP and the NEEAP), expenditure on diesel imports corresponds to 8.4% of STP's GDP[19] (USD 23,627,631). With the implementation of the measures, this percentage is reduced to 0.6% in 2030 (USD 2,529,826) and 0.9% in 2050 (USD 8,447,240.71). It can be seen that in 2050 the cost of diesel imports in comparison to GDP is higher due to the growing demand for electricity, which will be partially supplied by thermoelectric power plants (diesel). If no new RE projects are implemented, from 2050 onwards, the diesel import cost relative to GDP will follow an upward trend.

The implementation of the NREAP measures will also guarantee universal access to energy for the entire population, improve their quality of life in general and, above all, contribute to:

- Improved health by reducing the use of traditional stoves, which will be replaced by improved ones and cleaner fuels or cleaner cooking technologies. At the same time, improved health will reduce the pressure on the health care system and the incidence of respiratory diseases (principally in women and children).
- Providing the opportunity to make productive uses of energy and, consequently, generate more job opportunities, which is positive for the country's economy.

[19] The country's estimated GDP in 2019 was USD 279,700,465 @ constant 2010 prices (source: World Bank), in 2030 is estimated at USD 423,039,635.68 and in 2050 is estimated at USD 910,596,621.18.

Strengthening the institutional, normative, legal and regulatory framework for RE will foster foreign investment in related projects. Finally, further studies on the real potential of RE (onshore and offshore) will provide up-to-date and accurate information that will allow potential investors to analyze potential business opportunities in STP.

6.2 Social

The most significant benefit for São Tomé's population is the improved access to reliable electricity services, which will have a direct impact on their quality of life, as previously described. In addition, the development of the RE market will promote the growth of employment opportunities in the sector and the increased capacity building and qualification/training opportunities therein will encourage the population, especially the younger generation, to study the subject and increase their interest in innovation, thereby contributing to the growth of the local market.

Access to electricity services in rural areas also has a positive impact on the provision of health and education services. If health institutions (e.g. hospitals) and educational institutions (e.g. rural schools) have access to electricity, they can offer a better service. For example, they can use electrical equipment and have better communication, lighting, internet, etc.

From the gender perspective, the measures presented for the advancement of STP's energy sector aim at the greater inclusion of women as stakeholders and beneficiaries, particularly those involved in productive agriculture and cattle raising activities. In STP, a large number of women own small parcels of land. This means that they are directly involved in productive activities that could benefit from access to electricity services, including the possibility of adding value to agricultural products and storage of them and to cattle raising products (preventing waste and loss of income). From a labor inclusion perspective, women would also benefit from training and education measures that would enable them to access technical positions and even participate more actively in decision making and the development of policies and incentives that are more responsive to their needs (such as access to funding for implementing clean technologies).

In general, women are also responsible for collecting biomass to supply household energy needs, mainly for lighting and cooking. Access to electricity services and cleaner and more efficient technological options for cooking will allow the population, especially women, to have more time available for other activities, such as productive activities, studying or simply having more family time. The situation with indoor air pollution will also improve as the use of cleaner and more efficient cooking sources will decrease this.

Better access to more reliable electricity services will also have a positive effect on young people and children, especially those in rural areas, providing greater and better opportunities to study, not only at the household level (as they can carry out their tasks after the hours of sunlight), but also because of the potential improvements that could occur in rural schools (if they had access to a better electricity service, for example, schools could eventually incorporate digital tools and greater connectivity to complement school activities). For young people, equitable access to electricity services can provide employment opportunities and foster entrepreneurship, especially in rural areas where the electrification rate (energy access rate) tends to be lower.

Access to electricity services will also positively impact the implementation of certain measures related to improving water and sanitation management, such as implementing technologies to purify water in isolated communities.

6.3 Environmental

The overall environmental benefit of implementing the NREAP and NEEAP is to significantly reduce GHG emissions in the power sector and to achieve the target of 27% emission reduction by 2030 set in the NDC (2021). Section 9 presents a detailed comparison of the results of the two scenarios (BAU and mitigation) in regard to GHG emission reduction. Another positive impact of the NREAP is the reduction in deforestation associated with the collection of firewood for cooking and charcoal production and, therefore, the plan will contribute to better conservation and management of forest resources.

7 COORDINATION WITH REGIONAL INITIATIVES

The ECCAS region has a number of regional initiatives underway in the RE field:

- **ECCAS/CAEMC regional policies, including** the ECCAS Green Economy and Renewable Energy Vision, the ECCAS Vision 2025, as well as the CAEMC White Paper and the Energy Policy 2035. The White Paper in particular sets out regional policy for universal access to modern energy services, and economic and social development. These policies are also linked to broader goals involving industrial development in the region.
- **The revised ECCAS Treaty, in particular the commitments of the Member States to (i) develop the Community's energy resources, and (ii) promote renewable energy within the framework of the policy of diversification of energy sources.**
- The **roadmap for promoting renewable energy in Central Africa**.
- The **CEREEAC** will also be created for the region, its main mission being: *"to ensure coordination of the implementation of the ECCAS Policy on RE and EE and to promote the creation of an integrated and inclusive ECCAS market for related products and services. The CEREEAC will be part of a global network of centers, under the GN-SEC, coordinated by UNIDO.*

The STP NREAP was developed on the basis of the regional guidelines for RE and EE, thereby ensuring the benefits from synergies between these programs and the measures proposed in the present plan, and good regional integration.

8 PREPARATION OF THE NREAP AND TRACKING ITS IMPLEMENTATION AND MONITORING

Plan Preparation:

- This plan was prepared between July 2020 and October 2021 by the DGRNE of STP. The plan was supported by UNIDO, MIRN and various Ministries and Governmental Directorates in the country, as well as a number of other intervening and transversal agents in the energy sector, which monitored and guided its execution through their participation in the PNES.

Entity responsible for the Preparation of the Plan and its Implementation

- DGRNE, an integral part of MIRN, will be the main body responsible for the execution and implementation of the NREAP, as well as the NEEAP.

Implementation, supervision and monitoring of the NREAP:

- The actions and measures must be accompanied by coherent economic and financial policies based on clear and defined goals, vision and missions. In the case of STP, Vision 2030 plays a major role up to 2030.
- The entities that handle these policies and plans should create synergies with others dedicated to this purpose.
- Mechanisms must be created to implement these actions, which must necessarily follow good public management.
- The mechanism for the supervision and monitoring of the implementation of the NREAP will be defined by DGRNE, which, in practice, will be responsible for following, evaluating and monitoring the implementation of the plans.
- CEREEAC will play a vital role in coordinating plans and strategies of member countries at the regional level, together with the overall vision regarding the implementation of RE and EE measures, strategies, plans, and policies for the entire region.

9 COMPARISON OF THE SCENARIO RESULTS: BAU VS. MITIGATION

Final energy demand

The evolution of final energy demand by 2050 will be reduced by implementing the proposed mitigation measures (in the NREAP and NEEAP), as shown in Figure 24 (the reduction in demand is illustrated in the figure by the white rectangles).

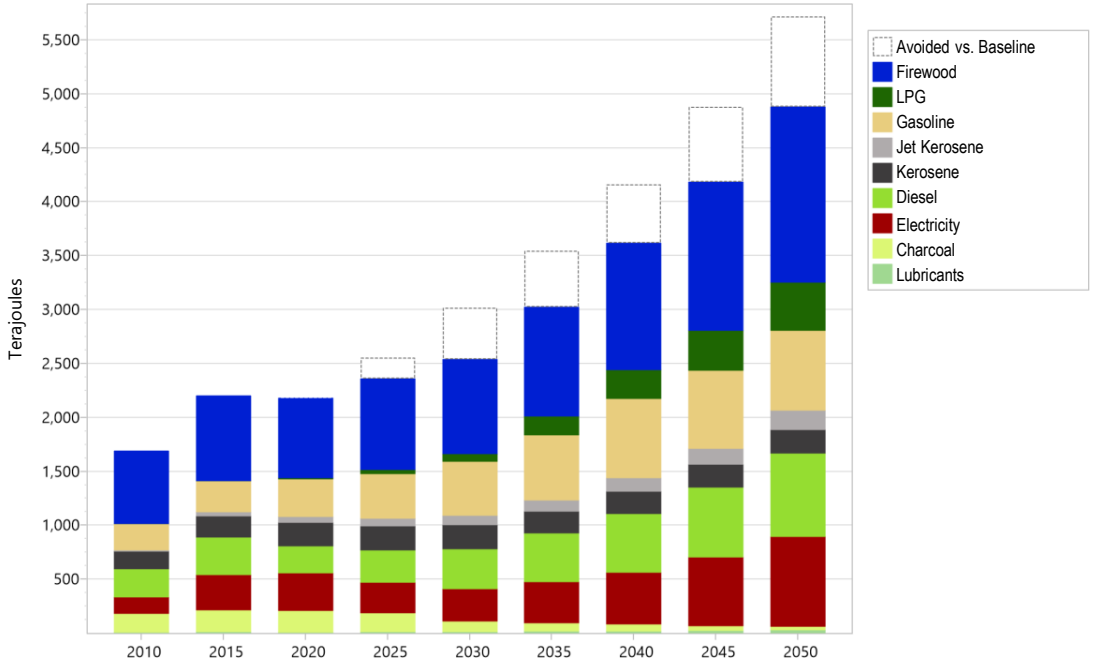

Figure 24: Reduction of final energy demand in TJ (white rectangles) and estimated demand by fuel type by 2050

By implementing the measures in the mitigation scenario, final energy demand will decrease by approximately 8.7% by 2030 (reduction in the period 2020-2030, relative to BAU) and will decrease by approximately 12.9% by 2050 (reduction in the period 2020-2050, relative to BAU). As explained earlier, the mitigation scenario considers the implementation of the both the RE and the EE measures. In addition, the result provided by LEAP includes the possible interactions between the various measures. In other words, the result of the joint modeling of all the measures is not necessarily the sum of the results from the individual modeling of each one.

Table 18: Evolution of final energy demand in the mitigation scenario by fuel type up to 2050 (in TJ), with the difference between the two scenarios in orange

Sector / Years	2010	2015	2020	2025	2030	2035	2040	2045	2050	
Difference in demand (mitigation vs. BAU)	-	-	22.2	192.1	477.0	524.8	544.4	698.7	837.8	
Firewood	678.8	786.7	740.4	846.0	877.2	1,011.1	1,180.1	1,374.6	1,627.0	MITIGATION
LPG	0.9	1.9	9.3	38.0	69.6	176.9	263.1	371.1	450.5	
Gasoline	245.0	290.9	346.6	416.6	503.1	605.0	736.6	722.8	737.6	
Aviation kerosene	9.2	36.6	57.4	69.0	85.1	103.6	125.4	151.2	181.7	
Kerosene	161.8	196.9	219.6	222.0	225.3	200.1	204.7	210.0	216.3	
Diesel	264.5	347.5	250.4	301.0	370.9	451.9	547.0	649.3	772.4	
Electricity	149.3	326.7	345.0	282.9	297.7	380.6	480.2	638.5	836.6	
Charcoal	173.3	200.8	200.3	175.1	97.9	78.2	63.4	42.4	33.1	
Lubricants	7.5	11.2	7.8	9.3	11.5	14.0	16.9	20.4	24.5	
Total - TJ	**1,690.3**	**2,199.2**	**2,198.9**	**2,552.0**	**3,015.3**	**3,546.2**	**4,161.7**	**4,878.9**	**5,717.6**	

BUSINESS-AS-USUAL

By way of example, comparing the two fuels with the highest demand, firewood and diesel, in Table 18 above with Table 23 (Annex I), it can be seen that the estimated demand for firewood in the BAU scenario in 2050 is 2,011 TJ and in the mitigation scenario it is 1,627 TJ for the same year, implying a reduction in demand for this fuel, due to the measures implemented in cooking in previous years, which includes a strong introduction of LPG. It is important to note that LPG demand in 2050 would be 22 TJ in BAU and is estimated at 450 TJ in the mitigation scenario for the same year.

By modelling "mini-scenarios" for each type of measure, it is possible to estimate the impact each would have in terms of demand reduction; this being presented in Figure 25. The main conclusion is that introducing RE into the grid to generate electricity is the measure that has the greatest impact in terms of demand reduction (of diesel in the case of STP). The second biggest impact stems from the measure to implement more efficient residential lighting since it reduces the demand for electricity (and, therefore, diesel).

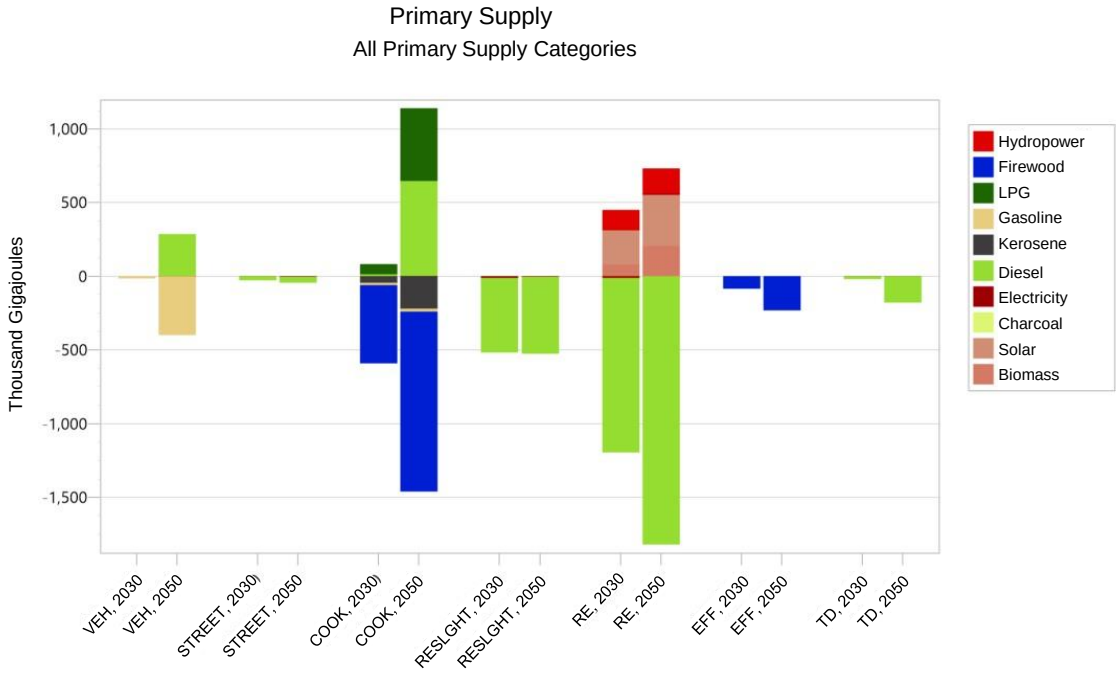

Figure 25: Impact of mitigation measures in 2030 and 2050 in terms of primary energy demand

Electricity Demand

Table 19 and Figure 26 show that electricity demand by 2050 will be reduced by implementing the mitigation measures compared to BAU. The estimated reduction in demand for the period 2020-2050 is approximately 20% relative to BAU. No further reductions are expected after 2050, principally because of the introduction of electrification of transport (which would start in 2040) and the economic development of the country. Note the demand from the residential sector, which represents approximately half of the total electricity demand in 2050, and also the inclusion and progressive increase of electrification measures in the transport sector from 2040 onwards (in green in Figure 26).

Table 19: Evolution of electricity demand by 2050, comparing the mitigation scenario to BAU, by sector (in GWh)

Sector / Years	2010	2015	2020	2025	2030	2035	2040	2045	2050
Difference in demand (mitigation scenario vs. BAU)	-	-	4.6	35.5	48.4	44.7	39.2	20.6	-5.1
Residential	28.5	56.8	60.1	38.6	36.4	52.5	70.9	92.1	122.9
Transport	-	-	-	-	-	-	-	12.4	24.9
Other	5.5	5.2	5.6	6.7	8.2	10.0	12.1	14.6	17.6
Commercial/Institutional	7.4	28.7	30.2	33.3	38.0	43.2	50.3	58.2	67.0
Total - GWh	**41.5**	**90.7**	**100.4**	**114.1**	**131.1**	**150.5**	**172.6**	**198.0**	**227.3**

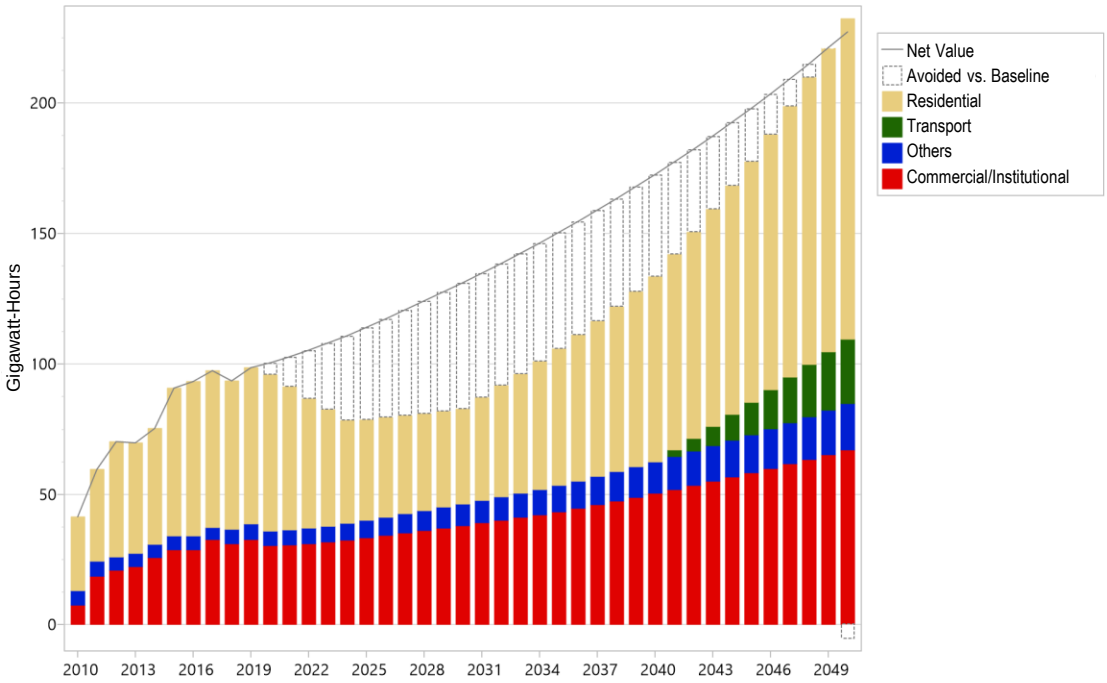

Figure 26: Evolution of electricity demand in the mitigation scenario in GWh by 2050 (with demand reduction indicated in white), by sector

Figure 27 compares the mitigation scenario ("MIT") and the baseline or BAU scenario ("BASE"), again with respect to electricity demand by sector (Table 20 gives the data corresponding to Figure 27). The significant decrease in electricity demand in 2030 and in 2040 is easy to identify in this graph. This decrease in electricity demand is due to implementing the following EE measures: the replacement of incandescent lightbulbs with more efficient ones in residential and public lighting, and the planned measures to reduce grid losses. The measures for replacing inefficient light bulbs will be almost completely implemented by 2030 and 2035. Measures to reduce grid losses are implemented progressively up to 2050. More detailed information on the EE measures is contained in the accompanying EEAP.

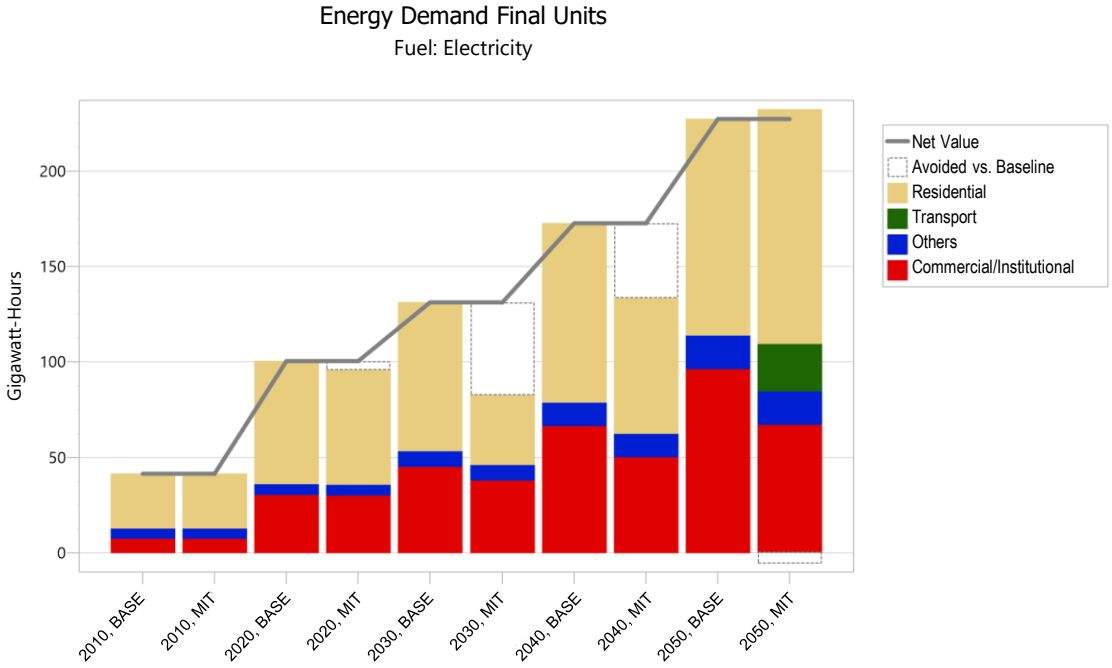

Figure 27: Comparison of baseline and mitigation scenarios on electricity demand by sector (in GWh), in 10-year periods

Table 20: Comparative data of baseline and mitigation scenarios on final electricity demand by sector (in GWh), in 10-year periods (complements the previous figure)

Scenario:	2010 BASE	2010 MIT	2020 BASE	2020 MIT	2030 BASE	2030 MIT	2040 BASE	2040 MIT	2050 BASE	2050 MIT
Difference in demand (mitigation vs. baseline scenario)	-	-	-	4.6	-	48.4	-	39.2	-	-5.1
Residential	28.5	28.5	64.4	60.1	77.7	36.4	93.8	70.9	113.2	122.9
Transport	-	-	-	-	-	-	-	-	-	24.9
Other	5.5	5.5	5.6	5.6	8.2	8.2	12.1	12.1	17.6	17.6
Commercial/Institutional	7.4	7.4	30.5	30.2	45.2	38.0	66.6	50.3	96.5	67.0

Energy for cooking

The most significant change in the residential sector is the replacement of traditional wood or charcoal-burning stoves with improved cooking ones, the introduction of liquid fuel stoves (kerosene and LPG) and, to a lesser extent, the use of other cooking technologies (e.g. electric and solar). Figure 28 shows the evolution over time of final energy demand (in TJ) in the residential sector. The evolution of the demand for the different types of energy sources, and the growth and decrease of each one until the end of 2050, is clear. Note how the demand for traditional firewood and charcoal drops by 2030, and how these two sources are gradually replaced by "efficient" firewood and charcoal (i.e. improved stoves), in addition to LPG and kerosene. In the period 2030-2050, STP aims to decrease the use of solid fuels and replace them with liquid fuels (mainly LPG, but also kerosene) and also with electricity, so as to continue increasing efficiency and the quality of life of the population.

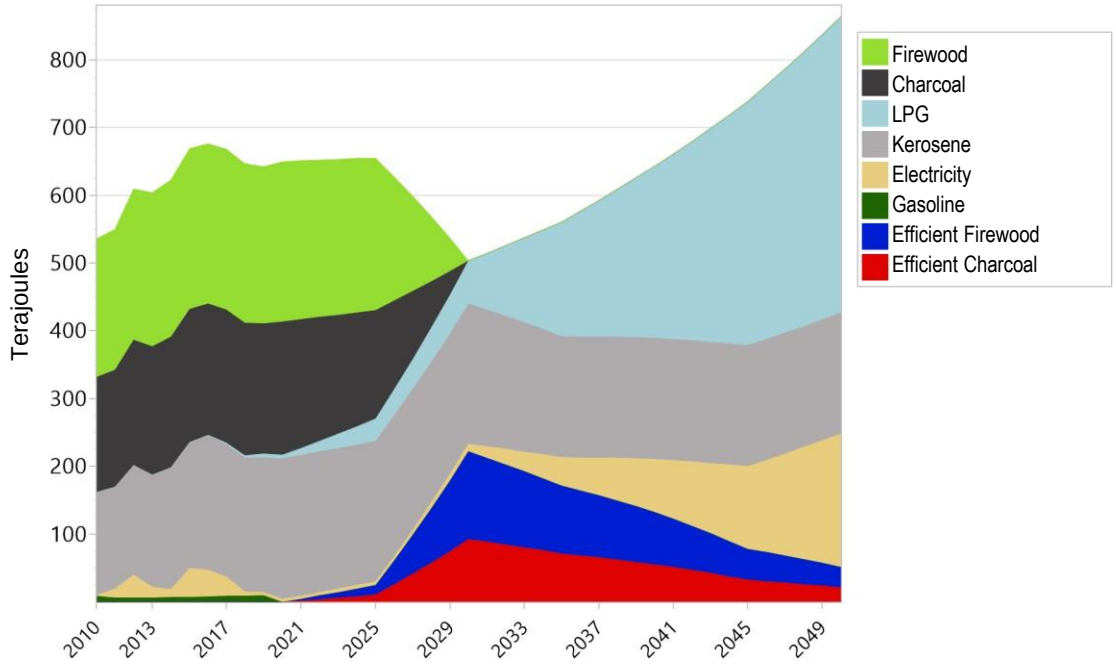

Figure 28: Change in cooking technologies in the period 2020-2050 in the mitigation scenario

GHG Emissions

The overall environmental benefit of implementing the NREAP and NEEAP is to significantly reduce GHG emissions in the power sector and to achieve the target of 27% emission reduction by 2030 set in the NDC (2021). Today, STP is a "non-emitting" country, as the amount of forest and plant cover makes it a natural carbon sink and, therefore, offsets the GHG emissions due to economic growth. However, it should be noted that this condition could change approximately in 2037, considering the BAU scenario. In the mitigation scenario, this change would happen in 2049, thanks to the RE and EE measures proposed in the NREAP and NEEAP (see Figure 29). With these mitigation measures, GHG emissions

will decrease and then the "non-emitting" country status would be maintained for longer (see Table 21 on the following page).

With regard to the contribution of each sector, that is, the total amount of GHG emitted by sector in 2050 (in Figure 30), it can be seen that, in general terms, the proportions remain the same, except for electricity generation, for which the contribution to total emissions is reduced from 2030 onwards (see Figure 31), when most RE facilities will start operating. Table 22 shows the difference between GHG emissions for the key sectors in 2050 after the measures contained in the two plans that impact these sectors have been implemented.

Table 21: GHG emissions in the mitigation scenario vs. BAU by 2050 (in thousands of tons of CO_2e)

Years																					
Scenarios	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Baseline	-208.2	-183.2	-170.5	-166.8	-154.0	-142.4	-133.9	-124.7	-124.6	-125.1	-128.3	-123.4	-118.0	-112.2	-105.9	-98.9	-91.9	-84.8	-75.3	-67.6	-60.0
Mitigation	-208.2	-183.2	-170.5	-166.8	-154.0	-142.4	-133.9	-124.7	-124.6	-125.1	-133.0	-134.6	-136.5	-142.7	-153.3	-176.5	-172.0	-167.5	-162.7	-157.9	-165.3
Years																					
Scenarios	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	
Baseline	-50.0	-41.7	-33.3	-22.6	-13.5	-4.2	7.3	17.2	27.2	39.6	50.4	61.3	74.9	86.6	100.8	113.4	128.3	141.7	155.2	171.6	
Mitigation	-158.4	-151.3	-143.9	-136.4	-128.6	-120.3	-111.7	-102.9	-93.9	-84.5	-76.6	-68.4	-59.9	-51.0	-41.3	-31.2	-20.6	-9.5	2.4	15.4	

Table 22: Comparison of estimated emissions in 2050 in tCO_2e in key energy consuming sectors

Sector	Estimated emissions in BAU, in 2050 (thousand tCO_2e)	Estimated emissions in the mitigation scenario, in 2050 (thousand tCO_2e)
Electricity generation and transmission/distribution	199.97	63.06 ↓
Residential	32.37	40.85 ↑
Transport	128.71	101.24 ↓

In the electricity sector, GHG emissions decrease due to the implementation of generation projects with RE and EE sources (more efficient lighting and reduction of grid losses). In the residential sector, emissions would increase due to the introduction of more fossil fuels (LPG and kerosene) for cooking instead of biomass, which is renewable (in this case, reductions in the residential sector from the introduction of more efficient lighting are already contained in the previous category of electricity generation and transmission/distribution). In the land transport sector, replacing inefficient units with more efficient ones, as well as replacing fossil fuel burning units with electric ones, reduces emissions from the sector. In total, the increase in the residential sector is offset by the reductions in the other sectors and allows the economy to develop and the quality of life of the population to improve.

Finally, producing charcoal with more efficient methods and the use of improved biomass stoves (which burn it more efficiently) prevent further degradation of forest biomass, since less forest resources are needed to generate the same amount of cooking energy (vegetation cover is conserved).

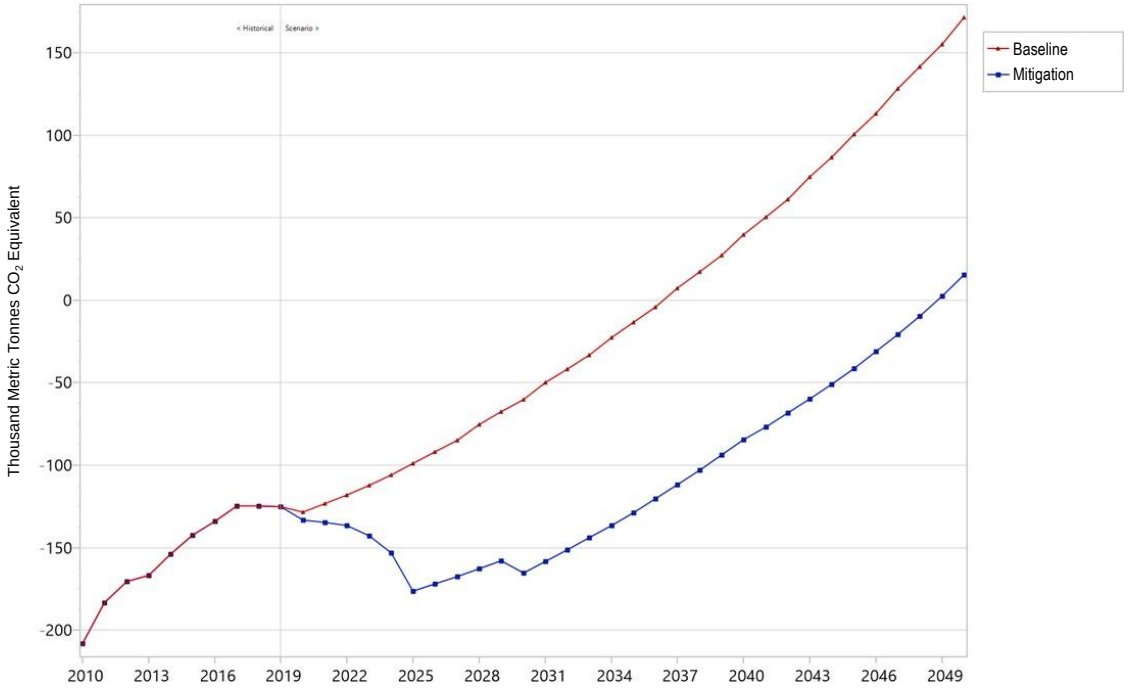

Figure 29: GHG emissions in the baseline (red) and mitigation (blue) scenarios in thousands of metric tons of CO_2e per year

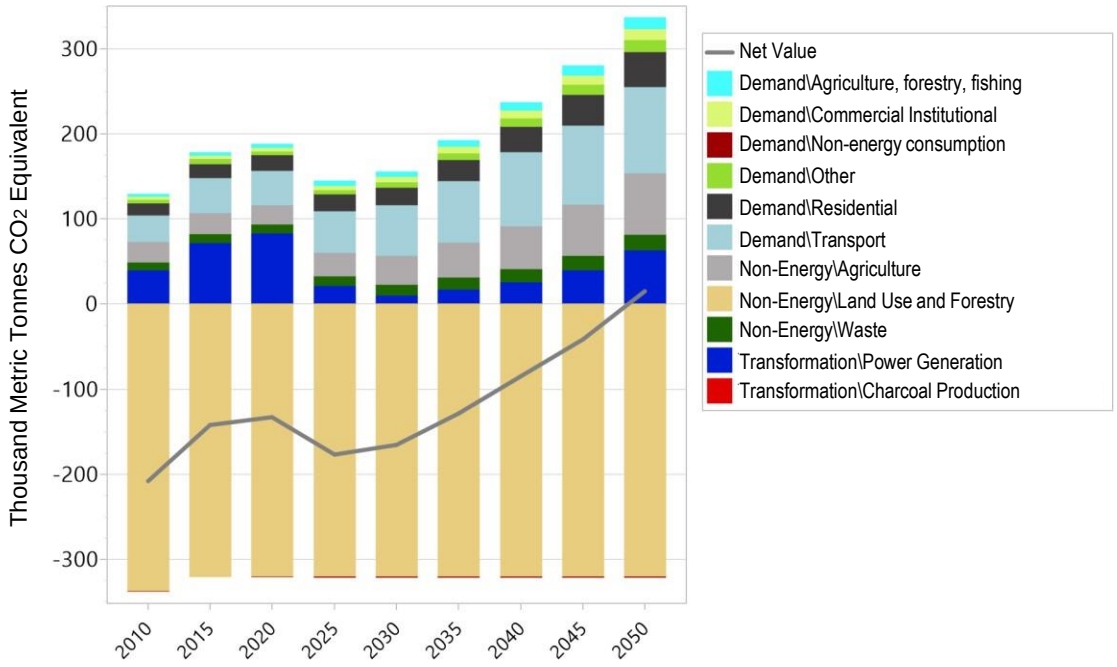

Figure 30: Evolution of GHG emissions by sector in the mitigation scenario by 2050

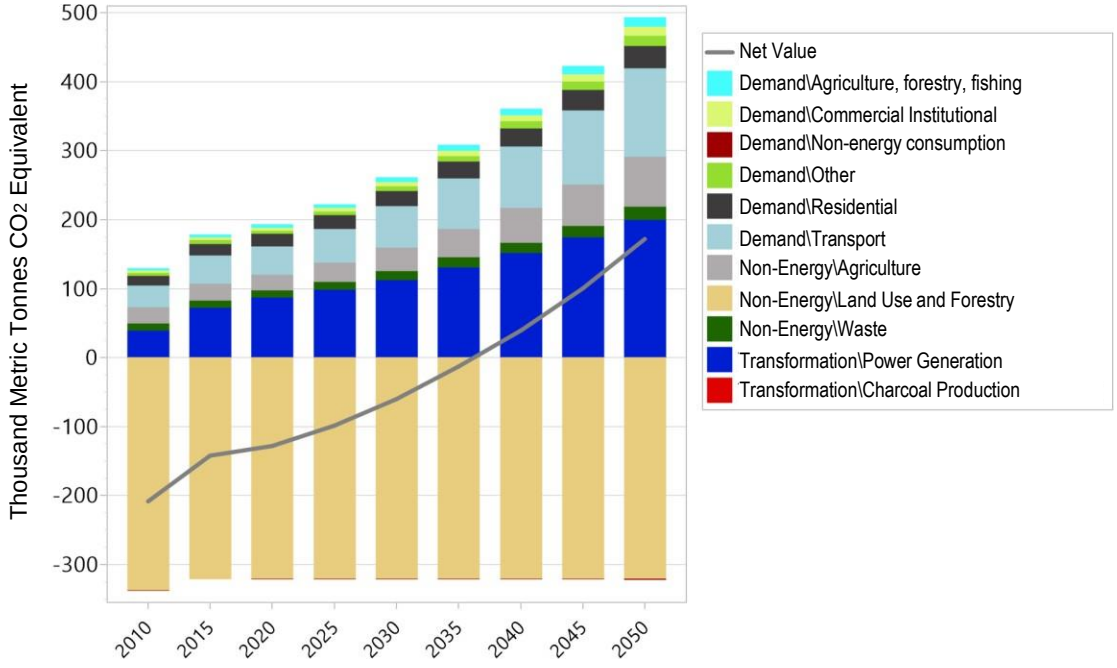

Figure 31: Evolution of GHG emissions by sector in BAU by 2050

Contribution of the plans to the SDGs (Sustainable Development Goals)

Implementing the measures contained in the NREAP, as well as in the NEEAP, has a clear benefit for São Tomé's population and shows the country's commitment to sustainable development and the improvement of its economy. The measures aim to contribute to the both the country's NDC and Vision 2030 goals, as explained in the introduction, but also to have a positive impact on the Sustainable Development Goals (SDGs).

Figure 32: The SDGs

The two plans will contribute directly to increasing access to clean and sustainable energy (**SDG-7**) by implementing generation projects based on renewable energy sources and by improving the power grid, which will reduce losses and offer a more stable and reliable service to consumers. For off-grid consumers, there will be a group of renewable generation projects that will supply power to isolated consumers, which will contribute to achieving 100% access to electricity by 2030. Considering that means of transport are a transversal part of the functioning of cities and access to them and fundamental for commercial exchanges, the proposed projects and measures for greater electrification of land transport, as well as the proposed studies in the scope of transport decarbonization, will contribute with **SDG-11**. The broad group of measures regarding the provision of capacity building, training, awareness raising and qualification in the areas of RE and EE will contribute to the provision of quality education, included in **SDG-4,** as well as to gender equity (**SDG-5**), since all measures in this scope take into account actions aimed at ensuring equitable access to options for training, capacity building and qualification. In addition, the awareness raising campaigns proposed in the plans will have a specific focus on gender issues. It is also important to note that the proposed awareness raising campaigns will include information on responsible energy consumption, thereby contributing to **SDG-12.** There are also measures in the NREAP and NEEAP that aim to enable and foster energy entrepreneurship in order to encourage innovation and the generation of new energy ideas, which contributes to **SDG-9,** in addition to the proposed studies on the use of other new technologies for energy generation, for which applicability to STP still requires further study (e.g. ocean energy, geothermal, floating solar/wind). Finally, despite the fact that STP is currently a "non-emitting" GHG country, it is important to note that the NREAP and NEEAP measures contribute to the reduction of emissions from the energy sector, and are therefore a way to collaborate with **SDG-13.** The plans are based on a sustainable economic growth model, taking advantage of natural resources and local human resources (which will be empowered), thereby generating quality work and services locally and decreasing the need for external resources (fossil fuels, other goods and services, etc.), thus collaborating with **SDG-8**. This will also allow resources to be redirected to other sectors of the economy (education, health, etc.), as well as to generate a positive cyclicality for the benefit of São Tomé's population.

ANNEX I. DATA TABLES FOR ENERGY DEMAND PROJECTIONS IN BAU

Table 23: Projection of energy demand in BAU (2010 - 2050) by fuel type

Fuel (demand in TJ)	Years								
	2010	2015	2020	2025	2030	2035	2040	2045	2050
Firewood	678.8	786.7	740.4	865.6	1,032.1	1,223.4	1,446.0	1,706.1	2,011.4
LPG	0.9	1.9	9.3	10.7	12.5	14.5	16.8	19.5	22.6
Gasoline	245.0	290.9	356.3	427.2	525.1	638.3	771.2	928.0	1,113.6
Jet Kerosene	9.2	36.6	57.4	69.0	85.1	103.6	125.4	151.2	181.7
Kerosene	161.8	196.9	215.5	238.0	263.4	291.6	322.7	357.3	395.8
Diesel	264.5	347.5	250.4	301.0	370.9	451.9	547.0	659.2	792.2
Electricity	149.3	326.7	361.6	410.7	472.0	541.6	621.3	712.8	818.3
Charcoal	173.3	200.8	200.3	220.4	242.7	267.3	294.5	324.4	357.4
Lubricants	7.5	11.2	7.8	9.3	11.5	14.0	16.9	20.4	24.5
Total	1,690.3	2,199.2	2,198.9	2,552.0	3,015.3	3,546.2	4,161.7	4,878.9	5,717.6

Table 24: Projection of energy demand in BAU (2010 - 2050) by sector

Sector (demand in TJ)	Years								
	2010	2015	2020	2025	2030	2035	2040	2045	2050
Residential	637.3	830.6	882.3	969.4	1,065.0	1,170.1	1,285.6	1,412.5	1,551.9
Agriculture, forestry and fishing	36.7	46.5	56.9	68.4	84.2	102.6	124.2	149.7	179.9
Transport	426.8	564.0	557.4	670.0	825.6	1,005.9	1,217.6	1,467.4	1,763.5
Other	83.2	93.4	82.5	99.2	122.2	148.9	180.2	217.2	261.0
Commercial/Institutional	507.0	660.4	623.5	749.5	923.6	1,125.2	1,362.1	1,641.6	1,972.8
Non-energy consumption	-0.8	4.2	-3.6	-4.4	-5.4	-6.6	-7.9	-9.6	-11.5
Total	**1,690.3**	**2,199.2**	**2,198.9**	**2,552.0**	**3,015.3**	**3,546.2**	**4,161.7**	**4,878.9**	**5,717.6**

ANNEX II. THE NATIONAL SUSTAINABLE DEVELOPMENT PLAN (PNDS) PILLARS AND PROGRAMS

OBJECTIVES OF THE PNDS	PROGRAMMATIC PILLARS OF THE PNDS		
	SUSTAINABLE ECONOMY New Development Model based on Service Provision	**SOCIAL DEVELOPMENT** Human Capital, Quality of Life Fighting Inequalities	**SOVEREIGNTY AND DEMOCRACY** New State model: strong, efficient and safe
	PROGRAMS		
Goal **1** **Transform STP into a Service Delivery Economy in the Middle of the Atlantic**	*Tourism sector *Maritime sector *Aviation sector *Commercial and industrial sector *Financial sector *Digital and innovation Sector *Business environment *STP - an accessible and open country *Modern and resilient infrastructure *Energy sustainability *Quality of statistical production and dissemination *Culture and creative industries *Research, science and technology	*Education of excellence *Gender equality *Integrated health development *Export of health services *Sport for national inclusion and cohesion	*Consolidation of democracy *State Reform *Independence and efficiency of justice *Flexible and inclusive labor market *Defense and security *Renewed and intensive diplomacy *Diaspora to third Island
Goal 2 **Promote Inclusive and Sustainable Economic Growth**	*Tourism sector *Maritime sector *Aviation sector *Commercial and industrial sector *Financial sector *Digital and innovation sector *Business environment *STP - an accessible and open country *Modern and resilient infrastructure *Energy sustainability *Quality of statistical production and dissemination *Culture and creative industries *Research, science and technology *Youth entrepreneurship *Transformation of agriculture *Water and sanitation *Protection of biodiversity *Environmental, climate and geological risk management *Decentralization, local and community development	*Education of excellence; *Decent and qualified employment *Gender equality *Export of health services *Integrated health development *Social Inclusion protection *Sport for national inclusion and cohesion	*Consolidation of democracy *State Reform *Independence and efficiency of justice *Flexible and inclusive labor market *Defense and security *Renewed and intensive diplomacy *Diaspora to third STP island
Goal 3 **Ensure social inclusion and protection, reduce social inequalities**	*Tourism sector *Maritime sector *Aviation sector *Commercial and industrial sector *Financial sector *Digital and innovation sector *Business environment	*Education of excellence; *Dignified and qualified employment *Gender equality; *Integrated health development;	*Consolidation of democracy *State Reform *Independence and efficiency of justice *Flexible and inclusive labor market *Defense and security

and regional asymmetries	*STP - an accessible and open country *Modern and resilient infrastructure *Energy sustainability *Quality of statistical production and dissemination *Culture and creative industries *Research, science and technology *Youth entrepreneurship *Transformation of agriculture *Water and sanitation *Protection of biodiversity *Environmental, climate and geological risk management *Decentralization, local and community development	*Guaranteeing rights and protection of children, adolescents and the elderly *Social Inclusion protection *Sport for national inclusion and cohesion	*Renewed and intensive diplomacy *Diaspora to third Island
Goal 4 **Strengthening Sovereignty, Deepening Democracy and Renewing Diplomacy for Development**	*STP – an accessible and open country *State Reform *Quality of statistical production and dissemination *Culture and creative Industries	*Gender equality	*Consolidation of democracy *State Reform *Independence and efficiency of justice *Flexible and inclusive labor market *Defense and security *Renewed and intensive diplomacy *Diaspora to third STP island

ANNEX III. DETAILS OF INSTALLED CAPACITY AND RE GENERATION BY YEAR

Installed renewable generation capacity by year 2010-2030 in MW

Type/Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Thermal	19.0	19.6	20.1	20.6	21.1	26.4	26.5	26.6	26.8	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.88
Solar	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.6	2.2	7.0	47.0	47.0	47.0	47.0	47.0	47.00
Hydropower	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	3.1	4.2	5.3	5.3	5.3	5.3	5.3	17.30
Biomass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.7	4.7	4.7	4.7	4.7	4.68
Total	21.0	21.5	22.0	22.5	23.1	28.3	28.4	28.6	28.7	28.8	28.8	28.8	29.4	32.2	38.1	83.9	83.9	83.9	83.9	83.9	95.86

Installed renewable generation capacity by 2031-2050 in MW

Type/Years	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Thermal	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.88
Solar	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.00
Hydropower	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.30
Biomass	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.68
Total	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.86

Renewable electricity generation by year 2010-2030 in GWh

Type/Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Thermal	41.8	61.2	72.5	71.9	76.9	95.3	99.1	104.2	99.9	104.9	101.7	96.3	90.0	78.0	60.1	25.9	26.2	26.5	26.8	27.1	12.3
Solar	-	-	-	-	-	-	-	0.1	0.1	0.1	0.1	0.1	1.2	4.7	14.5	44.7	45.1	45.5	45.9	46.4	40.0
Hydropower	4.8	5.7	6.4	6.4	7.7	6.6	5.8	5.0	5.1	5.8	5.8	5.8	5.8	9.5	12.8	11.7	11.8	11.8	11.8	11.9	37.0
Biomass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4	5.4	5.5	5.6	5.6	2.6
Total	46.6	67.0	78.9	78.3	84.6	102.0	104.9	109.4	105.1	110.9	107.6	102.2	97.1	92.1	87.4	87.8	88.5	89.2	90.1	90.9	91.9

Renewable electricity generation by 2031-2050 in GWh

Type/Years	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Thermal	14.0	15.8	17.6	19.4	21.3	23.3	25.3	27.4	29.6	31.8	35.0	38.3	41.6	45.0	49.0	53.9	58.9	64.2	70.1	76.9
Solar	42.0	44.0	46.1	48.2	50.4	52.8	55.2	57.7	60.2	62.7	66.5	70.4	74.3	78.3	81.7	85.1	88.4	91.2	93.5	94.9
Hydropower	37.5	38.1	38.6	39.2	39.8	40.4	41.1	41.7	42.4	43.1	44.1	45.1	46.2	47.2	48.2	49.1	50.0	50.8	51.4	51.8
Biomass	2.9	3.3	3.7	4.0	4.4	4.8	5.3	5.7	6.1	6.6	7.3	8.0	8.7	9.4	10.2	11.2	12.2	13.4	14.6	16.0
Total	96.4	101.1	105.9	110.8	115.9	121.3	126.8	132.5	138.3	144.2	152.9	161.8	170.8	179.9	189.1	199.3	209.5	219.6	229.6	239.6

ANNEX IV. DEFINITION OF THE TERMS USED IN THE PLANS (NREAP AND NEEAP)

Biofuels: liquid or gaseous fuels for use in the transport sector, produced from biomass.

Solid biofuels: solid fuels derived from biomass (typically firewood and charcoal)

Liquid biofuels: liquids derived from biomass and generally used as fuels. Liquid biofuels include biogasoline, biodiesel and other liquid fuels (see below for definitions of biogasoline, biodiesel and other liquid fuels).

Biogasoline: liquid fuels derived from biomass and used in spark ignition internal combustion engines. Common examples are: bioethanol, biomethanol, bio ETBE (ethyl-tertiary-butyl-ether) and bio MTBE (methyl-tertiary-butyl-ether)

Biodiesel: liquid fuels that are generally modified so that they can be used as fuel directly in engines or in blends with conventional diesel. Biological sources of biodiesel include, but are not limited to, vegetable oils from rapeseed or canola, soybeans, corn, palm oil, peanuts and sunflower. Some liquid biofuels (direct vegetable oils) can be used without the chemical modifications that are usually required for use in engines.

Other liquid biofuels: liquid biofuels not specified elsewhere in this document.

Biogas: gases derived from the anaerobic fermentation of biomass. The gases are composed mainly of methane and carbon dioxide, and include landfill gas, sewage sludge gas and other biogases (see definitions for landfill gas, sewage sludge gas and other biogases). They are mainly used as fuel, but can also be used as a raw material in the chemical industry. They are particularly relevant for cooking purposes or in the context of industrial uses (e.g. breweries, slaughterhouses).

Biomass: the biodegradable fraction of products and waste of biological origin from agriculture (including animal and plant substances), forestry and related industries, including the fishing industry and aquaculture, as well as the biodegradable fraction of industrial and municipal waste. The use of biomass for energy is diverse: from the traditional, inefficient burning of wood in open fires for cooking purposes, to the modern use of wood pellets for electricity and heat production, and the use of biodiesel and bioethanol as a substitute for petroleum-based products in the transport sector.

Base load: the minimum level of electricity demand in a grid during a given period (e.g. a week or a day).

Charcoal: the solid residue resulting from the carbonization of wood or other vegetal matter through pyrolysis. The amount of biomass (usually firewood) needed to produce a given quantity of charcoal depends primarily on three factors:

- The wood density of the parent trees - the main factor in determining the amount of charcoal from fuelwood is the wood density of the parent trees, since the weight of charcoal can vary by a factor of two for equal volumes
- The moisture content - the moisture content of the wood also has a great effect on production - the drier the wood, the higher the production;
- Charcoal production methods: Charcoal is produced in earth-covered holes, oil drums, brick or steel furnaces, and in retorts. The less sophisticated methods of charcoal production usually involve losses of powdered charcoal, incomplete carbonization of the wood and combustion of part of the charcoal obtained, resulting in a lower yield.

Traditional, inefficient methods of charcoal production: traditional methods of charcoal production include open holes, oil barrels and kilns with low efficiency (60-80% of wood energy is lost) and have health and environmental impacts.

Efficient charcoal production: Efficient charcoal is a term used in this model for charcoal produced by modern methods, which are more efficient than traditional ones. Modern methods use sealed containers and have higher efficiency and, consequently, a higher yield. Improved carbonization techniques offer yields > 25%.

Conservation: The reduction of energy use through increased efficiency and/or waste reduction.

Distributed Electricity and Microgeneration (micro-grids): This is when the electricity is produced for local distribution and is not directly connected to the national grid. Microgeneration is generally used to describe small-scale energy production technologies.

Efficient equipment: electrical appliances or devices that operate using less electricity than appliances with low efficiency. The electrical inefficiency of many devices is directly related to the heat they produce. For example, efficient light bulbs use most of the electricity received to produce light, not heat.

Electricity: The transfer of energy through a physical phenomenon involving electrical charges and its effects at rest and in motion. Electricity can be produced by different processes: for example, by converting the energy contained in moving water, wind or waves, or by directly converting solar radiation through photovoltaic processes in semiconductor devices (solar cells); or by burning fuels.

Electricity demand: The total electricity consumption in GWh or MWh of a country within a specified period. The sequence of demand values over time is called the Load Curve. Its graphical representation is called the Load Profile.

Access to energy: universal and affordable access to modern forms of energy. Access to clean and safe cooking fuels is implied, leaving behind the traditional methods of cooking through firewood or charcoal. It also implies access to sustainable electricity services that can guarantee energy supply to localities and households, providing access to modern living and paving the way for economic development.

Energy Efficiency (EE): the ratio of the performance or result of the performance of services, goods or energy in relation to the energy supplied. The energy efficiency of a process is improved if it produces the same service using less energy. Efficient light bulbs produce the same amount of light, but use up to 75% less energy to do so. Improving energy efficiency enables reductions in energy use or the production of more services using the same amount of energy.

Energy Intensity: the ratio of energy use to economic benefit in terms of goods and services. Energy intensity is generally considered to be a good macroeconomic indicator of energy efficiency. It can be calculated for an entire nation or for specific economic sectors. The unit of energy intensity is the currency divided by a unit of energy.

Final Energy Consumption: the total energy consumed by final consumers, such as households, industry and agriculture. It is the energy that reaches the door of the final consumer and excludes what is used up in the energy sector. This includes electricity and fuels (such as oil, gas, coal, firewood, etc.)

Gross final energy consumption: Gross final energy consumption is defined as energy products supplied for energy purposes to final consumers (industry, transport, households, services, agriculture, forestry and fishing), which is the electricity and heat consumed for electricity generation and heat production, including electricity and heat losses in distribution and transmission.

Fossil fuel: an energy source formed in the earth's crust through the degradation of organic matter. The most common fossil fuels are oil and its derivatives (diesel, gasoline, kerosene or gasoil, lubricants, avgas or jet kerosene), coal and natural gas.

Firewood, wood waste and by-products: wood or firewood (in the form of logs, kindling, pellets or chips) obtained from natural or managed forests, or isolated trees. They also include wood waste used as fuel, where the original composition of the wood is not altered.

Grid-connected: a system (photovoltaic, hydro, diesel, etc.) that is connected to a central power grid (electricity grid).

Production or Generation (of electricity): This covers the production of electricity in power plants.

Heat: heat is an energy carrier, generally used for heating spaces and for industrial processes.

Hybrid system: an electrical system consisting of two or more generation subsystems (e.g. combination of a wind turbine or diesel generator and a photovoltaic system)

Mini-grids: generator sets and, possibly, energy storage systems connected to a distribution network that supplies the entire energy demand of a localized group of customers. This power supply architecture can be differentiated from single customer systems (e.g. residential solar systems), where there is no distribution network interconnecting the customers, and from centralized grid systems, where power is transmitted over long distances from large power plants for when local generators are not able to meet local demand. Mini-grids are particularly relevant in the rural African context, where hybrid systems can be more cost-effective alternatives.

Improved stoves (also called clean/efficient stoves): are appliances that are designed to consume less fuel and save time in the cooking process, meet its requirements and create a smoke-free environment in the kitchen or reduce the volume of smoke produced during cooking compared to traditional stoves, consequently addressing the health and environmental impact associated with these stoves. Traditional stoves (open fires and rudimentary stoves where solid fuels such as wood, charcoal, crop residue and animal excrements are used) are inefficient, unhealthy and unsafe, and inhaling the smoke and fine particles emitted leads to serious health problems, possibly culminating in death. Traditional stoves also put additional pressure on the ecosystem and forests, contributing to climate change through the emission of greenhouse gases and soot.

Installed capacity: the nominal power of a given electricity production plant, expressed in megawatts (MW) for active power.

Kilowatt (kW): 1000 watts

Kilowatt-hour (kWh): 1000 watt-hours.

LPG: Liquefied Petroleum Gas

Electrical load: in an electrical circuit, any appliance or device that uses electricity (such as a light bulb or a water pump)

Megawatt (MW): 1 000 000 watts

Megawatt-hour (MWh): 1 000 000 watt-hours

Modern alternative (cooking) fuels: known as non-conventional or advanced fuels, these are any materials or substances that can be used for cooking, in addition to conventional solid fuels such as coal, firewood and charcoal. These alternatives include LPG, biogas, ethanol, solar energy (e.g. solar stoves) and kerosene. These modern alternative fuels are the subject of a separate study In this model and so it does not include an analysis of improved stoves using them.

Off-grid applications: a designation for facilities that produce their own energy and are not connected to an external source of energy, such as the power grid.

Photovoltaic (PV) system: a complete set of interconnected components for converting sunlight into electricity through the photovoltaic process, including panels, components for balancing the system, and the load.

Power grid: a system of high-voltage cables through which electrical power is distributed throughout a region.

Renewable Energies (RE): the term 'Renewable Energy' is used to describe energy produced using inexhaustible natural resources. This includes solar, wind, geothermal, bioenergy, wave and tidal, and hydropower.

Renewable energy options - in this model the renewable energy options refer to the following technologies:

- Small-scale hydropower, up to a maximum of 30 MW installed capacity (mini-hydropower plants);
- Bioenergy/biomass, which includes: wood (firewood and charcoal) used for domestic cooking and commercial applications (restaurants, breweries, potteries and bakeries). Surplus woody resources could be used for electricity generation with other biomass sources (such as by-products of agricultural crop production for electricity generation (stalks, straws, bark, seeds, etc.). These can be used for electricity generation when grouped together on an agro-industrial site. Electricity can also be produced from biogas using industrial or municipal waste, as well as animal excrements (concentration of resources in dairies and slaughterhouses or livestock and vegetable markets)).
- Solar PV (photovoltaic), which can be utility scale or distributed solar power (or "rooftop").

Renewable energy penetration in electricity consumption – this is the fraction of total electricity consumption for a given year produced from renewable sources, given as a percentage (%). In this model, this is calculated as the ratio of electricity production from renewables (in MWh/year) to total consumption (in MWh/year) for the same year.

Rural electrification: guarantee of a regular supply of electricity to rural populations. It involves extending the power grid into rural areas, or using mini-grids or isolated systems (in the case of STP, these are solar home systems).

Percentage of population served by off-grid (mini-grids and stand-alone systems) renewable electricity generation: this is the percentage (%) of the total population that is served by mini-grids or stand-alone systems.

Rural communities: these are administrative units in rural areas. This includes the population living in rural centers and towns with between 200 and 2500 inhabitants, and some larger cities that are not covered by the national grid due to their peripheral geographical location.

Solar stoves: are appliances that use the direct energy of the sun's rays (that is the heat coming from the sun) to heat, cook or pasteurize food or beverages.

Stand-alone power systems: also known as power supply systems for remote areas, they are off-grid electricity generation systems for places that do not have an electricity distribution system. SAPS include one or more methods of electricity generation, energy storage and regulation.

Support scheme: indicates any instrument, scheme or mechanism applied by a country or group of countries that promotes the use of energy from renewable sources by reducing the cost of that energy, increasing the price at which it can be sold or increasing, through a bond or similar means, the volume of energy purchased. This includes, but is not limited to, investment aid, tax exemptions or reductions, tax refunds, renewable energy bond support schemes, such as green certificates, and direct price support schemes, such as feed-in tariffs and premium payments. The support schemes for renewable energy include:

- Production-based incentives:

o Feed-in Tariffs ("FIT"): a policy that supports the development of renewable resources. FITs offer guaranteed payments to renewable energy producers for the energy actually produced ($/kWh). These payments are usually guaranteed as long-term contracts.

o Quota system: a policy that rewards the producer with certificates that can be sold on a market (without price guarantee)

o Quota system with competitive auctions: the setting of mandatory production quotas for the supply of green energy. These quotas are imposed on power plants and/or electricity distribution companies (calculated as a percentage of production/sale). Operators can meet these obligations in three ways: (i) by producing their own green electricity, (ii) by purchasing the electricity under long-term contracts, and (iii) by purchasing on the financial market so-called "Green Certificates" corresponding to the amount of electricity required.

o Decentralized quota system with markets for green certificates, also called tradable green certificates (TGC): the setting of mandatory production quotas for green electricity. These quotas are imposed on power plants and/or electricity distribution companies (calculated as a percentage of production/sales). Operators can meet these obligations in three ways: (i) by producing their own green electricity, (ii) by purchasing the electricity under long-term contracts, and (iii) by purchasing on the financial market "Green Certificates" corresponding to the amount of electricity required.

- Investment-based incentives

o Grants and loans: financing instruments in which governments provide grants or loans for the development of renewable energy projects. Grants do not have to be repaid, whereas loans do.

o Microloans: the extension of small loans (microloans) to poor borrowers, who generally have neither a steady, secure job nor a verifiable credit history.

o VAT exemptions: allow households or investors to avoid paying VAT on renewable energy or energy efficiency equipment.

Technical losses: Losses in the electrical system that are caused by the physical properties of system components. Technical losses occur naturally (caused by internal actions) and consist mainly of the dissipation of electricity in the system’s electrical components, such as transmission lines, transformers, metering systems, etc.

Commercial losses or non-technical losses: Losses in the electricity system caused by theft and fraud in the use of electricity, miscalculations and accounting errors. Non-technical losses are caused

by actions outside the electrical system, or by loads and conditions that the calculation of technical losses did not take into account. Non-technical losses are more difficult to measure because they are often unaccounted for by system operators and so no information is recorded.

Total losses: the sum of the technical losses and the commercial or non-technical losses.

Watt-hour (Wh): a measure of electrical energy equal to the electrical power multiplied by the period of time (hours) during which the power is applied.

Waste: in energy statistics, waste corresponds to that part of the waste that is incinerated with heat recovery in facilities designed for mixed waste or co-combustion with other fuels. The heat can be used for heating or electricity generation. Waste is sometimes a mixture of fossil and biomass materials.

Industrial waste : non-renewable waste that is burned with heat recovery in factories, with the exception of that used for urban/municipal incineration. Examples are used tires, specific waste from the chemical industry and hazardous waste from healthcare. Combustion includes co-combustion with other fuels. The renewable portions in industrial waste combustion with heat recovery are classified according to the biofuels that best describe them.

Urban/municipal waste: household waste, and company and utility waste that resembles it and is collected in facilities specifically designed for mixed waste disposal with recovery of liquid fuels, gases or heat. Municipal waste can be divided into renewable and non-renewable fractions.

ANNEX V. WORK METHODOLOGY ADOPTED FOR THE DEVELOPMENT OF THE NREAP AND NEEAP

Objective and general approach to the work

The objective of this project was to support UNIDO and DGRNE in developing an integrated and holistic vision of sustainable energy through a National Renewable Energy Action Plan (NREAP) and a National Energy Efficiency Action Plan (NEEAP). The following figure illustrates the approach adopted by the consulting team in performing this service:

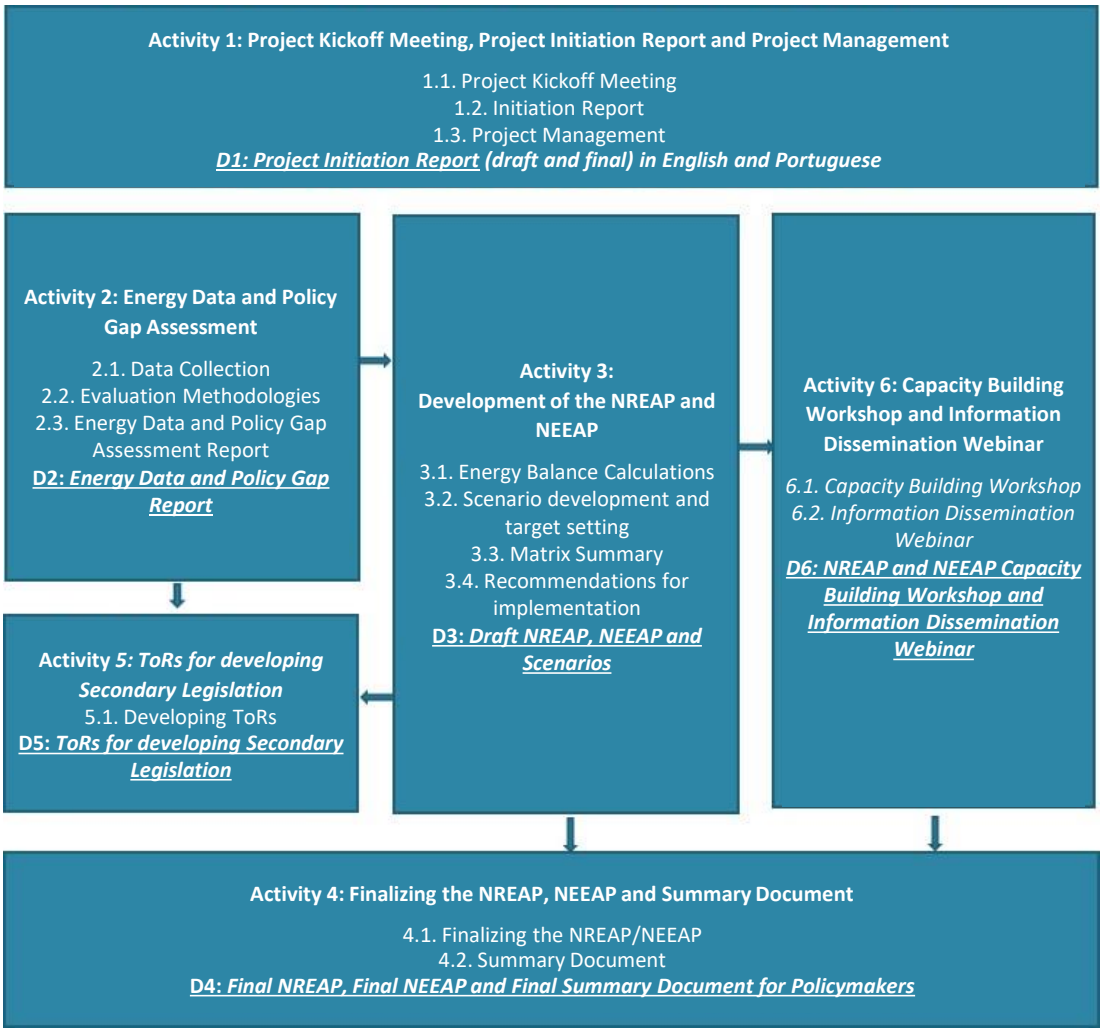

Figure 33: Scope of work

During this process, various stakeholders were involved, mainly through the meetings held with the National Sustainable Energy Platform (PNES – Plataforma Nacional de Energia Sustentável), led by DGRNE. A total of five (5) meetings of the PNES and the consulting team took place, in addition to frequent communications via email and phone with Mr. Gabriel Maquengo and other colleagues from DGRNE to check information when necessary. In addition, the consulting team present locally in STP had the opportunity to interview representatives from other areas of government, such as transport, forestry and biodiversity, customs, etc. in order to collect background information and data to build the model and develop the two plans.

Methodology for developing the scenarios

Energy Balance Calculations

LEAP can automatically generate results as standard format energy balance reports. These closely follow the standard format used by the IEA and most national energy planning agencies. LEAP energy balances can be displayed in table graph, chart and sankey format, and can be customized to

summarize information for detailed or simplified fuel categories, for different years or different regions. The energy balance results can also be shown by sector or by subsector in any energy unit.

Energy balance calculations will provide an understanding of current power generation capacity, the current state of renewable energy penetration and electricity generation for the grid and transmission, and distribution as a source of energy losses. This exercise will also identify the national energy intensity. Installed capacity, annual generation and imports will also be part of this baseline understanding that provides the basis for creating scenarios.

In addition to globally reproducing historical energy balances, a notable capability of LEAP is that it can present estimates of possible future energy balances and how they could vary between scenarios depending on the implementation of different policies.

Scenario development and target setting:

LEAP was developed around the concept of scenario analysis. Scenarios are consistent stories of how an energy system might evolve over time.

Using LEAP, the Project Team can create and evaluate alternative scenarios, comparing their energy needs, costs, social benefits and environmental impacts.

LEAP will be used to explore the potential of renewable resources for the targets – the dataset will be able to illustrate the evolution of energy balances in STP:

- LEAP will consider the potentials of existing resources and the cost-benefit ratio of different technologies (e.g. hydropower; and biomass, geothermal, wind and solar power);
- Other important social, economic and environmental criteria (energy security, national development goals and sustainability).
- It can also be used to examine the local climate and air pollution impacts associated with different scenarios.

The scenarios to be evaluated will be agreed upon with DGRNE and the PNES subcommittee.

They will be intentionally designed to be transparent and relatively simple in terms of modeling methodology to make them readily accessible and easy to consult by local stakeholders and policy makers.

ANNEX VI. BIBLIOGRAPHY

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COMMUNICATION - EMAILS AND MEETINGS

Project Administration Supervision Agency (AFAP).

Directorate for Forests and Biodiversity (DFB).

Directorate General of the Environment (DGA).

Directorate General of Tourism and Hotels (DGTH).

Directorate General of Natural Resources and Energy (DGRNE).

National Oil and Fuel Company (ENCO).

National Institute of Statistics (INE).

National Institute of Meteorology (INM)

National Sustainable Energy Platform (PNES)