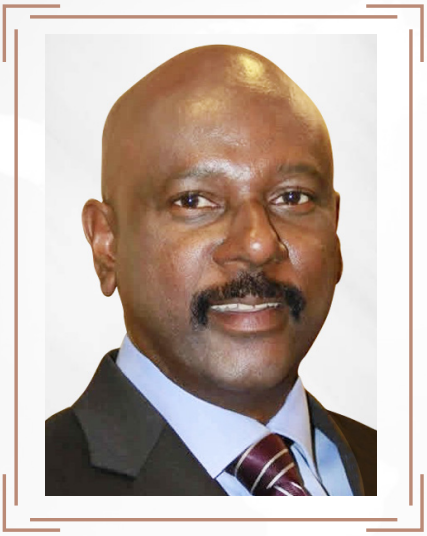
RENEWABLE ENERGY

ROADMAP 2030 FOR THE ELECTRICITY SECTOR

REVIEW 2022



FOREWORD

Mauritius as a Small Island Developing State, is mostly dependent on imported fossil fuel to meet its energy demands. This reliance exposes our country to external shocks on the international market and the impact of the recent conflict between Russia and Ukraine has further brought attention to this dependence. Countries globally have not been spared by the rising costs of energy which have impacted households, industries and businesses. As a Small Island Developing State, Mauritius is furthermore vulnerable to the impact of climate change although our contribution to the Greenhouse Gas (GHG) emissions can be considered negligible.

This exposure and vulnerability demand a smart transformation of our electricity sector to better address the impacts of climate change, foster sustainable growth and ensure energy security. The Government of Mauritius has committed not only to abate GHG emissions by 40% by 2030 but more importantly to pursue its green energy transition and develop a more resilient national electricity sector that is grounded in a richer mix of Renewable Energy. These initiatives are expected to trigger economic growth, job creation and an overall improvement in social welfare.

Clear objectives for the energy sector have been set by Government, some of which have been announced in the budget 2021/2022 namely:

- The establishment of the Green Energy Industry as an economic pillar of activity;
- An accelerated increase in the share of Renewable Energy in the electricity mix to 60% by 2030;
- Phasing out of the use of coal in electricity generation by 2030; and
- Increase of 10% energy efficiency by 2030 (with 2019 as base year).

The above measures have necessitated a review of the Renewable Energy Roadmap for the Electricity Sector published in 2019. The 2019 version had aimed at a target of 35% of Renewable Energy by 2025 with scenarios to reach 40 % by 2030. The current document is a review of the initial Roadmap and highlights the different initiatives that will be envisaged to attain Government's objectives in the Renewable Energy sector. The document is a dynamic one and stands to be revisited on a regular basis especially with emergence of new technologies and opportunities. All measures proposed in the review of the Roadmap have been put forward after consultation with relevant stakeholders from the public as well as from the private sector, while aligning with the different frameworks, policies and strategies of other economic sectors. The focus remains on the increased deployment of well-tested Renewable Energy technologies in the short term, while actively investigating and de-risking relatively novel technologies towards a further timeline. The gradual shift to the use of cleaner energy technologies such as Liquefied Natural Gas will also be explored in parallel.

I wish to thank the Technical Committee chaired by the Mauritius Renewable Energy Agency comprising representatives of the Ministry of Energy and Public Utilities, the Central Electricity Board and the Energy Efficiency Management Office for the laudable piece of work in this review exercise. I rely on the full support and collaboration of all stakeholders in achieving the targets set in the Roadmap Review (2022) which provides the energy portfolio to enable Mauritius to reach its target of 60% RE in the energy mix by 2030 as per its pledges made at COP26 in Glasgow last year.

Hon. Georges Pierre Lesjongard
Minister of Energy and Public Utilities
May 2022

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ADEME	Agence De l'Environnement et de la Maitrise de l'Energie	kWh	Kilo Watt Hours
AFD	Agence Francaise de Developpement	LDC	Load Duration Curve
AGC	Automatic Generation Control	MARENA	Mauritius Renewable Energy Agency
AIS	Air Insulated Switchgear	MRA	Mauritius Revenue Authority
ARE	African Renewable Energy	MEPU	Ministry of Energy and Public Utilities
BESS	Battery Energy Storage System	MRIC	Mauritius Research and Innovation Council
CAPEX	Capital Expenditure	MSB	Mauritius Standards Bureau
CEB	Central Electricity Board	MSDG	Medium Scale Distributed Generation
CEL	Consolidated Energy Ltd	MSIRI	Mauritius Sugarcane Industry Research Institute
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement	MW	Mega Watt
CO_2	Carbon Dioxide	MWac	Mega Watt Alternate Current
DBSA	Development Bank of Southern Africa	NSEIRET	National Scheme for Emerging/Innovative Renewable Energy Technologies
EE	Energy Efficiency	PMU	Phasor Measurement Units
EEMO	Energy Efficiency Management Office	PPFA	Project Preparation Facility Agreement
EOI	Expression of Interest	PV	Photovoltaic
EV	Electric Vehicle	RE	Renewable Energy
FPV	Floating Photovoltaic	REHF	Renewable Energy Hybrid Facilities
FTE	Full Time Equivalent	RERT	Renewable Energy and Related Technology
GCF	Green Climate Fund	RESP	Renewable Energy Strategic Plan
GDP	Gross Domestic Product	RFI	Request for Information
GEF	Global Environment Facility	RFP	Request for Proposal
GHG	Green House Gas	SADC	Southern African Development Community
GIS	Gas Insulated Switchgear Station	SG	Strategic Goals
GWh	Giga Watt Hours	SSDG	Small Scale Distributed Generation
IEA	International Energy Agency	TEG	Total Energy Generated
IPP	Independent Power Producer	TEGRS	Total Energy Generated from Renewable Sources
IRENA	International Renewable Energy Agency	UNDP	United Nations Development Programme
$ktCO_2$	kilotonnes of Carbon Dioxide	UNFCCC	United Nations Framework Convention on Climate Change
kV	Kilo Volt	URA	Utility Regulatory Authority
$ktCO_{2eq}$	kitotonnes of Carbon Dioxide Equivalent		

1.0 Objective of the Review of the Renewable Energy (RE) Roadmap 2030 for the Electricity Sector

The Ministry of Energy and Public Utilities published a RE Roadmap 2030 for the Electricity Sector in 2019 charting the way to meet the RE targets of 35% by 2025[1]. The RE Roadmap catered for the investment required by technology and included energy scenarios to meet the 40% RE target by 2030. In 2020, the COVID-19 pandemic affected both the local and international economy. Worldwide lockdowns implied disruptions in the supply chain, in the RE technology market and human capital transfer as well as delays in project construction. The repercussion of the pandemic was profoundly observed in Mauritius and has similarly impacted on the implementation of RE projects. This led to achieving an integration of 23.9% of RE in the electricity mix (source: Statistics Mauritius) as compared to the forecasted RE target of 25.2% by 2020.

In the Budget Speech 2021/22, the Government of Mauritius announced the Green Energy as a new economic pillar of Mauritius. In the same breath, the RE target in the energy mix was increased from 40% to 60% by 2030 together with the announcement of the phasing out of coal in the generation of electricity by the same timeframe. The announcement was made well before the COP26 held in Glasgow in November 2021. In the light of these developments, a review of RE Roadmap 2019 was warranted in order to meet the new challenges of the revised targets and to cater for the substitution of displacement of coal by other renewables.

1.1 Policy Measures and Schemes

In order to create an environment conducive to a transition to a greener economy by 2030, in addition to the budget measures, a series of schemes have been initiated by the Government of Mauritius. A snapshot of a few of such RE schemes launched is provided in Figure 1.

[1] The RE Roadmap for the Electricity Sector 2030 published in 2019 can be accessed at https://www.climate-laws.org/geographies/mauritius/policies/renewable-energy-roadmap-2030-for-the-electricity-sector

RE Measures and Schemes

- International Request for Information to gauge the interest for RE hybrid facilities
- Launching of an Expression of Interest for the feasibility study of ocean renewable energy technologies
- Launching of utility scale PV 3x10 MW
- Implementation of 8 MW PV Farm at Henrietta
- Revision of the Nationally Determined Contributions in 2021 to increase the GHG emission abatement from 30% to 40% by 2030
- Elaboration of a National Biomass Framework
- Greenfield RE Scheme of 90 MW for public entities
- Solar PV Scheme for Charging of Electric Vehicles for 10 MW
- Solar PV Scheme for Educational Institutions for 6 MW (MSDG Educational institutions)
- RE Scheme for domestic households for 10 MW (Home solar Project)
- Pilot project of 2 MW Floating PV at Tamarind Falls
- CEB Smart City Scheme for 20 MW
- CEB MSDG Gross Metering Scheme for 42 MW
- CEB Public Sector Scheme for 15 MW
- CEB RE Scheme for Religious Bodies for 4 MW
- CEB RE Scheme for NGOs and Charitable Institutions for 2 MW
- CEB Green Energy Scheme for SMEs for 4 MW
- Home Solar Project for 10 MW
- SSDG Net Billing Scheme 5 MW

Figure 1: RE Measures and Schemes
(Source: Ministry of Finance, Economic Planning and Development)

1.1.1 RE Share and RE Target

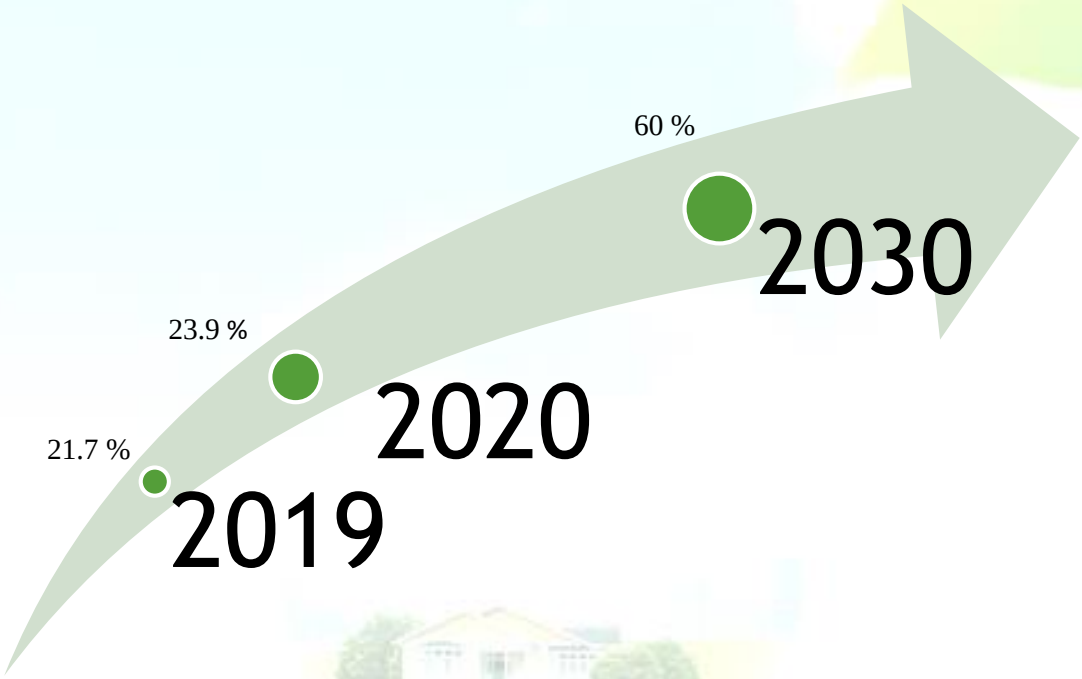


Figure 2: RE share from 2019 to 2020 and RE target for 2030
(Sources: Statistics Mauritius for year 2019 and 2020)

Figure 2 shows the RE share from 2019 to 2020 in the energy mix and the RE target to be achieved by 2030 as set by the Government. The RE share has increased from 21.7% in 2019 to 23.9% in 2020. It is to be noted that the demand in 2020 was relatively low due to the Covid-related factors, while there was no major RE projects between 2020 and 2021, such that installed RE capacity remained more or less fixed. A gradual increase in demand was observed as from 2021 with the opening up of borders and economic recovery.

However, in February 2022, the world economic recovery witnessed another set-back with the break-out of war between Ukraine and Russia which has been considerably affecting energy security, energy prices as well as causing inflationary pressures. As a Small Island Developing State, remote from its main markets and logistics, Mauritius stands to be impacted severely due to food and energy-related crises, among others.

In line with the target set by the Government of Mauritius and against this challenging background, the share of RE in the coming years would have to be further bolstered by the implementation of new RE projects to attain 60% in 2030.

1.2 Institutional Framework

This section presents an overview of the main actors in the electricity sector in Mauritius and their respective roles according to the current regulations.

1.2.1 Ministry of Energy and Public Utilities (MEPU)

The MEPU has as one of its main objectives to "*ensure that polices and strategies are defined and implemented for energy security and the development of renewable energy*". The MEPU, as the policy-maker, sits at the apex of the pyramidal formation of the electricity sector. It is responsible for the formulation of policies and strategies in the utilities sectors namely the energy, water and wastewater sectors. It also has the responsibility to put in place a responsive legal framework to govern the development of these sectors. The following organizations directly related to the energy sector fall under the purview of MEPU:

- Mauritius Renewable Energy Agency (MARENA) – Promotion of Renewable Energy.
- Central Electricity Board (CEB) – Generation, Transmission, Distribution and Sale of Electricity.
- Energy Efficiency Management Office (EEMO) – Promotion of Energy Efficiency.

1.2.1.1 Mauritius Renewable Energy Agency (MARENA)

The MARENA is the prime Agency for advising the MEPU on all matters related to RE. The main objectives of MARENA are to promote the adoption and use of RE with a view to achieving sustainable development goals (SDGs); create an enabling environment for the development of RE; share information and experience on RE research and technology; and foster collaboration and networking, at regional and international levels, with institutions promoting RE. MARENA has developed a National Scheme for Emerging/Innovative Renewable Energy Technologies (NSEIRET) in collaboration with the CEB and Mauritius Research and Innovation Council (MRIC) to promote emerging technologies to diversify the RE mix. Four projects have been awarded under the NSEIRET, namely Skysails Power for base load renewable wind energy, using flying kite of 100 kW, Tesla Cascading Hydro Power Plants using low level lying water courses to harness energy of 100 kW, Easycool Ltd's "Innovative Advanced WindWall Rooftop Wind Power Generation" and SUNfarming Africa Holding Ltd's SUNfarming Research and Training Centre for Mauritius for an allocated capacity of 18 kW and 200 kW respectively. In view to de-risk RE technologies in Mauritius, MARENA, under the UNDP-Green Climate Fund (GCF) project has commissioned a study on a feasibility study on floating solar PV in Mauritius. Additionally, the Agency has launched an Expression of Interest (EOI) for consultancy services to carry out a feasibility study on ocean renewable energy technologies, including offshore wind, wave energy and tidal energy. In view to build the local RE workforce, MARENA has launched a Scholarship Scheme in collaboration with the British High Commission and UNDP for Training of Renewable Energy Professionals in 2021/22. Under the UNDP-GCF project, MARENA has carried out awareness sessions targeting women at the community level on RE. A training program targeted for women on Entrepreneurship and RE was also carried out in collaboration with the Mauritius Institute for Training and Development (MITD), funded by UNDP-GCF and Clinton Climate Initiative. MARENA is furthermore developing Regulations on Standards for RE technologies in view to ensure that quality products enter the country.

1.2.1.2 The Central Electricity Board (CEB)

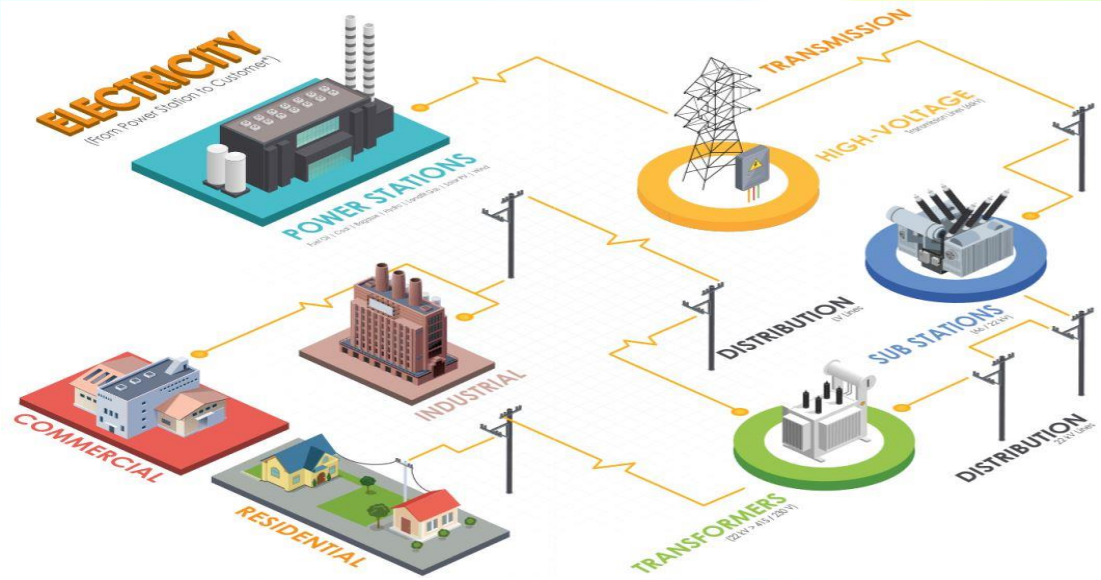


Figure 3: Framework for CEB
(*Source: CEB (https://ceb.mu/our-activities/overview*)

The CEB is a parastatal body operating under the aegis of MEPU. It is governed by the provisions of the CEB Act 1963. Its objects are, among others, to "*prepare and carry out development schemes with the general object of promoting, coordinating and improving the generation, transmission, distribution and sale of electricity*" in Mauritius and Rodrigues Island. The CEB Act was amended in 2020 *inter-alia* to provide for the conduct of RE-related schemes. In 2021, provision was made by CEB for RE related training.

The CEB produces around 45% of the country's total power requirements from its four thermal power stations and ten hydroelectric plants, the remaining 55% are being purchased from Independent Power Producers (IPPs). Currently, the CEB is the sole organisation responsible for the transmission, distribution and supply of electricity to the population. Figure 3 shows the electrical utility framework.

With respect to RE, the CEB has launched a number of schemes for utility scale and distribution generation for different categories of consumers such as domestic, public sector, NGOs, religious bodies, charitable institutions and smart city, among others. The CEB has also embarked on several initiatives to improve and upgrade its infrastructure in order to allow for the integration of more variable energy and to ensure stability and security on the Grid. These are elaborated at paragraph 6.1.

1.2.1.3 Energy Efficiency Management Office (EEMO)

The EEMO has been set up under Section 4 of the Energy Efficiency Act 2011 with the objectives, among others, of promoting awareness for the efficient use of energy as a means to reduce carbon emissions and protect the environment. The functions of the EEMO are, in particular, to implement strategies and programmes for the efficient use of energy, establish links with regional and international institutions and participate in programmes pertaining to the efficient use of energy. EEMO highlights the initiatives in energy in the domestic, industrial,

transport and services sector in view of sensitizing and creating a synergy around an effective management of energy. It also develops guidelines for the various economic sectors with respect to energy efficiency.

1.2.2 The Utility Regulatory Authority (URA)

The URA is an independent body set up by the Government of Mauritius in 2016 in accordance with the URA Act 2004 to regulate the utility services, namely electricity, water and wastewater. Its objects are to ensure the sustainability and viability of the utility services; protect the interests of consumers; promote efficiency in both operations and investments in respect of utility services; and promote fair competition in the utility services industry.

1.2.3 Institutional Map

Figure 4 depicts the linkages between the different institutions and stakeholders in the electricity sector. Independent Power Producers (IPPs) produce energy and sell to CEB under a Power Purchase Agreement signed between the two parties.

In Figure 4 below, the continuous lines mean a direct link (meaning control: single pointed arrow, or interaction: double-headed arrow); the small segment lines mean future links and the large segment lines indicate coordination.

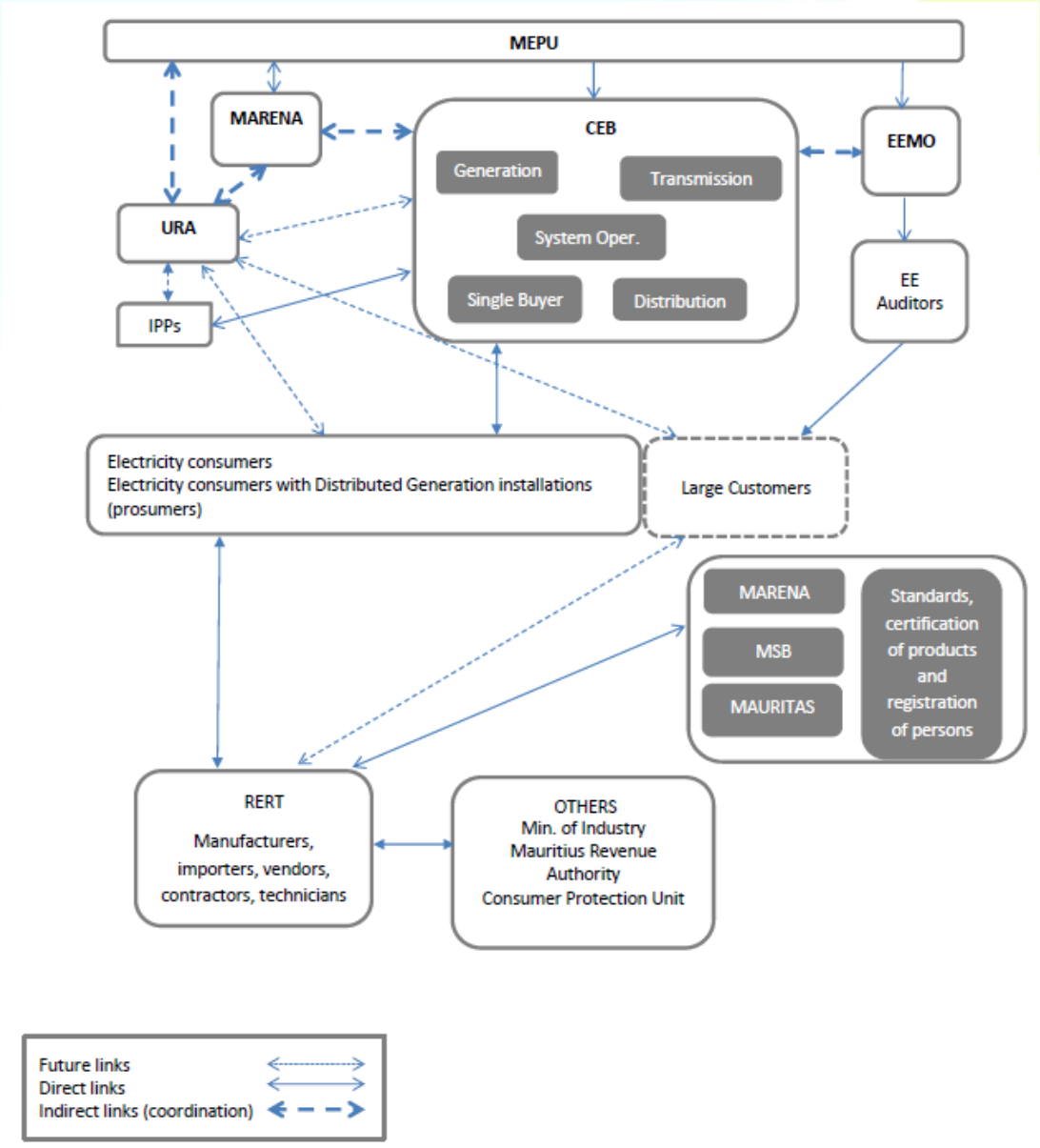


Figure 4: Institutional framework of the Energy Sector
(Source: Institutional Mapping of the Electricity Sector, MARENA)

1.2.4 Regulatory Framework

The relevant Acts for the electricity sector are summarized as follows:

- The Electricity Act 1939
- The Central Electricity Board Act 1963
- The Utility Regulatory Authority Act 2004
- The Electricity Act 2005
- The Energy Efficiency Act 2011
- The Mauritius Renewable Energy Agency Act 2015

1.2.4.1 Amendments to the Electricity Act 2005 and CEB Act 1963

In December 2020, amendments were brought to the Electricity Act and CEB Act. The amendments to the CEB Act 1963 were mainly to (a) harmonise the CEB Act and the Electricity Act for the proper functioning of the electricity sector; (b) amend and clarify the functions of the CEB; (c) remove from the CEB the powers conferred upon it to grant permits for the supply of electricity and to fix the prices to be charged for electricity and thereby, align the Act with the Electricity Act 2005 which gives the Utility Regulatory Authority the power to issue licences and determine tariffs for electricity services.

The amendments to the Electricity Act 2005 were mainly to (a) harmonise the Electricity Act 2005 and the CEB Act 1963 for the proper functioning of the electricity sector; (b) bring amendments to some of the types of licences which may be issued under the Act; (c) eliminate the concept of "eligible customer".

1.3 Impacts of COVID-19 on the Electricity Sector

Due to the COVID-19 pandemic, lockdown and sanitary restrictions were imposed in Mauritius as from March 2020. These have been gradually relaxed in 2021. With the closure of borders from March 2020 to September 2021, the tourism sector, which is a main pillar of the economy has been affected, with reduced energy demand in the hospitality sector and commercial sector. From 2019 to 2020, the total electricity generation decreased by around 11%. Peak demand of electricity dropped from 507 MW (December 2019) to 438.3 MW (December 2020 – post COVID-19), which has also resulted in a decrease in the sales of electricity from 2716 GWh to 2409 GWh, with the commercial and industrial sectors being most impacted. Imports and consumption of petroleum products such as gasoline, diesel oil and aviation fuel had also decreased. These combined effects led to a relative increase of RE share in the electricity mix to 23.9%. With the resumption of economic activities leading to an increase in energy demand, and the sharp increase in global fossil fuel prices, it is expected that the RE share would pick up as post-COVID green recovery projects and energy security projects are implemented.

2.0 Current Status of The Electricity Sector in Mauritius

The current electricity sector is dominated by fossil fuel energy source accounting for 76% of electricity production, while renewables represented only 24% in 2020 (Figure 5).

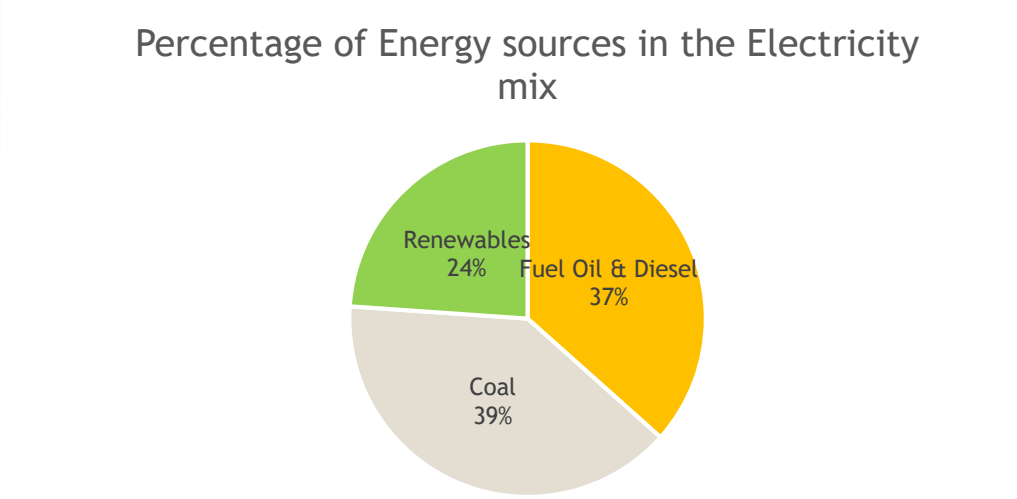


Figure 5: Energy Sources in the Electricity Mix (2020)
(Source: Statistics Mauritius)

Figure 6 shows the breakdown of the contribution of renewable energy comprising different RE technologies in the electricity mix in 2020.

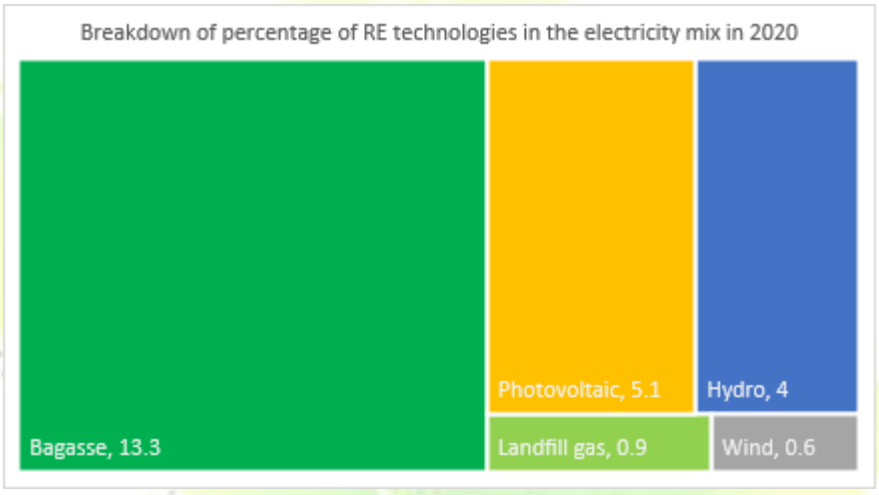


Figure 6: Share of RE by Technology in the Electricity Mix in 2020
(Source: Statistics Mauritius).

2.1 Evolution of Total Installed Capacity and RE Installed Capacity

The installed capacity of RE increased from 329.5 MW to 378.1 MW from 2015 to 2021, as shown in Figure 7. It is to be noted that the decrease in RE capacity in 2019 is due to the expiry of the Power Purchase Agreement (PPA) with the IPP Consolidated Energy Limited (CEL) and termination of PPA with Medine. (*Source: CEB*).

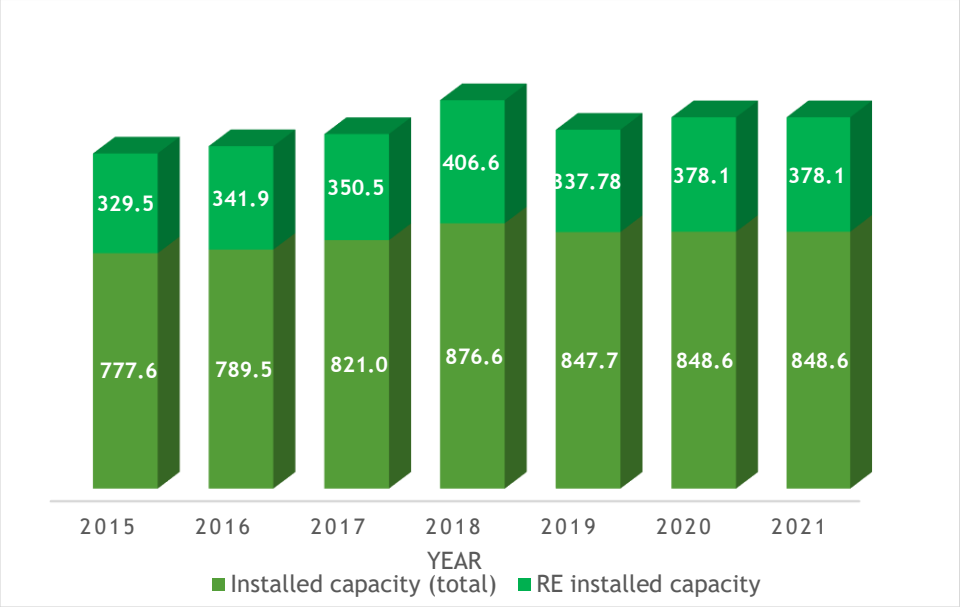


Figure 7: Total Installed Capacity and RE Installed Capacity Evolution from 2015 till 2021
(Source: CEB)

2.2 Actual RE Portfolio

Table 1 shows the power plants/projects and schemes already operational in the RE landscape in Mauritius.

Table 1: Power Plants*/Projects/Schemes Operational in Mauritius*
(Source: CEB, 2020)

Sub-Category	Power Plants/Projects/Schemes	Effective Capacity* (MW)	Total Effective Capacity (MW) per Sub-Category
Hydro	CEB Hydro Generation	56.4	56.4
PV Farm	CEB PV Farm (Henrietta)	1.7	94.78
	SSDG	11.99	
	MSDG	6.5	
	Sarako PV farm	15	
	Solar Field Ltd	1.99	
	Synnove Energy Esperance	1.44	
	Voltas Green Ltd PV Farm	12.24	
	Voltas Yellow PV Farm	13.6	
	Helios Beau Champ Ltd PV farm	9	
	Akuo PV farm	15	
	Synnove Petite Retraite	1.44	
	SPV Petite Riviere	4.88	
Landfill Gas	Landfill Gas (Mare Chicose)	3.0	3.0
Wind	EOLE Wind farm	9.35	9.35
Bagasse	IPP bagasse	131.5	131.5
	Total	295	295

**The effective capacity is the plant capacity after deduction of the absorbed power by auxiliary installations and losses through Inverters and Transformers.*

2.2.1 Hydropower

Though the hydropower which produces 56.4MW of electricity is considered to be fully tapped, it is considered that there is still further potential for setting up of mini/micro hydropower plants. There is a pilot project of 100 kW mini hydropower under the NSEIRET by MARENA in collaboration with the CEB and MRIC. Should this project operate satisfactorily, it can be replicated on other rivers with a view to further boosting RE generation. Furthermore, CEB is also investigating the possibility, together with the support of MEPU, to harness hydro power from the upcoming Riviere des Anguilles Dam project. As per the preliminary design report, there is a potential to generate around 160 kW from that site. In the event the water earmarked for irrigation purposes are not exploited, the hydro power can be up-scaled to some 300 kW.

2.2.2 Landfill Gas Power Plant

There is currently a single landfill gas power plant of an effective capacity of 3.0 MW at the sole landfill site, at Mare Chicose, which has been operational since 2011. Presently, the Solid Waste Management Division of the Ministry of Environment, Solid Waste Management and Climate Change is working on the vertical expansion of the Mare Chicose Landfill which would in turn increase its operation for some additional years. It is projected that there may be enough landfill gas to keep this plant operational for at least ten further years.

2.2.3 EOLE wind farm

The first 9.35 MW onshore wind farm launched in 2016 with an expected annual output of 16.3 MWh, is located in the surroundings of Plaine des Roches, and has an average wind speed between 6 to 7 m/s. The wind farm consists of 11 cyclone-resistant wind turbines of 850 kW each of the Gamesa make (Spain).

2.2.4 Small Scale Distributed Generation (SSDG)

In collaboration with MEPU, CEB has launched the SSDG project in an attempt to improve access to the national electricity grid. The SSDG was established in order to permit the integration of photovoltaic, wind turbine, and mini-hydro technologies within the CEB grid for low voltage connected renewable energy systems, with capacities up to 50 kW. This technical limit was set following a consultancy exercise funded by the UNDP.

2.2.5 Medium Scale Distributed Generation (MSDG)

As part of the policy of the Government to promote and encourage clean energy production, the CEB came forward with the CEB MSDG Net-Metering Scheme for the integration of RE systems in 2016. This scheme was set up to cater for RE projects of new capacities of the order of 50 kW to 2 MW which are to be connected to the medium voltage network (22 kV) via a dedicated transformer.

3.0 Major Schemes and Projects under Implementation/forecast

3.1 Request for Information (RFI)

The CEB launched a Request for Information (RFI) exercise in June 2021 through the local and international press, inviting potential interested bidders to indicate deployment of RE technologies so as to provide firm power to the CEB grid for 8000 hours. Each RE Hybrid Facility (REHF) would have a net output capacity ranging from 2MW to 50MW and would be connected to the medium or high-voltage network. The REHFs would also have to ensure stability of the CEB's grid.

For the purpose of the exercise, the CEB had set a purchase price not exceeding MUR 4.50 per kWh (maximum 80% Euro/dollar and minimum 20% MUR) for the purchase of the electrical energy exported by the REHF and the sale of the electricity would be governed by a Power Purchase Agreement to be signed with the CEB for a period of 25 years. Out of 49 proposals received as at the closing date, 22 were from local firms, 14 from foreign firms and the remaining 13 were from a combination of local/foreign firms. The outcome of the RFI has demonstrated a proposed aggregated intended injectable capacity on the grid of 1409MWac, which exceeded requirements to meet the 60% target of renewables by 2030.

It is to be highlighted that the most popular RE Hybrid Technologies proposed in the RFI exercise are "Solar PV + Battery Storage", "Solar PV + Wind + Battery Storage" and "Biomass only". As regards the proposals received in relation to biomass plant technology, these are namely, cane straw, wood waste, eucalyptus, Arundo Donax (fatak), elephant grass, macro algae, garden waste, bamboo, bana grass and imported wood chips/pellets. The RFI has indicated that the most affordable RE Hybrid Facility was solar PV together with Battery Storage with investment cost ranging from Rs 46M to Rs 81M per MW, while the highest proposal received was from wave energy which stood at some Rs 250M per MW. The equity component represented around 20% to 30 %, while the debt component represented 80% to 70 % of the project cost. Given the massive investments involved, some of the financing institutions proposed by the respondents were the EU Community Shareholder Fund, Sunref, Exim Bank and AfDB among others.

3.2 Request for Proposal (RFP) for RE-Hybrid Facilities

In light of the outcome of the RFI exercise and demand-supply balance as well as affordability considerations, CEB will be proceeding with the launching of relevant Request for Proposals (RFP) for the purchase of firm and stable power from REHF.

3.3 CEB Greenfield Renewable Energy Scheme

The CEB Greenfield RE Scheme was launched in October 2021 as a follow-up initiative to increase RE in the energy mix. In this initial phase of the Scheme, the CEB will consider application for greenfield RE projects from Public Sector Entities, including RE projects from the Rodrigues Regional Assembly, if any. A total cumulated capacity of 90 MW has been earmarked for the present phase of this Scheme in the Mauritius. The maximum capacity of a project should not exceed 15 MW. The Scheme offers greater opportunity for electricity generation

business by allowing Public Sector Entities to engage in electricity production in the national green energy transition.

3.4 CEB Solar PV Scheme for Charging of Electric Vehicles

In line with its policy to shift towards cleaner energy and reduce carbon emissions, the Government of Mauritius has approved, in December 2020, the adoption of a 10-Year Electric Vehicle Integration Roadmap for Mauritius up to the year 2030, which enunciates measures to be taken to increase the uptake of EV in Mauritius. In the Budget Speech 2021/22, it was announced that "*to further promote demand for electric vehicles, owners will be allowed to install a PV system not exceeding 10 kW to charge their vehicles and export any surplus to the grid"*. Subsequently CEB has launched Schemes for Domestic, Commercial and Industrial Customers who are supplied with electricity via the CEB low-voltage network and have installed or intend to install an electric charger for four-wheel EVs namely, the CEB Solar PV Scheme for EV, the CEB Scheme for Corporate Entities EV Charging and the CEB Scheme for Service Providers Offering Public Charging of EVs Service.

Other CEB Customers can make application for RE installations for the purpose of generating electricity to charge electric vehicles under other current active Schemes (including MSDG RE Scheme, Public Sector Entities RE Scheme and Smart City RE Scheme). A total cumulated capacity of 10 MW has been initially allocated for charging of EVs. While the Schemes which operate under the gross metering method will enable the eligible Customers (also referred to as prospective Prosumers) to participate in renewable electricity generation using solar PV technology, it will also provide the Prosumers the opportunity to achieve net-zero carbon emission in the use of their EVs.

3.5 CEB Solar PV Scheme for Domestic Customers (Households)

The CEB Solar PV Scheme for Domestic Customers (Households) Scheme has been launched in November 2021 for a total cumulated capacity of 10 MW. The Scheme engages the Domestic Customers (households) by offering the opportunity to enhance electricity generation. The Scheme will operate under the gross metering method.

3.6 CEB Solar PV Scheme for Educational Institutions

The CEB Solar PV Scheme for Educational Institutions-Scheme which operates under the gross metering method was launched in December 2021 with a total capacity of 6 MW and caters for Government and Government Grant-Aided Private Educational institutions, willing to install a solar PV system. Out of the 6 MW, CEB expects to connect 5.5 MW of solar PV installations in the grid in Mauritius and 0.5 MW in Rodrigues. Under this Scheme, an eligible educational institution (a prospective Prosumer) will be allowed to interconnect a solar PV system in the CEB grid after the signing of a Connection Agreement, which will last for a period of twenty (20) years. In accordance with the Connection Agreement, the eligible educational institution will engage in electricity production for export to the CEB grid.

3.7 Purchase of Electrical Energy from Utility Scale Solar Photovoltaic Farms

The Purchase of Electrical Energy from Utility Scale Solar Photovoltaic Farms tender was launched by the CEB in July 2021. The purpose was to install utility scale solar PV projects in Mauritius with a net output capacity of 10 MWac. ESPAs have been signed with two successful bidders and the total capacity to be procured is 20 MWac.

3.8 Bioelectricity

A FEXTE Energie Convention was signed between MEPU, Agence Française de Développement (AFD) and l'Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) in March 2017 for the purpose of enhancing dialogue and sharing of experiences between the key stakeholders in the field of RE in Mauritius and Réunion. One of the studies conducted under Phase I consisted of the development of a strategy for the furtherance of bioelectricity in Mauritius. This study, conducted by CIRAD and MSIRI, entailed the mapping of biomass resources in Mauritius, a survey on abandoned lands and optimisation of existing biomass resources.

The Phase 2 of the study was carried out with the collaboration of AFD under the African Renewable Energy (ARE) Scale Up programme and the firm Nodalis was awarded the Consultancy Contract. The study consisted of formulating appropriate strategies to support the development of bioelectricity in Mauritius.

Moreover, National Biomass Framework, spearheaded by the Ministry of Agro-Industry and Food Security, is being elaborated to chart the way for the different sources of biomass in the country.

3.9 Consultancy services for the setting up of a 2 MW floating PV plant at Tamarind Falls Reservoir

MARENA, under the UNDP-GCF project, had engaged RINA Consultancy to conduct pre-feasibility study for the installation of a 2 MW power plant based on Floating Photovoltaics at Tamarind Falls Reservoir in Mauritius, as a pilot project. The CEB has invited proposals for consultancy services in September 2021 where the selected consultant would assist CEB in tender preparation, evaluation and also provide site supervisory services during project implementation phase. This pilot FPV plant, the first in Mauritius, is expected to be operational by August 2023.

3.10 Expression of Interest (EOI) for Provision of Consultancy Services required for conducting a feasibility study of ocean renewable energy technologies in the Republic of Mauritius

Mauritius has a vast Exclusive Economic Zone of 2.3 million square kilometres and a continental shelf of 396,000 square kilometres. The potential of marine/ocean renewables, which encompasses among the most common, offshore wind, tidal, wave, ocean currents and OTEC technologies, cannot be underrated.

In this context and as announced in the Budget Speech 2021/22 whereby *"a detailed feasibility study will be carried out for offshore wind"*, MARENA has launched an EOI for a feasibility study on ocean renewable energy technologies, including offshore wind, marine and tidal energy technologies. This EOI aimed to de-risk the ocean RE sector technologies by carrying out detailed techno-economic studies on the mentioned ocean RE technologies

and to diversify the energy mix. Marine renewables including offshore wind, and marine/tidal energy technologies are expected to enter the energy mix beyond 2025, and play an important role in reaching the 60% RE target.

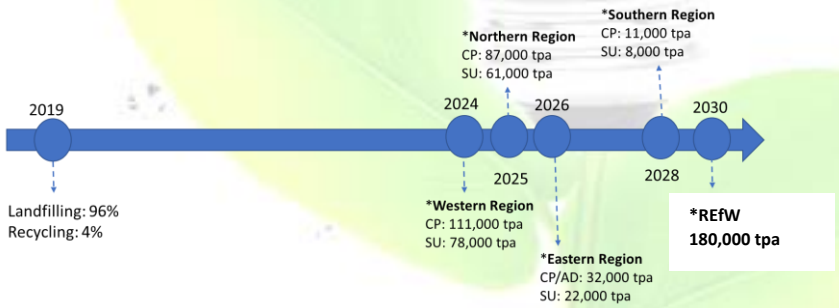
3.11 Renewable Energy (RE) from Waste (REfW).

Currently, the landfilling is the only method for waste management in Mauritius. The amount of waste disposed in the year 2020 at Mare Chicose which is the sole landfill in Mauritius has been around 509,000 tons per annum (tpa) and this amount is expected to increase in the coming years. Since 2011, landfill gas is being used to generate electricity through a plant with an effective capacity of 3 MW from which around 23 GWh of electricity was generated in 2020 [Source: Statistics Mauritius].

The Government Programme 2020-24 states that "*the development of the circular economy will also be given greater prominence by promoting the reduction, reusing and recycling culture and sustainable production, distribution, and consumption of goods and services".* This is expected to have a significant impact on the quality and quantity of waste in the short, medium and long term.

In its transition to a greener economy, MEPU will continue to work with the Ministry of Environment, Solid Waste Management and Climate Change to reconcile, in the most efficient and effective manner, both objectives of circular economy and greener energy. New technologies have emerged that produce energy while generating lesser and even zero carbon emissions. In line with the circular economy policy of the relevant Ministry, the RE Roadmap has proposed projects using "waste" for generation of energy in the 2029 timeline as it is considered that adequate preliminary assessment of the quantity and quality of waste is required. Notwithstanding same, ad-hoc and pilot projects involving waste may be considered in shorter time frame.

A rough estimate of the quantity of waste available for a RE from Waste (REfW) project has been provided by the Solid Waste Management Division as shown in Figure 8. A feasibility study will have to be carried out before the launching of an RFP for Renewable Energy from Waste.



CP: Composting SU: Recycling-sorting unit AD: Anaerobic Digestion tpa: tonnes per annum
REfW: Renewable Energy from Waste
Figure 8: Project Implementation Timeline for REfW
(Source: Solid Waste Management Division)

4.0 Review of RE Roadmap for The Electricity Sector 2030

The review of the RE Roadmap was carried out based on an analysis of the demand forecast and the forecasted projects. The first step includes the determination of baseline demand forecast. Table 2 shows the forecast figures of the energy demand and peak demand from 2022 to 2030. The demand forecast is subject for regular revision so as to capture the evolving market conditions.

Table 2: The electricity demand (GWh) and peak power (MW) from 2022 and 2030

Year	Energy (GWh) Demand			Peak Power (MW)		
	Low-case	Base-case	High-case	Low-case	Base-case	High-case
2022	2576	2660	2722	474	487	498
2023	2676	2787	2876	490	508	523
2024	2778	2910	3010	506	528	544
2025	2900	3076	3169	526	555	570
2026	3023	3138	3251	547	565	584
2027	3062	3199	3335	553	575	598
2028	3100	3261	3421	559	585	612
2029	3135	3322	3509	565	596	626
2030	3169	3384	3600	571	606	641

(Source: CEB)

Determination of Generated Energy Forecast

The energy sales forecast has to be adjusted with the following parameters to compute the total energy generation*:

a) Network Loss (both technical and non-technical losses);
b) CEB Power Plant Used on Works;
c) IPP Power Plants Auxiliary Consumptions – estimated from historical trends; and
d) CEB produces 45% and IPPs produce 55% of the total energy generated.

*A Network Loss of 6.5% and a CEB Power Plant Use on works of 3.5% have been assumed to determine the Generated Energy Forecast.

Figure 9 shows the conversion of energy generation to energy demand.
[2]

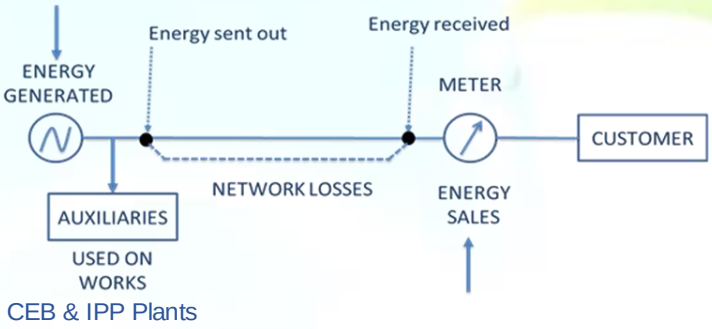


Figure 9: Conversion of energy generation to energy demand (Source, CEB)

Based on the above analysis, a RE forecast has been prepared and presented in Table 3. Table 3 shows the proposed scenario (base case) for meeting the RE target by 2030, taking into consideration the load duration curve, the grid infrastructure and the economic implications for meeting the 60% RE target by 2030.The low case and high case scenarios can be found at Annex 3.

[2] The IPP own consumption includes electrical energy exported to sugar mill during crop season for the processing of sugar.

RE forecast (Base Case)

Table 3: RE Forecast
(Source, CEB)

	Power Plants/Projects/Schemes	2022		2023		2024		2025		2026		2027		2028		2029		2030	
		GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW
In Operation	Hydro Generation	93	60	93	60	93	60	93	60	93	60	93	60	93	60	93	60	93	60
	PV Farms - Henrietta	5	3.1	16	10	16	10	16	10	16	10	16	10	16	10	16	10	16	10
	SSDG - Feed in Tariff	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3
	SSDG -Net Metering Schemes	7	5	7	5	7	5	7	5	7	5	7	5	7	5	7	5	7	5
	MSDG - Net Metering	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7
	Subtotal	**118**	78.1	**128.5**	85	**128.5**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85
SSDG Schemes Currently under Implementation	Home Solar Project	3	2	6	4	8	5.3	10	7	12	8	15	10	15	10	15	10	15	10
	Green Energy Scheme for SMEs	4	2.7	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4
	SSDG Net-Billing Schemes	1	0.6	5	3.1	8	5	8	5	8	5	8	5	8	5	8	5	8	5
	Religious Bodies	1	0.5	3	2	4.5	3	6	4	6	4	6	4	6	4	6	4	6	4
	Non-Governmental Instituition (NGOs) - 2 MW	1	0.5	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2
	Electric Vehicle (EV) Scheme (10 MW)	1	0.7	2	1.3	4.0	2.7	6	4	10	7	15	10	15	10	15	10	15	10
	SSDG Gross Metering Scheme (10 MW)	5	3.3	10	6.7	15	10	15	10	15	10	15	10	15	10	15	10	15	10
	Subtotal	**16**	10.3	**35**	23.1	**48.5**	32	**54**	36	**60**	40	**68**	45	**68**	45	**68**	45	**68**	45
MSDG Schemes Currently under Implementation	MSDG -Gross Metering	10	6.7	20	13.3	30	20	40	27	50	33	60	40	63	42	63	42	63	42
	MSDG Smart City Scheme	5	3.3	10	6.7	15	10	18	12	22	15	25	17	30	20	30	20	30	20
	MSDG Public Sector Entities Scheme	1.5	1	4.5	3.1	9	6.1	15	10	18	12	22	15	22	15	22	15	22	15
	Greenfield RE Public Sector Entity	0	0	0	0	45	30	60	40	90	60	125	83	135	90	135	90	135	90
	MSDG Educational Institutions	1	1	3	2	6	4	9	6	9	6	9	6	9	6	9	6	9	6
	Subtotal	**17.5**	11.7	**37.5**	25.1	**105**	70.1	**142**	95	**189**	126	**241**	161	**259**	173	**259**	173	**259**	173
IPP RE Projects in Operation	IPP Bagasse Generated [4]	350	129	350	129	350	129	350	129	350	129	100	37	0	0	0	0	0	0
	Cane Trash	8		8		8		13		13		0		0		0		0	
	Landfill Gas (Mare Chicose)	23	3	23	3	23	3	23	3	23	3	23	3	23	3	23	3	23	3
	EOLE Wind Farm	15	9	15	9	15	9	15	9	15	9	15	9	15	9	15	9	15	9
	Sarako PV Farm	22	15.7	22	15.7	21	15	21	15	21	15	21	15	21	15	21	15	21	15
	RFP Solar PV 5 x 2 MW (2012)	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6
	RFP Solar PV 10-15 MW (2016)	78	41	78	41	78	41	78	41	78	41	78	41	78	41	78	41	78	41
	RFP Solar PV 1-9 MW (2016)	25	14	25	14	25	14	25	14	25	14	25	14	25	14	25	14	25	14
Ongoing RE Project	RFP Solar PV 3 x10 MW (2021)	0	0	0	0	35	20	35	20	35	20	35	20	35	20	35	20	35	20
Planned New RE Projects	REHF Solar PV + Battery Energy Storage	0	0	0	0	150	50	300	100	300	100	300	100	300	100	300	100	300	100
	REHF Solar PV + Wind + Battery Energy storage	0	0	0	0	0	0	0	0	0	0	0	0	175	50	350	100	350	100
	Small Scale REHF	0	0	0	0	70	20	140	40	140	40	140	40	140	40	140	40	140	40
	Large Scale REHF Biomass	0	0	0	0	0	0	0	0	0	0	400	58	685	100	685	100	685	100
	Floating PV	0	0	2	2	3	2	3	2	32	17	32	17	60	32	60	32	60	32
	Offshore Wind Farm	0	0	0	0	0	0	0	0	60	20	60	20	60	20	150	50	150	50
	Renewable Energy from Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	10	75	10
	Marine Renewables (Wave and/or Tidal)	0	0	0	0	0	0	0	0	25	10	25	10	25	10	50	20	50	20
	Subtotal	**530**	**218**	**532**	**220**	**787**	**309**	**1012**	**379**	**1126**	**424**	**1263**	**390**	**1651**	**460**	**2016**	**560**	**2016**	**560**
Total		**681**	**318**	**733**	**353**	**1069**	**496**	**1337**	**594**	**1504**	**675**	**1701**	**681**	**2107**	**763**	**2472**	**863**	**2472**	**863**
Total Forecasted Annual Energy Generation (Base Case)		3102		3240		3369		3548		3621		3687		3754		3820		3886	
Total Expected Annual RE Generation		681		733		1069		1337		1504		1701		2107		2472		2472	
	Share of RE Generation	**21.9%**		**22.6%**		**31.7%**		**37.7%**		**41.5%**		**46.1%**		**56.1%**		**64.7%**		**63.6%**	[5]
	New Schemes																		
	On-going RE Projects - Only 2x10 MW Solar PV shall be commissioned																		
	Planned new RE Projects																		

Legends

GWh	Electrical Energy Generation capacity
MW	Production Capacity
SSDG	Small Scale Distributed Generation
MSDG	Medium Scale Distributed Generation
IPP	Independent Power Producer
RFP	Request for Proposal
REHF	Renewable Energy Hybrid Facilities
BESS	Battery Energy Storage System

- Sarako: The energy generation decreases over time with the degradation of the solar system
- Generation with cane trash at Year 2027 will be 0 GWh as Omnicane being the sole IPP producing electricity with bagasse will be in operation until 2027 as per-PPA signed
- FPV represents only two (2) GWh in 2023 and three (3) GWh in 2024 as the FPV plant is commissioned around mid-year hence representing only half of its annual energy generation
- For the solar PV Henrietta farm, the 8MW is expected to be commissioned by late 2022/early 2023, hence contributing fully towards the energy generation in year 2023
- In general, a timeline of two (2) years is the observed trend from the launching of procurement to completion of projects

As enunciated in the Budget Speech 2021/2022, the Government intends to phase out coal completely by horizon 2030 and achieve a target of 60% for RE in the energy mix. Consistent with this budget measure, the CEB revisited its power expansion plan with a view to harnessing firm power from Renewable Energy technologies so that peak power demand can be met along with meeting RE targets.

The replacement of coal by intermittent and non-firm renewable energy sources such as wind and solar remains a major challenge especially for an insular island where there are no interconnected networks. With a view to overcoming these limitations and taking into account declining cost in battery technologies, the CEB decided to combine both technologies to obtain a firm and stable power to the grid. To this end, the Request for Information exercise conducted in June 2021 to probe the market for potential suppliers who can supply such hybrid system with firm power output, has yielded interesting responses. The outcome of this exercise has paved the way for the development of power expansion inclusive of RE Hybrid Facilities (REHF) which would not only meet the power demand but also allow for the decarbonizing of the grid. Such REHF installations are quite common around the world. Subsequent to the RFI, relevant RFPs would be launched, the objective being to cover a wide range of RE technologies as well as providing an opportunity to all types of energy market players (small, medium and big) to participate in the competitive bidding exercise.

Finally, an analysis of the demand supply balance was carried out to ensure efficiency of system operation, with a view to circumventing any overcapacity.

In the first instance, CEB has launched RFP for Solar and battery storage and that of Small Scale REHF. These 2 RFPs shall allow for the addition of at least 140 MW of firm power into the generation park. Furthermore, the cost of solar PV technologies is most competitive among the targeted mature RE technologies under the hybrid system and was hence given priority deployment. With regard to the RFP on Biomass, same will be launched following finalisation of the National Biomass Framework, currently under preparation at the level of the Ministry of Agro-Industry and Food Security.

4.1 Violation check of the Load Duration Curve (LDC)

The LDC violation tests were undertaken for the low case, medium case and high case scenarios for the RE target 60% by 2030. The analysis of the LDC is subdivided into three loads, namely the base load, semi-base load and peak load. Typically for Mauritius, the peak load occurs for about 1000 hours, while the base load is the minimum load throughout the year. The difference between the peak load and base load gives the semi-base load (Figure 10).

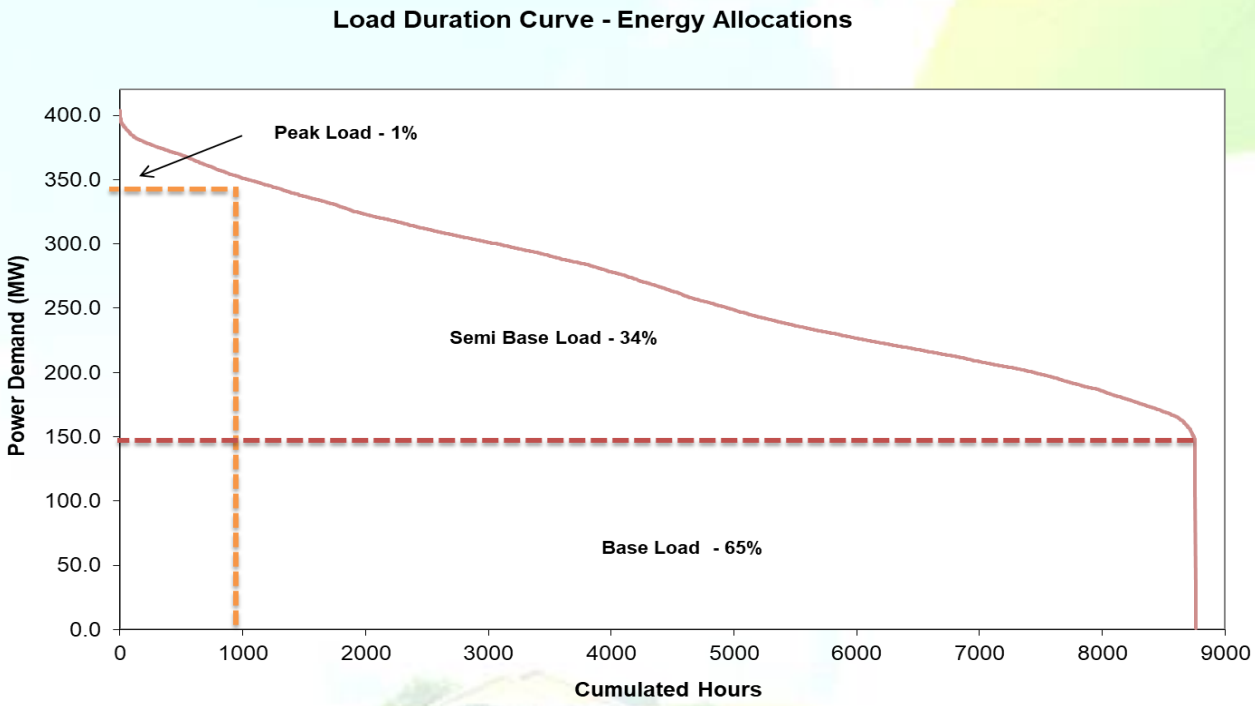


Figure 10: Typical Year Energy Allocation under Load Duration Curve
(Source: CEB)

The generation technology and fuel source which provide for each type of load is given in Table 4. In Mauritius, peak energy is about 1% of total energy, semi-base load is 34% and base load energy is 65%. As a first step in the LDC violation check, the generation technology/power plant which would contribute to the peak load, base load and semi-base load was allocated, based on CEB's dispatchability plans.

Table 4: Generation technology/power plant based on the load type

Load Type	Generation Technology/Power Plant
Base	Coal, bagasse, cane trash, RE hybrid facility – small and large scale, Onshore wind, Offshore wind, marine renewables (tidal/wave), Renewable Energy from Waste, Combined Cycle Gas Turbine, Fort George Power Station
Semi-Base	Solar, RE Hybrid Facility, Fort Victoria Power Plant, St Louis Power Plant
Peak	Nicolay Power Plant, Hydro Power Plant

(Source: CEB)

Following the allocation of the generation technology to the load type, the maximum energy for peak load, semi base load and base load was calculated. The total energy generated by the RE sources was then calculated and the remaining energy distributed among the fossil fuel-based power plants.

The LDC was not violated, in all three cases. The results of the LDC violation tests are given in Annex 4.

4.2 Investment Costs

Based on the RE forecast, the investment costs required have been calculated. The source of the information for solar utility and solar rooftop have been devised from survey of investment costs carried out by MARENA with local companies and promoters. The investments costs for onshore wind and offshore wind have also been

reviewed based on reports from IRENA, IEA and Lazard. The investment costs for the REHF have been obtained from CEB, based on the RFI findings.

For 2030, the investment costs for solar utility, rooftop and FPV have been calculated based on the projections of IRENA and IEA on the costs of these technologies. As such, investment costs for solar PV are expected to decrease by 58%, and offshore wind by 55% (IRENA, 2020). LCOE for solar PV has been obtained from the recent bids received by CEB, and the LCOE for FPV was obtained from the Consultancy report on the feasibility study for FPV in Mauritius by RINA.

4.2.1 Investment Required

Table 5 shows the investment required to meet the RE target of 60% by 2030.

Table 5: Investment required to reach 60% by 2030*

	2030					
Renewable Energy Technology	**Estimated LCOE (USD/MWh)[9]**	**CAPEX (USD/MW)**	**Actual Capacity (MW) 2020**	**Planned Installed Capacity in 2030 (MW)**	**Additional Capacity (MW)**	**Investment Costs (Million USD)***
Solar (Utility)	62-79	405,000	77	106	29	11.745
Solar (Rooftop)	84	564,000	19	233	214	120.696
Solar (Floating PV)	98	618,000	0	32	32	19.776
Onshore Wind	90-110	1,276,000	9.35	9.35	0	0
Offshore wind	85-100	1,986,000	0	50	50	99.3
Marine Renewables	150	5,720,000	0	20	20	114.4
Renewable Energy from Waste	90	4,810,000	0	10	10	48.1
REHF Solar+Battery storage	85-168	1,450,000	0	100	100	145
REHF Biomass	100-130	3,250,000	0	100	100	325
REHF Small Scale	85-168	5,000,000	0	40	40	200
REHF Solar+Wind+Battery storage	123-174	2,610,000	0	100	100	261
Total			**105.35**	**800.35**	**695**	**1,345**

In order to meet the RE target of 60% by 2030, an estimated USD 1345 M is required to be invested. This amounts to around MUR 59 billion. * *Conversion rate: (1 USD – 44.15 MUR)*

5.0 Socio-Economic Analysis of the 60% RE Target

Based on the RE forecast for 2030, a socio-economic analysis is undertaken to study the impacts of the addition of RE in the energy mix in terms of job creation, gross domestic product (GDP) and on the avoided carbon emissions.

The GDP used in the analysis was taken as USD 10.51 billion, as per Statistics Mauritius. The grid emission factor used was as per the Energy Observatory Report, 2020 published by the EEMO.

The socio-economic impacts of the following technologies were analysed using the socio-economic benefits tool developed by MARENA :

- Offshore wind
- Solar Energy
- REHF Biomass
- Renewable Energy from Waste
- Marine Renewables
- *REHF (Small Scale and Solar + Wind+ battery storage, REHF Solar and battery storage).

**It is to be noted that employment factor for REHF (Small Scale, Solar + Wind + battery storage, Solar and battery storage) was not available, and therefore, the employment factor used was assumed as solar and wind.*

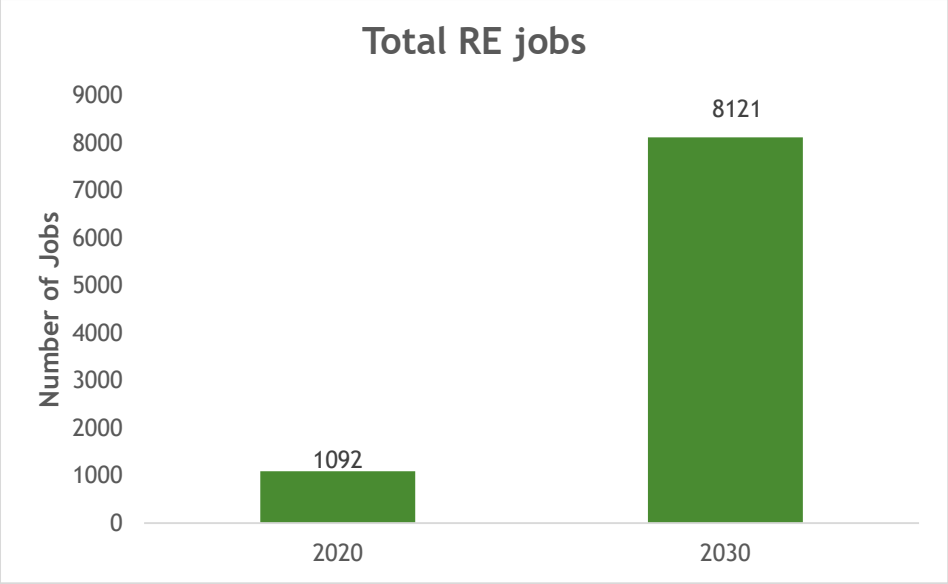


Figure 11: Number of jobs expected to be created by additional RE in 2030

Figure 11 shows that the number of jobs will increase considerably in 2030 due to addition of RE. Based on the socio-economic analysis, an estimated additional 7000 jobs would be generated by 2030.

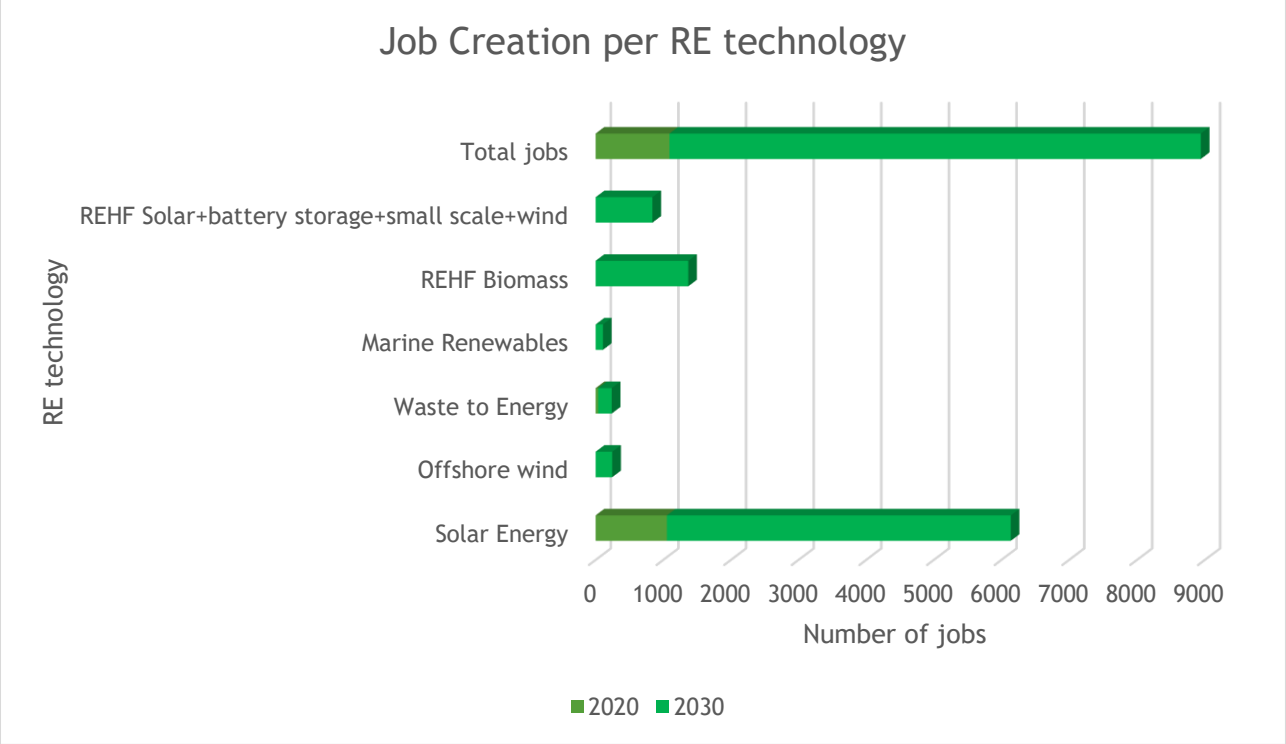


Figure 12: Number of jobs created by addition of RE by 2030

Figure 12 shows the number of jobs created by technology and it shows that the solar PV technology is expected to create about 60% of the total jobs in the RE sector.

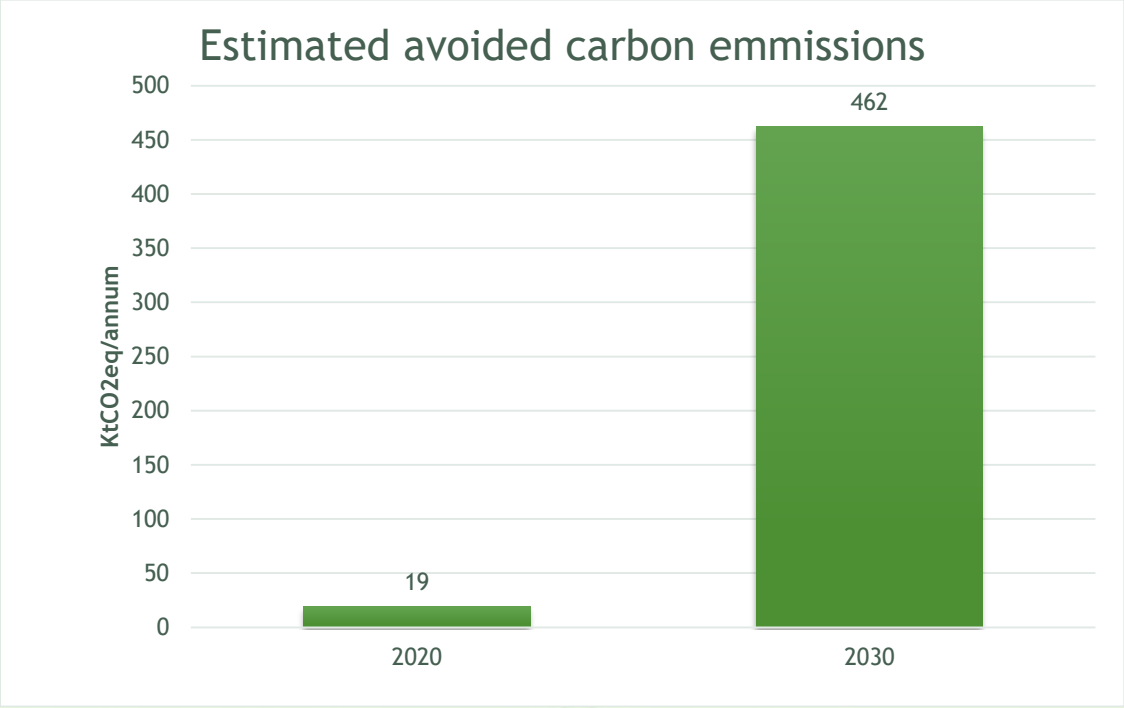


Figure 13: Avoided carbon emissions from addition of RE by 2030

Figure 13 shows the avoided carbon emissions based on the RE forecast in 2030. The avoided carbon emissions for 2020 will increase from around 19 ktCO2eq in 2020 to 462 ktCO2eq in 2030 as per the RE forecast in this review of the RE Roadmap. With the phasing out of coal by 2030, an additional estimated emission of 1400 ktCO2eq will be avoided in 2030. As per the Revised NDC to the United Nations Framework Convention on Climate Change, Ministry of Environment, Solid Waste Management and Climate Change, December 2021, Mauritius aims to reduce overall GHG emissions by 40% in 2030 compared to Business as Usual (BAU) (equivalent to around 2800 ktCO2eq of avoided emissions) for all sectors including energy sector. The electricity sector will, by 2030, contribute up to around 69% of this targeted avoided CO2eq emission.

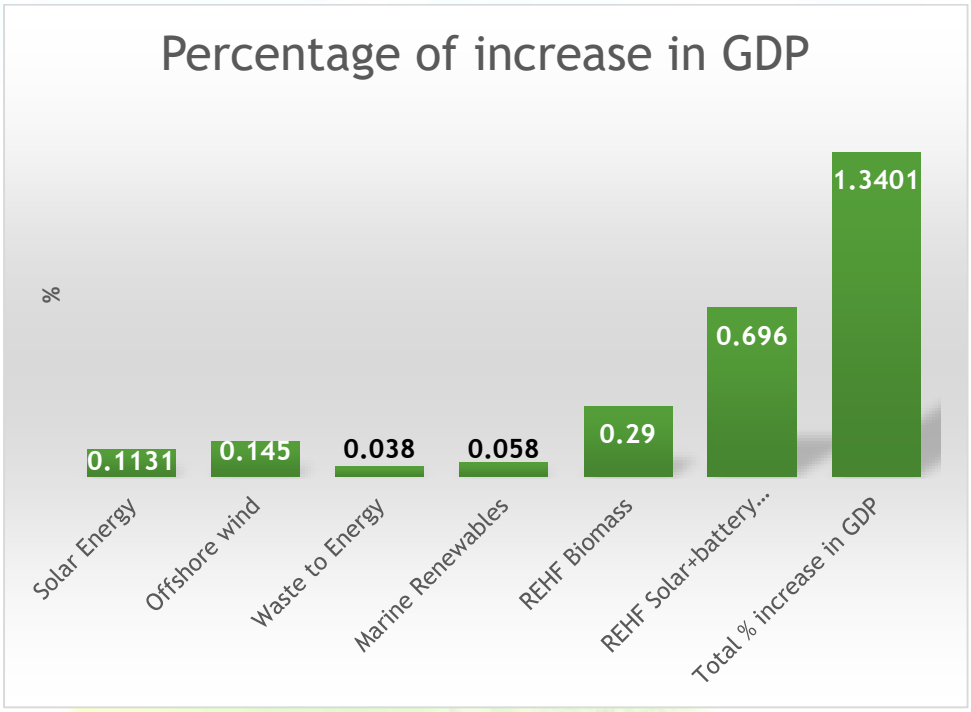


Figure 14: GDP increase due to addition of RE by 2030

From Figure 14, it can be seen that solar energy and REHF projects will contribute most to the increase of GDP by 2030. An expected 1.3% increase in the GDP is expected by 2030, confirming the Government's vision to make Green energy and economic pole of growth for Mauritius. The detailed workings of the socio-economic analysis can be found at Annex 5.

6.0 Grid Infrastructure Measures

RE, being intermittent in nature, may cause fluctuating power injection, which requires grid infrastructure reinforcements to keep the grid stable.

There are presently three (3) coal-bagasse and one dedicated coal power plants in the island thus aggregating a total installed capacity of 230 MW (effective capacity of 193 MW). The three coal-bagasse plants namely Terra, Alteo and Omnicane La Baraque generally operate on coal during the intercrop season, while Omnicane St Aubin (CTDS) operates all year round on coal. This capacity needs to be replaced with hybrid RE and/or biomass plants which will be able to meet the base energy requirement of presently around 1100 GWh.

The following measures are taken to stabilize the grid and mitigate the adverse impacts of variable RE technologies on grid stability.

6.1 Grid-Scale Battery Energy Storage Systems (BESS)

Under Component 2 of the UNDP-GCF project "*Accelerating the transformational shift to a low-carbon economy in the Republic of Mauritius"*, whereby CEB is the implementing Agency and UNDP the supporting Agency, funding has been received to install 18 MW of BESS in the country. Table 6 shows the location of the BESS installations:

Table 6: BESS installations in Mauritius

Location	Capacity (MW)
Amaury Sub-station	2
Henrietta Sub-Station	2
Jin-Fei Substation	4
Wooton Sub-station	4
La Tour Koening Substation	2
Anahita Substation	4
Total	18

(Source: CEB)

The 18 MW BESS will enable around 185 MW of RE in the grid by 2025. It is to be noted that as at 2018, only 34 MW of RE was integrated to the grid. With the operationalisation of the 18 MW BESS, they are contributing to a larger share of intermittent RE on the grid, with 115.5 MW in August 2021.

This high-tech, latest technology and ultra-fast response BESS is the first of a series of upgrades to the electricity grid in order to achieve a smarter, more modern and cleaner electricity network in Mauritius. The battery systems will allow more renewable energy, which are typically of intermittent nature such as solar and wind, to be on-boarded onto the national grid by carrying out the crucial role of helping to stabilize the frequency of electricity supply to customers. In so doing, the BESS will help to reduce what is known as the Grid Emission Factor (GEF) of the CEB grid to bring it more at par with the cleaner electricity networks in modern countries. As such, the key objective of the CEB with the installation of grid-tied BESS is to strengthen its grid in terms of frequency regulation to support the integration of variable renewable energy projects with its fast reaction time. In addition, the installation has two other functionalities which can be activated if need be. The two functionalities are voltage control and manual dispatch similar to that of a conventional generating unit.

In the Budget Speech 2021/22, it was also announced that the "*absorption capacity of intermittent RE will be raised by tenfold through increased battery capacity to some 40 MW*". In light with the above, CEB launched an invitation for bids for the "*design, manufacture, supply, installation testing and commissioning of a 20 MW BESS*" in October 2021. The site for the 20 MW BESS of Lithium-Ion technology is to be located at Amaury. The primary function of the BESS shall be to provide peak shaving capability to contribute in meeting the evening peak demand on the national grid. In addition, the BESS shall have functions of frequency regulation, voltage regulation, automatic charging mode, stand-by mode and black start. The BESS will also be used to support the integration of variable renewable generation systems through frequency regulation.

6.2 Modernization and Upgrading of the Grid

6.2.1 Sub-Stations

The CEB is shifting from the traditional Air Insulated Switchgear (AIS) substations to indoor Gas Insulated Switchgear Substations (GIS) equipped with the latest smart technologies. Unlike AIS substation, an indoor GIS substation has a smaller footprint and is more resistant to adverse climatic conditions. The CEB will construct four new GIS substations (L'Avenir, Cote D'Or, Airport, Rose Belle) and replace six AIS substations by GIS Substations (Chaumiere, Belle Vue, Henrietta, Wotton, Ebene, Fuel) in order to further increase the reliability of its grid and the number of injection points for RE generating facilities.

6.2.2 Smartening of the Grid

With the assistance of a consultant, and as part of the Global Environment Facility (GEF) project "*Removing Barriers to Solar Photovoltaic Power Generation in Mauritius, Rodrigues and the Outer Islands*", the CEB has developed a roadmap for a smart grid in Mauritius. Currently, the CEB is focusing on key technologies such as an advanced energy and distribution management system, and automated distribution feeder and metering infrastructure, identified for the Smart Grid programme.

With the integration of more and more variable RE in the energy mix of Mauritius, it has become necessary to match continuously the total power generation with the load demand, and maintain the frequency within safe operating limits in order to ensure power quality and safe grid operation. In that respect, Phasor Measurement Units (PMUs) were installed at five locations (Fort George, Belle Vue, FUEL, Henrietta and Combo substations) together with WAMS software to collect continuously real-time and historical information on the dynamic performance of the power system. The implementation of an Automatic Generation Control (AGC) system at the System Control Centre ia also in progress. The AGC modelling has been completed for the St Louis G10-G13 generating units and the Fort Victoria G1-G6 generating units. It is planned to proceed with the AGC tuning phase for the above-mentioned generating units as the next step. (Source: Annual Report of CEB, 2019-2020).

7.0 Economic Measures/Incentives

The RE sector is an expensive field to invest in, and in order to attract investors in the field, a series of economic incentives/measures have been taken by the Government of Mauritius to promote this sector. Figure 15 shows some of the salient economic measures/incentives taken for moving forward the RE sector.

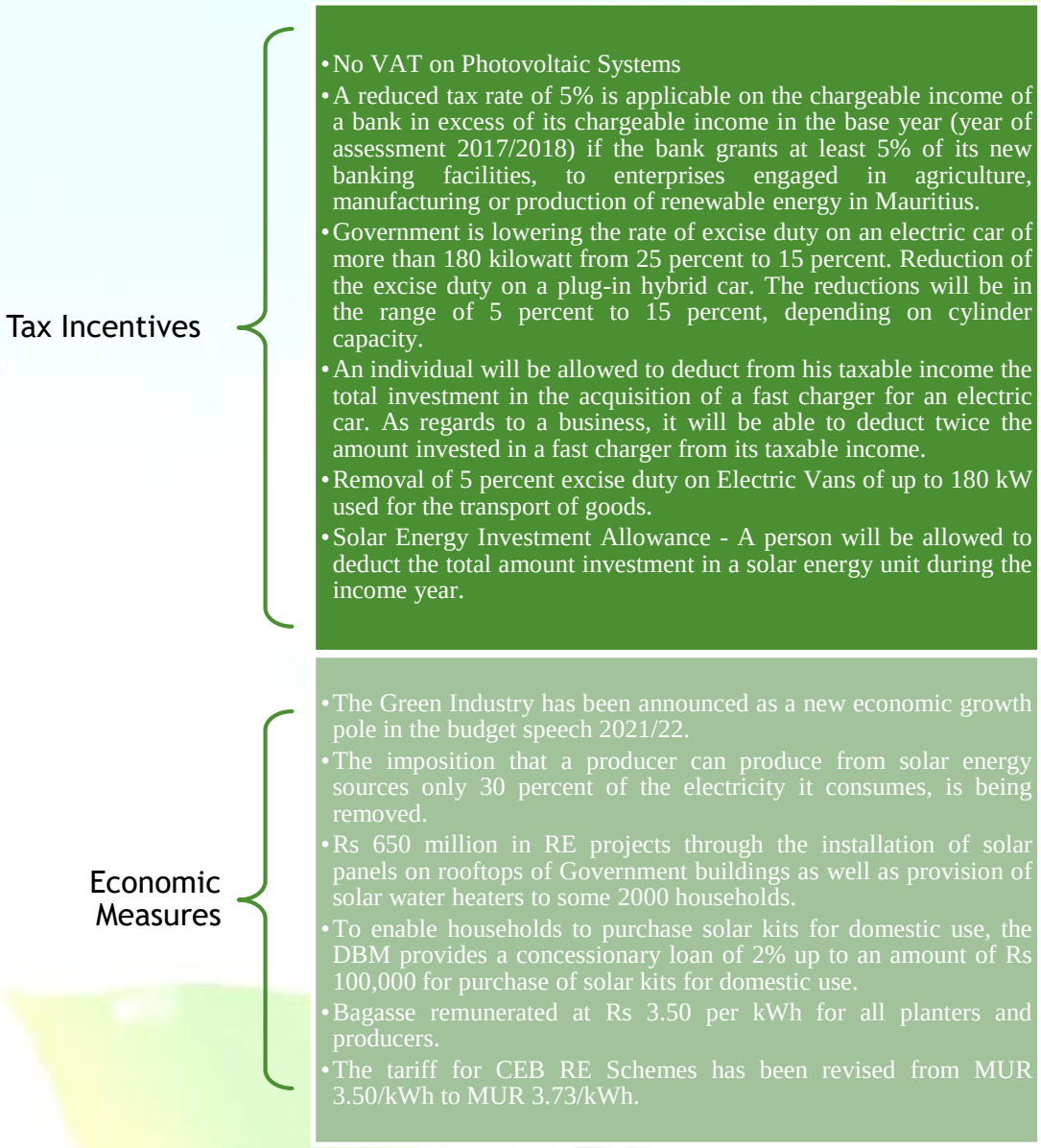


Figure 15: Tax incentives and economic measures for RE (Budget Speeches 2015-2021)

8.0 Outlook

This review of the RE Roadmap follows the announcement of an acceleration of RE target to 60% of renewables in the electricity mix by 2030. The document will stand to be revised whenever required given the dynamic nature of RE technologies. Furthermore, the Government of Mauritius is seeking the assistance of IRENA to prepare an Integral Energy Roadmap which will encompasses energy, transport and energy efficiency.

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- The LCOE of REHF varies depending on the percentage mix of the RE sources in the hybrid system and the capacity of battery storage allotted to the system.

ANNEX 1: LOW CASE and HIGH CASE RE FORECASTS

Table 7: Low case scenario
(Source: CEB)

		2022		2023		2024		2025		2026		2027		2028		2029		2030	
	Power Plants/Projects/Schemes	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**
In Operation	Hydro Generation	93	60	93	60	93	60	93	60	93	60	93	60	93	60	93	60	93	60
	PV Farms - Henrietta	5	3	16	10	16	10	16	10	16	10	16	10	16	10	16	10	16	10
	SSDG - Feed in Tariff	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3
	SSDG -Net Metering Schemes	7	5	7	5	7	5	7	5	7	5	7	5	7	5	7	5	7	5
	MSDG - Net Metering	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7
	Subtotal	**118**	78	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85
SSDG Schemes Currently under Implementation	Home Solar Project	3	2	6	4	8	5	10	7	12	8	15	10	15	10	15	10	15	10
	Green Energy Scheme for SMEs	4	3	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4
	SSDG Net-Billing Schemes	1	1	5	3	8	5	8	5	8	5	8	5	8	5	8	5	8	5
	Religious Bodies	1	1	3	2	5	3	6	4	6	4	6	4	6	4	6	4	6	4
	Non-Governmental Instituition (NGOs) - 2 MW	1	1	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2
	Electric Vehicle (EV) Scheme (10 MW)	1	1	2	1	4	3	6	4	10	7	15	10	15	10	15	10	15	10
	SSDG Gross Metering Scheme (10 MW)	5	3	10	7	15	10	15	10	15	10	15	10	15	10	15	10	15	10
	Subtotal	**16**	10	**35**	23	**49**	32	**54**	36	**60**	40	**68**	45	**68**	45	**68**	45	**68**	45
MSDG Schemes Currently under Implementation	MSDG -Gross Metering	10	7	20	13	30	20	40	27	50	33	60	40	63	42	63	42	63	42
	MSDG Smart City Scheme	5	3	10	7	15	10	18	12	22	15	25	17	30	20	30	20	30	20
	MSDG Public Sector Entities Scheme	1.5	1	4.5	3	9	6	15	10	18	12	22	15	22	15	22	15	22	15
	Greenfield RE Public Sector Entity	0	0	0	0	45	30	60	40	90	60	125	83	135	90	135	90	135	90
	MSDG Educational Institutions	1	1	3	2	6	4	9	6	9	6	9	6	9	6	9	6	9	6
	Subtotal	**17.5**	12	**37.5**	25	**105**	70	**142**	95	**189**	126	**241**	161	**259**	173	**259**	173	**259**	173
IPP RE Projects in Operation	IPP Bagasse Generated	350	129	350	129	350	129	350	129	350	129	100	37	0	0	0	0	0	0
	Cane Trash	8		8		8		13		13		0		0	0	0	0	0	0
	Landfill Gas (Mare Chicose)	23	3	23	3	23	3	23	3	23	3	23	3	23	3	23	3	23	3
	EOLE Wind Farm	15	9	15	9	15	9	15	9	15	9	15	9	15	9	15	9	15	9
	Sarako PV Farm	22	16	22	16	21	15	21	15	21	15	21	15	21	15	21	15	21	15
	RFP Solar PV 5 x 2 MW (2012)	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6
	RFP Solar PV 10-15 MW (2016)	78	41	78	41	78	41	78	41	78	41	78	41	78	41	78	41	78	41
	RFP Solar PV 1-9 MW (2016)	25	14	25	14	25	14	25	14	25	14	25	14	25	14	25	14	25	14
Ongoing RE Project	RFP Solar PV 3 x10 MW (2021)	0	0	0	0	35	20	35	20	35	20	35	20	35	20	35	20	35	20
Planned New RE Projects	REHF Solar PV + BESS	0	0	0	0	150	50	300	100	300	100	300	100	300	100	300	100	300	100
	REHF Solar PV + Wind + BESS	0	0	0	0	0	0	0	0	0	0	0	0	175	50	350	100	350	100
	Small Scale REHF	0	0	0	0	70	20	140	40	140	40	140	40	140	40	140	40	140	40
	Large Scale REHF Biomass	0	0	0	0	0	0	0	0	0	0	400	58	685	100	685	100	685	100
	Floating PV	0	0	2	2	3	2	3	2	32	17	32	17	60	32	60	32	60	32
	Offshore Wind Farm	0	0	0	0	0	0	0	0	60	20	60	20	60	20	150	50	150	50
	Renewable Energy from Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	10	75	10
	Marine Renewables (Wave and/or Tidal)	0	0	0	0	0	0	0	0	25	10	25	10	25	10	50	20	50	20
	Subtotal	**530**	**218**	**532**	**220**	**787**	**309**	**1012**	**379**	**1126**	**424**	**1263**	**390**	**1651**	**460**	**2016**	**560**	**2016**	**560**
Total RE Generated (GWh)		**681**	**317**	**733**	**353**	**1069**	**496**	**1337**	**594**	**1504**	**675**	**1701**	**681**	**2107**	**763**	**2472**	**863**	**2472**	**863**
Total Forecasted Annual Energy Generation (Base Case)		3004		3111		3217		3345		3488		3529		3569		3605		3640	
Total Expected Annual RE Generation		681		733		1069		1337		1504		1701		2107		2472		2472	
Share of RE Generation		**22.7%**		**23.6%**		**33.2%**		**40.0%**		**43.1%**		**48.2%**		**59.0%**		**68.6%**		**67.9%**	

New Schemes
On-going RE Projects - Only 2x10 Solar PV shall be commissioned.
Planned new RE Projects

Legends

GWh	Electrical Energy Generation capacity
MW	Production Capacity
SSDG	Small Scale Distributed Generation
MSDG	Medium Scale Distributed Generation
IPP	Independent Power Producer
RFP	Request for Proposal
REHF	Renewable Energy Hybrid Facilities
BESS	Battery Energy Storage System

Table 8: High Case Scenario

		2022		2023		2024		2025		2026		2027		2028		2029		2030	
	Power Plants/Projects/Schemes	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**
In Operation	Hydro Generation	93	60	93	60	93	60	93	60	93	60	93	60	93	60	93	60	93	60
	PV Farms - Henrietta	5	3	16	10	16	10	16	10	16	10	16	10	16	10	16	10	16	10
	SSDG - Feed in Tariff	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3
	SSDG -Net Metering Schemes	7	5	7	5	7	5	7	5	7	5	7	5	7	5	7	5	7	5
	MSDG - Net Metering	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7
	Subtotal	**118**	78	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85	**129**	85
SSDG Schemes Currently under Implementation	Home Solar Project	3	2	6	4	8	5	10	7	12	8	15	10	15	10	15	10	15	10
	Green Energy Scheme for SMEs	4	3	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4
	SSDG Net-Billing Schemes	1	1	5	3	8	5	8	5	8	5	8	5	8	5	8	5	8	5
	Religious Bodies	1	1	3	2	5	3	6	4	6	4	6	4	6	4	6	4	6	4
	Non-Governmental Instiiution (NGOs) - 2 MW	1	1	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2
	Electric Vehicle (EV) Scheme (10 MW)	1	1	2	1	4	3	6	4	10	7	15	10	15	10	15	10	15	10
	SSDG Gross Metering Scheme (10 MW)	5	3	10	7	15	10	15	10	15	10	15	10	15	10	15	10	15	10
	Subtotal	**16**	10	**35**	23	**49**	32	**54**	36	**60**	40	**68**	45	**68**	45	**68**	45	**68**	45
MSDG Schemes Currently under Implementation	MSDG -Gross Metering	10	7	20	13	30	20	40	27	50	33	60	40	63	42	63	42	63	42
	MSDG Smart City Scheme	5	3	10	7	15	10	18	12	22	15	25	17	30	20	30	20	30	20
	MSDG Public Sector Entities Scheme	1.5	1	4.5	3	9	6	15	10	18	12	22	15	22	15	22	15	22	15
	Greenfield RE Public Sector Entity	0	0	0	0	45	30	60	40	90	60	125	83	135	90	135	90	135	90
	MSDG Educational Institutions	1	1	3	2	6	4	9	6	9	6	9	6	9	6	9	6	9	6
	Subtotal	**17.5**	12	**37.5**	25	**105**	70	**142**	95	**189**	126	**241**	161	**259**	173	**259**	173	**259**	173
IPP RE Projects in Operation	IPP Bagasse Generated	350	129	350	129	350	129	350	129	350	129	100	37	0	0	0	0	0	0
	Cane Trash	8		8		8		13		13		0		0	0	0	0	0	0
	Landfill Gas (Mare Chicose)	23	3	23	3	23	3	23	3	23	3	23	3	23	3	23	3	23	3
	EOLE Wind Farm	15	9	15	9	15	9	15	9	15	9	15	9	15	9	15	9	15	9
	Sarako PV Farm	22	16	22	16	21	15	21	15	21	15	21	15	21	15	21	15	21	15
	RFP Solar PV 5 x 2 MW (2012)	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6
	RFP Solar PV 10-15 MW (2016)	78	41	78	41	78	41	78	41	78	41	78	41	78	41	78	41	78	41
	RFP Solar PV 1-9 MW (2016)	25	14	25	14	25	14	25	14	25	14	25	14	25	14	25	14	25	14
Ongoing RE Project	RFP Solar PV 3 x10 MW (2021)	0	0	0	0	35	20	35	20	35	20	35	20	35	20	35	20	35	20
Planned New RE Projects	REHF Solar PV + BESS	0	0	0	0	150	50	300	100	300	100	300	100	300	100	300	100	300	100
	REHF Solar PV + Wind + BESS	0	0	0	0	0	0	0	0	0	0	0	0	175	50	350	100	350	100
	Small Scale REHF	0	0	0	0	70	20	140	40	140	40	140	40	140	40	140	40	140	40
	Large Scale REHF Biomass	0	0	0	0	0	0	0	0	0	0	400	58	685	100	685	100	685	100
	Floating PV	0	0	2	2	3	2	3	2	40	22	40	22	75	42	75	42	75	42
	Offshore Wind Farm	0	0	0	0	0	0	0	0	60	20	60	20	60	20	150	50	150	50
	Renewable Energy from Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	10	75	10
	Marine Renewables (Wave and/or Tidal)	0	0	0	0	0	0	0	0	25	10	25	10	25	10	50	20	50	20
	Subtotal	**530**	**218**	**532**	**220**	**787**	**309**	**1012**	**379**	**1134**	**429**	**1271**	**396**	**1666**	**470**	**2031**	**570**	**2031**	**570**
Total RE Generated (GWh)		**681**	**317**	**733**	**353**	**1069**	**496**	**1337**	**594**	**1512**	**680**	**1709**	**687**	**2122**	**773**	**2487**	**873**	**2487**	**873**
Total Forecasted Annual Energy Generation (Base Case)		3175		3343		3485		3655		3751		3843		3939		4035		4135	
Total Expected Annual RE Generation		681		733		1069		1337		1512		1709		2122		2487		2487	
Share of RE Generation		**21.4%**		**21.9%**		**30.7%**		**36.6%**		**40.3%**		**44.5%**		**53.9%**		**61.6%**		**60.1%**	

ANNEX 2: VIOLATION CHECK OF LDC

Table 9: LDC Violation Test for 2030 target

	Year 2030			
	Actual	**Low Case**	**Base Case**	**High Case**
PEAK				
Nicolay Power Station (GWh)	5	11.4	13.86	16.35
Hydro (GWh)	25	25	25	25
Total (Energy Generation) (GWh)	30	36.4	38.86	41.35
Maximum energy for peak (GWh)	30	36.4	38.86	41.35
SEMI-BASE				
Solar (GWh)	160	591	591	606
REHF Solar+Battery storage (GWh)	0	300	300	300
Total Energy generated by RE (GWh)	160	891	891	906
Fort Victoria (GWh)	383	190.63	193.6	225
St Louis (GWh)	468	155.97	236.6	275
Total (Energy Generation) (GWh)	1010	1237.6	1321.2	1405.9
Max Energy for Semi-Base (GWh)	1010	1237.6	1321.24	1405.9
BASE				
Hydro (GWh)	68	68	68	68
Biomass-Bagasse (GWh)	430	0	0	0
Biomass-Cane Trash (GWh)	8	0.0	0	0
REHF (Solar+Wind+battery storage) (GWh)	0	350	350	350
Small Scale REHF (GWh)	0	140	140	140
Large Scale REHF-Biomass (GWh)	0	685	685	685
Onshore Wind (GWh)	15	15	15	15
Offshore Wind (GWh)	0	150	150	150
Marine Renewables (tidal/wave energy) (GWh)	0	50	50	50
Landfill gas (GWh)	23	23	23	23
WtE (GWh)	0	75	75	75
Total Energy generated by RE (GWh)	544	1556	1556	1556
Coal (GWh)	800	0	0	0
Fort George/CCGT (GWh)	587	810	969.9	1132
Total (Energy Generation) (GWh)	1932	2366	2525.9	2687.8
Max Energy for Base (GWh)	1932	2366	2525.9	2687.75
Total Energy demand forecast (GWh)	2971	3640	3886	4135
% Renewables	24.5	67.9	63.6	60.1
% Non-renewables	75.5	32.1	36.4	39.9

ANNEX 3: SOCIO-ECONOMIC ANALYSIS WORKINGS

Table 10: Socio-economic analysis of the different RE technologies of the 60% RE target by 2030

Renewable Energy Technology		Existing	Projected 2030
Solar Energy	Capacity (MW)	77	371
	Construction and Installation	1001	4823
	Operation and Maintenance	54	260
	Potential % in GDP		0.1131
	Carbon dioxide avoided per annum (tonne CO2)	11018.7	56629.4
	Cost saved from carbon price/year (USD)	110187	566294
		Existing	**Projected 2030**
Offshore Wind	Capacity (MW)	0	50
	Construction and Installation	0	400
	Operation and Maintenance	0	10
	Potential % in GDP	0	0.145
	Carbon dioxide avoided per annum (tonne CO2)	0	14310
	Cost saved from carbon price/year (USD)	0	143100
		Existing	**Projected 2030**
Renewable Energy from Waste	Capacity (MW)	3	13
	Construction and Installation	32	182
	Operation and Maintenance	5	20
	Potential % in GDP	0	0.038
	Carbon dioxide avoided per annum (tonne CO2)	8543	9301
	Cost saved from carbon price/year (USD)	85430	93015
		Existing	**Projected 2030**
Marine renewables (tidal/wave)	Capacity (MW)	0	20
	Construction and Installation	0	204
	Operation and Maintenance	0	12
	Potential % in GDP	0	0.058
	Carbon dioxide avoided per annum (tonne CO2)	0	55156.5
	Cost saved from carbon price/year (USD)	0	551564.6
		Existing	**Projected 2030**
REHF (Biomass)	Capacity (MW)	0	100
	Construction and Installation	0	1300
	Operation and Maintenance	0	70
	Potential % in GDP	0	0.29
	Carbon dioxide avoided per annum (tonne CO2)	0	71550
	Cost saved from carbon price/year (USD)	0	715500
		Existing	**Projected 2030**
REHF (Small Scale and Solar, wind, wave, Solar and battery storage)	Capacity (MW)	0	240
	Construction and Installation	0	768
	Operation and Maintenance	0	72
	Potential % in GDP	0	0.696
	Carbon dioxide avoided per annum (tonne CO2)	0	80136
	Cost saved from carbon price/year (USD)	0	801360

(Source: MARENA)

STATUS UPDATE FROM 2019 TO 2021 IN TERMS OF RE

In terms of electricity generation, a status is presented from 2019 to 2021.

ELECTRICITY GENERATION

Table 11: Electricity generation (GWh) from different energy sources from 2019 till 2021

	2019 (GWh)	2020 (GWh)	2021 (GWh)
Electricity generated	3237	2882	2844[i]
Electricity generated from coal	1174	1138	1130
Electricity generated from fuel oil and diesel	1349	1056	1052
Electricity generated from renewable sources	702	688	540
Landfill gas	20	25	19
Hydro	99	116	107
Wind	15	18	12.5
Bagasse	440	384	361[ii]
PV	129	146	161[iii]

(Sources: Statistics Mauritius, MEPU and CEB)

[i] Provisional data from CEB: 2722 GWh; Provisional data from MEPU: Own consumption of IPP estimated at 121.7 GWh

[ii] Provisional data from CEB: 251 GWh; Provisional data from MEPU: Own consumption of IPP estimated at 110 GWh

[iii] Provisional data from CEB: 151 GWh; Provisional data from MEPU: Own consumption of IPP estimated at 10 GWh

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Central Electricity Board
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