National Biomass Framework

Potential Sources & Recommendations

MAURITIUS CANE INDUSTRY AUTHORITY

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MCIA
Mauritius Cane Industry Authority

CONTENTS

EXECUTIVE SUMMARY

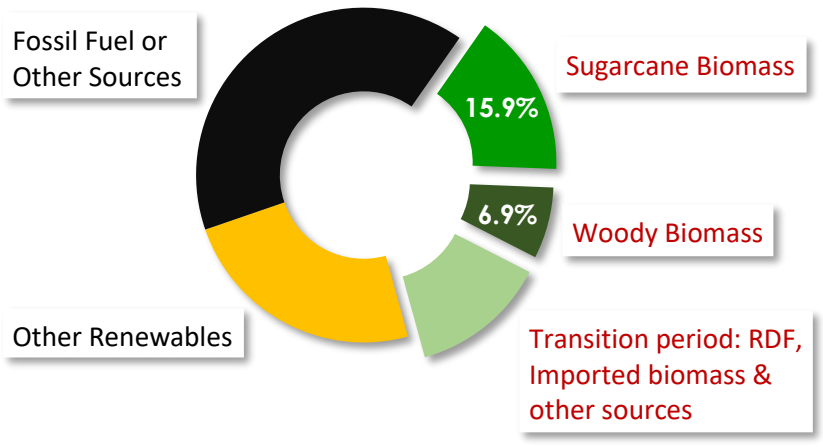
The Framework Implementation Committee (FIC), through three working groups, has investigated into the potential, opportunities, pricing of sugarcane (bagasse and trash) and woody biomasses (forest, plantations, domestic & industrial woody wastes) respectively.

With a production of 3.8 M t of sugarcane by 2030, the net electricity export will be some 538 GWh. Coupled with 235 GWh generated from woody biomasses, the net electricity export from local biomasses will reach 773 GWh in 2030; representing 22.8% of the island's electricity mix, and equivalent to 491 000 t of coal displaced (worth USD 61 M based on an average price of USD 125/t prior December 2021).

❑ Bioelectricity Production from Biomass

	Short-Term			Medium-Term	
	2023	2024	2025	2026	2030
Cane to be Harvested Area (ha)	40 200	42 000	42 000	42 600	45 000
Cane Total (million t)	2.7	3.0	3.2	3.4	3.8
Electricity Sugarcane (GWh)	266	302	450	486	538
Electricity Woody (GWh)	20	41	137	168	235
Electricity Local Biomass (GWh)	286	343	587	654	773

❑ Electricity Mix in Mauritius by 2030



With electricity generation from sugarcane and woody biomass sources totalling 773 GWh in 2030, there will be a positive impact on the avoided CO_2 by keeping the level of its emission at 18% despite significantly higher electricity demand. Furthermore, the planting of additional trees would increase the carbon sequestration potential.

❑ Sugarcane Lands

- The amount of electricity exported to the National grid from bagasse has declined from 381 GWh in 2015 to 246 GWh in 2021, due to a significant decrease in cane production resulting from both land abandonment and a loss in productivity.
- To sustain current efforts being deployed to rehabilitate abandoned sugarcane lands, it is proposed to revisit the regulations for land conversion with the objective to '**Lock**' all lands under sugarcane production (45 000 ha).
- Loss in productivity is mainly due to a higher ratio of ratoon crops older than seven years. A **Cane Replantation Scheme** amounting to Rs 200 M, annually over six years as a low-interest loan and renewable after seven years, is proposed. It will be operated as a revolving fund. The beneficiaries will be the Large and Corporate Growers. A crop cycle of seven years will be instated.
- Capital investment in a more efficient power plant at Alteo will increase electricity production from 77 to 125 kWh/t cane, representing a gain of 65 GWh.
- The collection of sugarcane trash on 60% of the area harvested mechanically over the island will generate 65 GWh per year as from 2026. The additional investment by the private sector is around Rs 300 M.
- The installation of bagasse dryers in all Power Plants will boost electricity production by 25 GWh per year as from 2025. Grants and Green loans for private investments should be assured. The estimated cost is USD 5.8 M per system according to the IPP's.
- A **Biomass Land Rehabilitation Scheme**, requiring a low interest loan of MUR 150 M, annually for four years is proposed to convert back an additional 2 400 ha under sugarcane production.
- An increase of the budget under the existing "**Accompanying Measures to restore Abandoned Cane Lands (ALMS Scheme)**" to Rs 100 M, annually over five years to cater for derocking, road mending, land preparation, and replanting is proposed. This scheme targets Small and Medium Growers.
- Some 3 500 ha of marginal lands with very low sugarcane yields have been identified for conversion into wood plantation (Eucalyptus or alternative specie) which will generate 50 GWh/yr of electricity by 2030. An **Afforestation Scheme**, with a low-interest loan of Rs 150,000/ha for biomass production on ex-sugarcane lands is proposed.

- A grant of Rs 20 M during the first two years, to finance R&D, analyses, and capacity building on woody biomass is proposed.
- In line with the recommendations from the World Bank report, an **Electricity/Irrigation Network Improvement grant** of Rs 50 M, annually over six years is proposed to cater for technology improvement and electricity use for the irrigation of cane fields.

❑ Forest Lands

- State forest lands are an important source of biomass, with an electricity potential of 100 GWh per year. Lease agreements for hunting purposes need to be reviewed
- The collection of biomass (invasive species) from the National Parks on 2 000 ha can add another 5 GWh.
- Private forests, 25 000 ha represent a significant source of biomass; the owners need to be identified and taken on board to produce biomass. Any potential of producing and collecting biomass for bioelectricity production in Rodrigues Island will similarly be assessed.

❑ Woody Wastes

- Two new 'Filières' have been identified for the collection of woody wastes from domestic and industrial sources. Development of SMEs for such collection is being recommended as well as the extension of wood processing and storage plants in different regions. Loan facilities with low-interest rates to purchase equipment for wood chipping stations, Rs 30 M, annually for four years is proposed for the SMEs. If properly executed, some 80 GWh of electricity can be produced.
- The Solid Waste Management Division of the Ministry of Environment has worked on the feasibility study for the setting up of a regional composting and waste sorting plants and a Residue Derived Fuel (RDF) production plant (termed an Integrated Waste Processing Facility-IWPF). This has the potential to produce an additional 25 GWh of electricity in replacement of coal.

❑ Proposed Price of Bagasse, Cane Trash, and Local Wood Chips

- All prices were at the gate of a power plant and included all downstream costs from production to delivery at the power plant gate.
- The price for bagasse is maintained at Rs 3.50/kWh.
- With amendments brought to the SIE Act concerned with repeal of the Bagasse Transfer Price, there is a quid pro quo sort of arrangement for the IPP's to relinquish the BTP share in exchange of millers benefiting the Rs 3.50/kWh.

- Following views expressed by Ministry of Finance, it was agreed that price of bagasse is a budget measure and need not be regulated.
- Following further discussions there was an agreement in principle that the price of trash and wood would be kept at par with bagasse, that is Rs 3.50/kWh as trash is mixed with bagasse and burnt in the same boiler and it is not possible to distinguish between trash energy and bagasse energy. **Any additional green premium on top of the Rs 3.50/kWh would be a policy decision**.

    - For baled trash from mechanically harvested cane, the value at the IPP gate (Rs 3.50/kWh) will be Rs 3,175/t (Moisture ~15% to 20%) or Rs 2,888 (Moisture >20% to 25%).
    - Planters' revenue (trash owner) will equal the above minus collection and transport cost, estimated to range between Rs 1,708 – Rs 2,155/t. Hence, net revenue will range between Rs 733/t (Rs 2,888 – Rs 2,155) and Rs 1,467/t (Rs 3,175 – Rs 1,708).

- The price for woody biomass (wood chips), ready for combustion, delivered at the IPP gate (Rs 3.50/kWh) will vary between Rs 3,620/t (>30% – 35% humidity) and Rs 4,396/t (<20% humidity). See Table 8 for pricing on other humidity contents.

- To guarantee the sustainability of this sector, it is proposed to index prices of bagasse and trash with Heavy Fuel Oil (HFO) and local inflation. For woody biomass, the indexation will also include the FOB price of imported wood chips. The weightage is to be fine-tuned when the fuel prices stabilized on the world market.

    - A pricing committee will be set comprising of the Ministry of Finance Economic Planning and Development, Ministry of Energy and Public Utilities, MCIA, URA, CEB and MARENA to determine and review the price and the indexation thereof when the price will be a pass on cost to CEB. This committee may co-opt other members.

❑ Financial implications to achieve targets on a yearly basis (2023 - 2030)

All data on a yearly basis			High-Pressure Power Plant + Bagasse Dryers					
	2023	2024	2025	2026	2027	2028	2029	2030
Cane to be Harvested Area (ha)	40 200	42 000	42 000	42 600	43 200	43 800	44 400	45 000
Electricity Local Biomass (GWh)	286	343	587	654	707	730	752	773
Coal Equivalent (1,000 t)	182	218	373	416	449	464	478	491
Coal Price (USD/t)	>250	200	125	125	125	125	125	125
FOREX Savings (USD million)	>45	44	47	52	56	58	60	61
Cane Replantation Scheme (Low-Interest Loan)	200	200	200	200	200	200		
Biomass Land Rehabilitation Scheme .(Low-interest Loan)	150	150	150	150				
Wood Chipping Stations (Low-interest loan)	30	30	30	30				
Afforestation Scheme for Eucalyptus/Biomass (Low-interest loan)	131	131	131	131				
Total Loan (Rs M/yr)	511	511	511	511	200	200		
Increase budget under existing Accompanying Measures to restore Abandoned Cane Lands/ ALMS Scheme	100	100	100	100	100			
Irrigation Electricity/Network Improvement Grant to Irrigation Authority	50	50	50	50	50	50		
Additional budget to MCIA - R&D and Capacity Building and Testing for Biomass	20	20	10	10	10	5	5	5
Total Grant (Rs M/yr)	170	170	160	160	160	55	5	5
Total Grant and Loan (Rs M/yr)	681	681	671	671	360	255	5	5

Payment for Cane Trash and Woody Biomass at IPP Gate								
Electricity Cane Trash (GWh)	20	30	55	65	65	65	65	65
Cane Trash Payment @ Rs 3.50/kWh (Rs M/yr)	70.0	105.0	192.5	227.5	227.5	227.5	227.5	227.5
Electricity Woody Biomass (GWh)	20	41	137	168	204	215	225	235
Wood Payment @ Rs 3.50/kWh (Rs M/yr)	70.0	143.5	479.5	588.0	714.0	752.5	787.5	822.5

Footnote

The resources and energy quarterly, December 2022, Australian Government, quote "*Thermal coal prices have eased slightly in recent months, but remain elevated amidst ongoing weather disruptions and issues with access to finance and insurance. As more normal conditions return, the Newcastle benchmark price is forecast to ease from an average of US$360 a tonne in 2022, to around US$200 in 2024 (still well above historical averages).*"

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1. INTRODUCTION

The setting up of a National Biomass Framework was announced within the Budget Speech 2021-2022. Consequently, the MCIA Act and SIE Act were amended in the Finance (miscellaneous provisional) Act 2021 to cater for the promotion of energy from such sources of biomass as may be prescribed.

The National Biomass Framework has been established under the *aegis* of the Ministry of Agro Industry and Food Security with the following goals, objectives and structure:

Goals of the National Biomass Framework

Provide policy and guidelines to participate in the attainment of the objectives of the country to reach its renewable energy mix of 60% by the timeline of 2030 by increased use of biomass and other green sources.

Objectives of the National Biomass Framework

Increase bioelectricity production by promoting and implementing projects for more efficient use of sugarcane bagasse, more trash collection, introduction of higher fibre cane varieties, cultivation of other energy crops and biomass import.

Structure of the Biomass Framework

- Steering Committee (SC) - The apex body under the aegis of the Ministry of Agro Industry and Food Security and chaired by the Senior Chief Executive (Fig. 1).
- Framework Implementation Committee (FIC) chaired by CEO, MCIA.
- Working Groups (WG)

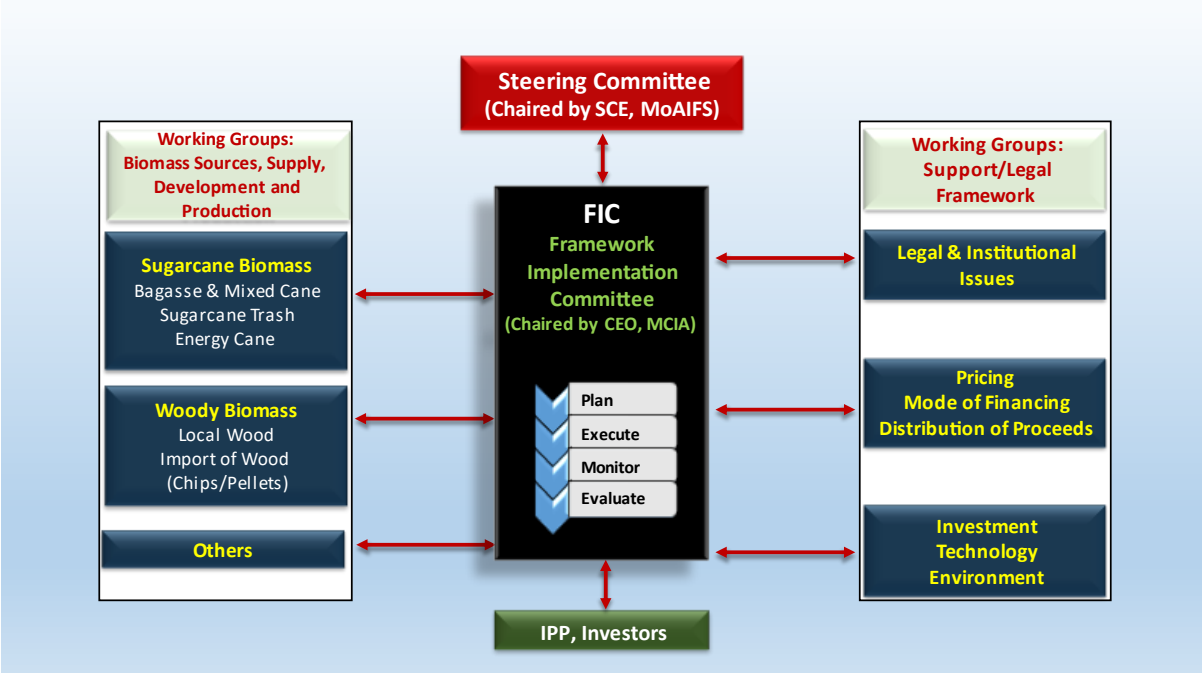


Figure 1. Structure of Biomass Framework

The Framework Implementation Committee (FIC) has met three times since 6 October 2021 under the chairmanship of the CEO, MCIA. After considering the views of its members on the different sources of biomass and its attributions, the FIC has established three working groups (WG) to review the potential and explore opportunities from the respective sources, and one WG to propose the respective pricing mechanism as follows:

WG1 Sugarcane Biomass - Bagasse and cane trash

WG2 Wood Biomass - Forest wood or plantations, domestic or industrial woody wastes

WG3 Pricing (WG 3) - Bagasse, trash and woody biomasses

The composition and Terms of References (TOR) of the SC, FIC and established WGs are listed in Annex 1. The various reports from the working groups have been presented and discussed at the level of the FIC; the outcomes and recommendations are presented in this report together with the respective pricing mechanism for each source of biomass.

2. STATUS AND POTENTIAL SOURCES OF BIOMASS

2.1 SUGARCANE BIOMASS

2.1.1 BAGASSE

Bagasse and cane trash are the main sources of renewable energy from cane sources in Mauritius, and it is currently the only biomass being exploited industrially, as shown in Figure 2.

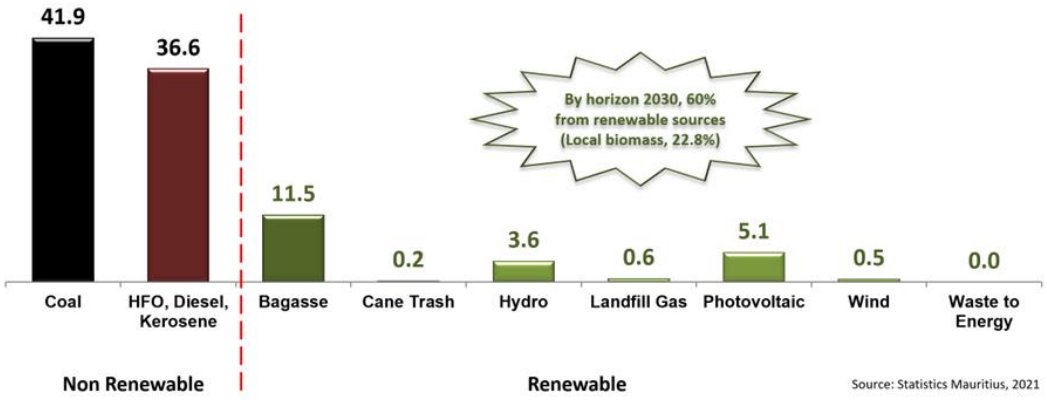


Figure 2. Share (%) of Bagasse in electricity generation mix in 2021

The amount of electricity produced from coal is around 1 200 GWh, compared to a peak of 381 GWh exported from bagasse in 2015. However, the electricity generated from bagasse has been declining over the recent years mainly due to a reduction in the area under sugarcane from 51 694 ha in 2015 to 39 641 in 2021, coupled with lower cane productivity. In 2021, the amount of electricity exported from bagasse has dropped to 252 GWh, including 6 GWh produced from 6 000 to 7 000 t of sugarcane trash.

Over the years there has been a significant decline in the area of sugarcane cultivation for various reasons. The potential and future reliance on bagasse are dependent on the acreage which will be maintained under sugarcane and the cane productivity (t/ha).

Table 1 shows the area harvested for the different categories of planters over the period 2015-2021. A total of 12 053 ha has been abandoned from 2015 to 2021, consisting of a reduction of 3 380 ha belonging to the small planters, 747 ha for medium & large planters and 7 926 ha for corporate planters.

Table 1. Area harvested by category (Sugar Insurance Fund Board, 2021)

Planters' Category

Year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Small <10ha	12 260	12 057	11 237	10 598	10 113	9 373	8 880
Medium & Large <100ha	1 734	1 813	1 620	1 369	1 156	1 128	987
Corporate >100ha	37 700	37 121	36 000	35 215	33 250	31 292	29 774
Total	**51 694**	**50 991**	**48 857**	**47 182**	**44 519**	**41 793**	**39 641**

The Working Group (WG1) has highlighted the financial difficulties experienced by the Large and Corporate Growers to replant their fields with old ratoon crops to mitigate the effect of ratoon decline and to invest in derocking and farm-planning for mechanization of practices before replanting in the more difficult area.

A new "**Biomass Land Rehabilitation Scheme**" low-interest loan of Rs 150 M, annually over four years to convert back abandoned sugarcane lands into production is proposed; a total area of 2 400 ha is earmarked for rehabilitation over this period.

An additional budget of Rs 100 M annually over five years is proposed under the existing "**Accompanying Measures to Restore Abandoned Cane Lands (ALMS) Scheme**" to cater for derocking, road mending, land preparation and replantation. The beneficiaries will be small and medium planters.

A reduction in the area replanted by the Corporate Growers in recent years has led to approximately 40% of their production coming from the 7th or older ratoon crops; having some 5 000 ha more with ratoons at the 7th ratoon or older in 2019 as compared to conventional crop cycles in 2003 or 2011 (Fig. 3).

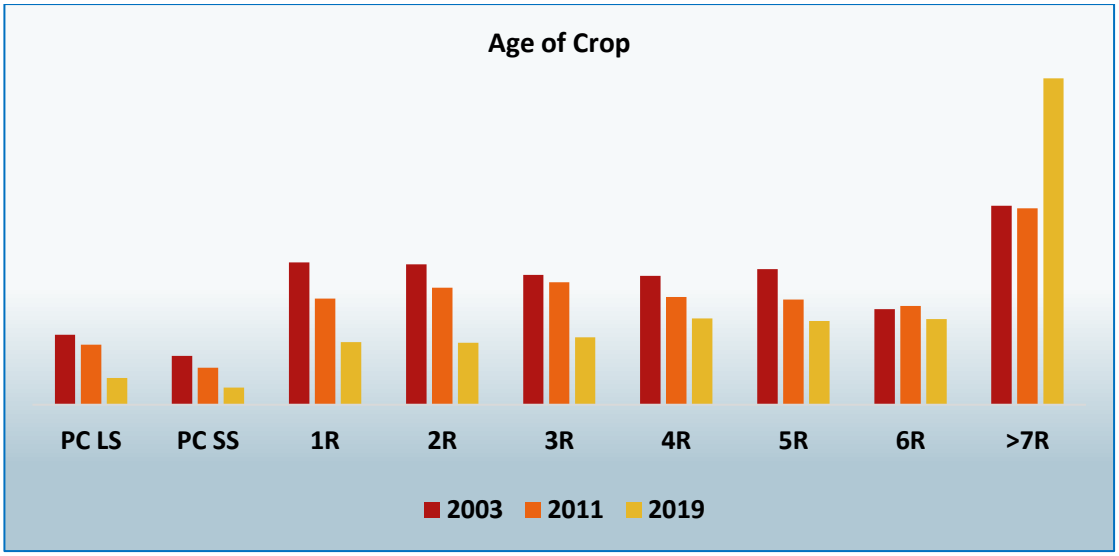


Figure 3. Area (ha) under respective crop cycles at the corporate level

The decline in yield from the "Plantcane" to the sixth ratoon crop may reach 25%, replanting a field after seven years will thus restore its yield potential and benefit from a higher productivity (Fig. 4). The mean annual loss (t/ha) for all ratoon crops beyond the 6th ratoon as compared to the mean for the first seven harvests varies between 10 t/ha and 12 t/ha.

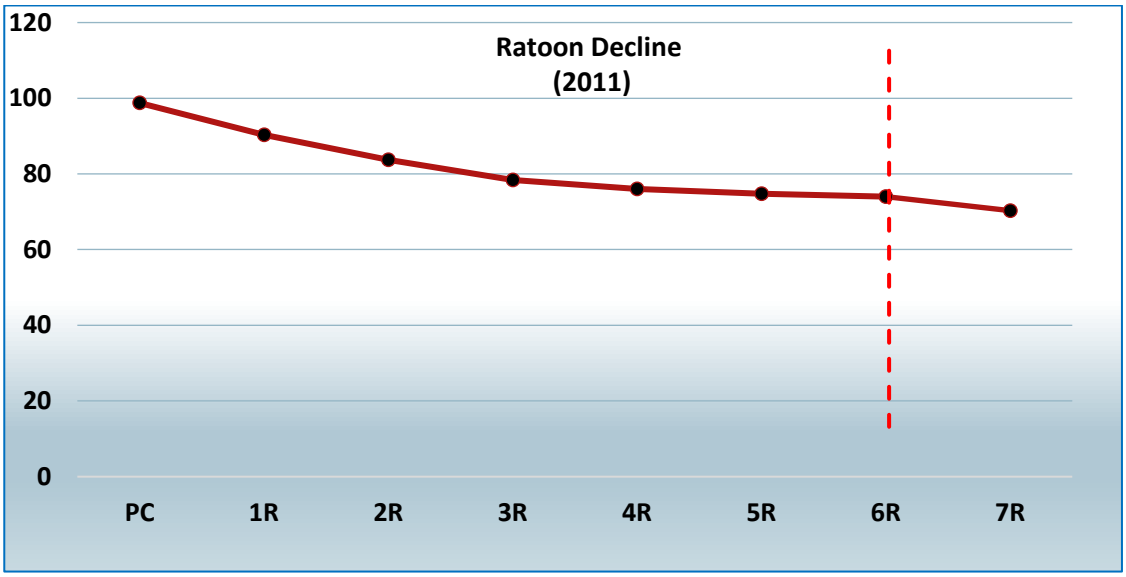


Figure 4. Effect of ratoon decline on cane yield

This ratoon decline, which is partly an inherent characteristic of sugarcane, can only be minimized by an appropriate and sustained replanting programme over the next five years. A replanting scheme of all fields beyond 6R will therefore restore the yield

potentials and benefit the sector on all fronts, i.e., sugar, bagasse, trash, molasses and alcohol. If the planting scheme is adopted over 5 000 ha within the next four years, representing an incremental yield of 50 000 - 60 000 t of cane, 5 000 to 6 000 t of sugar and 6 to 7 GWh/year of bioelectricity four years after start of the scheme.

While the MCIA is implementing several schemes to replant abandoned fields at Small Growers level, there is a need to offer incentives for replanting fields at the level of Large and Corporate Growers. The setting-up of a "**Cane Replantation Scheme**" for the Large and Corporate Growers has been announced in the Budget 2022/2023 for the setting up of a Cane Replantation Revolving Fund by DBM to provide loans at an annual preferential rate of 2.5%.

2.1.2 HIGH BIOMASS CANE

Replanting of fields will also be an opportunity to introduce newly released and more productive cane varieties within the system. It has been proposed by the MSIRI that some of the recently released varieties and a few new ones in the pipeline will yield a higher total biomass per unit area (high biomass cane).

The possibility of introducing "Higher Fibre Cane" or "Canne-Mixte" has also been discussed during the meetings; the only variety (R585) in this category, with an additional 2.5% or more of fibre with the same sugar yield, is not currently recommended by the MSIRI. R&D will be pursued to develop such varieties in the near future. Research is ongoing on new cane varieties with the capability of having two harvest per year for biomass production.

2.1.3 BAGASSE DRYER

The installation of a mill pressurizer and bagasse dryer using flue gas may increase the current electricity export by 10% with the same amount of bagasse. The investment in such technology may cost some USD 5.8 M per system; this value as provided by the IPP's would have to be validated at a later stage. The improvement in technology will bring an increase in electricity generation from bagasse and this additional electricity generation will be remunerated at Rs 3.50/ kWh, at the same tariff as bagasse energy. An incentivized tariff or new mode of remuneration would not be used.

The funding mechanism for such investments can be in terms of grants from different authorities; the possibility for IPPs to secure any "green" grants available with respect to climate change mitigation would be investigated.

2.1.4 EFFICIENT BOILER AT ALTEO

The production of bioelectricity from bagasse is also dependent on the efficiency of the boilers at the IPP. It has been proposed that the old and low-pressure boiler at Alteo be replaced by a more efficient one, operating at a higher pressure. Such technical improvement will increase the electricity export from 77 kWh/t of bagasse to 125 kWh/t, thus enabling an annual incremental production of 65 GWh.

2.1.5 SUGARCANE TRASH

Cane trash is a biomass left in fields after the harvest of the crop; exploited mainly as a green blanket to minimize weed infestations and improve soil moisture conservation. The current practice consists of the collection of some 50% of the total trash left behind in mechanically harvested fields; the amount of trash left after harvest is proportional to the yield and also varies across varieties. From an average amount of trash of 12 t/ha, only 5-6 t/ha are collected for agronomic reasons and to avoid the collection of soil particles. Some 14 000 t cane trash has been collected at Alteo and Terragen in 2018 (Fig. 5).

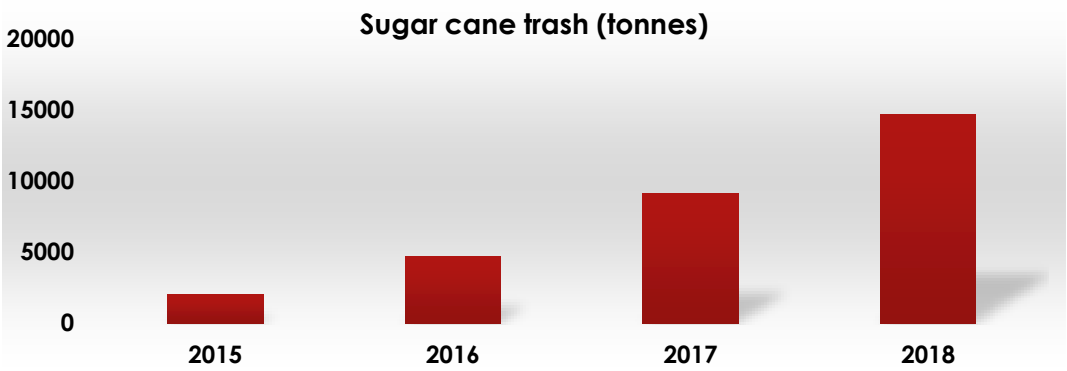


Figure 5. Cane trash collected at Alteo and Terragen

After successful trash collection trials in combination with R&D works to address the agronomic apprehensions of this new practice, trash is currently being collected and burnt for electricity generation at Terra and Alteo on an industrial scale, but not at full capacity in absence of a formal payment mechanism and financial incentives. Furthermore, as the trash should be collected within 3 to 15 days after harvest, factors such as difficult site access, rainy days and the presence of rocks restrict the collection.

With an average collection of 5 t/ha and assuming that only 60% of the area harvested mechanically can be exploited due to the factors mentioned above, a potential of 65 GWh of bioelectricity can be realistically produced with a conversion ratio of 910 kWh/t.

The potential from sugarcane trash may be higher than 65 GWh; collecting trash in fields with higher cane yields will enable the collection of 5.5 t/ha of trash on average.

Furthermore, it is also expected, that a proper payment mechanism for trash will trigger additional motivations for its collection. Trash from non-mechanized fields is excluded in the 65 GWh as the collection appears more difficult and expensive, but further R&D may propose solutions to exploit trash from these fields including those of Small-Growers.

2.2 WOODY BIOMASS

2.2.1 FOREST WOOD

Biomass production from trees has been lengthily discussed and considered by the respective working group. Biomass from tree crops may be produced or collected from three different sources namely:

I. Production on marginal sugarcane lands,
II. State forest lands, and
III. National and Conservation Parks.

Presentations have been made by the various stakeholders on the potential in each sector, together with the expected constraints and resources required for such development.

❑ Marginal Sugarcane Lands

The requisite condition set by the FIC has been that woody biomass would only be promoted and produced in difficult and marginal lands where sugarcane production is no longer sustainable (very low yield of less than 60 t/ha and mechanization of crop husbandry practices too difficult) (Fig. 6). Representatives from the different sugarcane sectors presented their respective potential for woody biomass production; a summary of the area which may be converted under tree production is listed in Table 2.

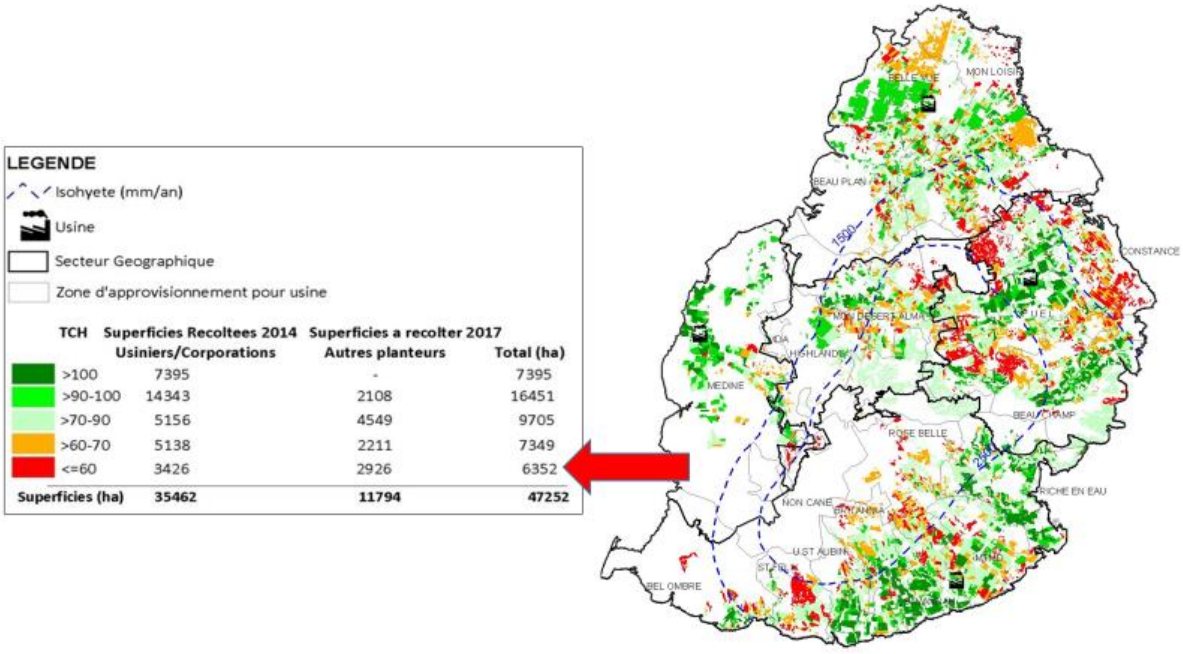


Figure 6. Sugarcane productivity analysis and Marginal Lands

Table 2. Proposed area for Woody Biomass production in ex-sugarcane areas

Sugar Producers	*By year*	*ha*
Alteo	2027	500
REE	2030	500
ENL	2029	385
FSA	2030	1 100
Rose Belle	2024	42
SIT	2025	200
Terra	2030	160
MCAF	2030	200
Others	2030	400
Total		**~3 500**

The largest area available from ex-sugarcane lands has been proposed by the Farmers Service Agency (MCIA) and concerns some 1 100 ha of abandoned fields, mainly from the ex-Tea lands which were converted to sugarcane production in the late 1990s. The sugar productivity in these areas has been very low (<50 t/ha), and mechanization of harvest with conventional harvesters is difficult. The agroclimatic conditions prevailing in these areas would suit the production of Eucalyptus.

The specie which is currently being earmarked for production on these lands is Eucalyptus. R&D works have already been initiated to evaluate imported *Eucalyptus* species with the objective to target higher productivity (higher yields in a shorter time frame). Based on the yield of local Eucalyptus varieties around 15 t/ha/yr (dry matter basis), a total energy production of 50 GWh by 2030 is expected. If the promising varieties under test maintain their advantages, an increase in bioelectricity production from these lands may be expected.

The FIC has been apprised of the capacity building which would be required before embarking in this 'new' sector; the Forestry Department has already proposed to share their experience and nursery facilities to promote this production. Some administrative and legal amendments, together with support mechanisms would need to be reviewed to convert the 1 100 ha of ex-tea lands.

❑ Forest Lands in Mauritius

According to the Forestry Service (Forestry, 2022), the total extent of forest cover in Mauritius is estimated at 47 159 hectares representing about 25% of the total land area. There are only two types of forest ownership: public and private. There are more forests on private lands with an estimated extent of 25 000 hectares as compared to about 22 000 hectares on state lands.

▪ State Forest Lands

These lands are an important source with the potential of producing at least 200 t/ha of biomass over a period of 10 years. However, the main constraint remains that 11 200 ha (out of 12 000) are already leased for hunting purposes; contracts are subject to renewal by the Ministry of Agro Industry & Food Security every seven years.

The Forestry Services confirmed that there should be no problem to integrate hunting activities and biomass production. Within hunting grounds, only 5% of the land is confined for grazing and the remaining may be exploited for biomass production (silviculture). Legally, all the trees present on these grounds belong to the State; there would be no need to change the law. The Working Group on woody biomass believes that the Tenants of the hunting grounds be allowed to arrange with potential biomass producers (e.g. Sugar Estates or IPPs) to exploit the same area.

The species currently available on these hunting grounds may need to be replaced gradually by higher yielding biomass species. According to the Forestry Services, some 8 000 ha may be targeted for biomass production; an average annual biomass production of 100 000 t (dry matter) may be produced from the forest lands by 2030. This biomass will enable the production of 100 GWh of bioelectricity[a]. The existing lease agreements between tenants of hunting grounds and the State will need to be reviewed accordingly.

[a] *According to FAO (2015) WOOD FUELS HANDBOOK, the net calorific value (NCV) of oven-dry wood of different species varies within a very narrow interval, from 18.5 to 19 MJ/kg. The 19 MJ/kg is equivalent 5,278 kWh/t (19/3.6 x 1,000). Assuming a generation efficiency of 27% @ 15% humidity, the theoretical electricity that can be generated is around 1,423 kWh/t. It is assumed that 30 kWh/t would be needed for wood Shredding and Chipping, as well as 10% electricity for Power Plant uses, hence a net theoretical electricity export of 1,251 kWh/t dry matter. Due to a lack of experience and uncertainties regarding the quality of local wood and power plant performances, 1,000 kWh/t dry matter is assumed, to be on the safe side.*

- **Private Forest Lands**

  As information on private forest was not available, this potential source was not taken on board by the working group. It is recommended to identify the owners of these private forests to access the potential and take them on board for biomass production.

❑ Forest Lands in Rodrigues Island

Any potential of producing and collecting biomass for bioelectricity production in Rodrigues Island will similarly be assessed.

❑ National Parks and Conservation Service (NPCS)

NPCS is the main institution responsible for the conservation of terrestrial biodiversity, focusing on endangered species recovery and park management. It manages an area of 6 000 ha out of which some 2 000 ha may be considered for bioenergy exploitation, but investors must comply with the stringent requirements, inherent with such parks.

Invasive species (e.g., "Goyave de Chine" - *Psidium cattleianum*) are contractually removed from these conservation areas; increasing the area annually cleared may be an important source of woody biomass. The estimated bioelectricity produced from biomass collected from the NPCS is forecasted at 5 GWh per year.

2.2.2 DOMESTIC WOODY WASTE

During discussions in the working group, it has been highlighted that a significant volume of trees, shrubs, and other greeneries may be available from domestic sources. In the premises of most habitants and around public or private buildings, trimming or lopping of trees is a common practice. Furthermore, institutions such as the CEB, Mauritius Telecoms, Road Development Authority (RDA), and local authorities (Municipalities and District Councils) invest in regular trimming or loping of trees, often through contractors who are required to include in their services the carting away of all branches and leaves.

The woody biomass (branches and greeneries) may be collected and converted into a valuable biofuel. The Solid Waste Management Division of the Ministry of Environment, Solid Waste Management and Climate Change are providing facilities for disposal through depot of the greeneries at Transfer Stations located in La Brasserie, La Laura, Poudre D'Or, Roche-Bois and La Chaumière. It is believed that SMEs should be promoted to collect these greeneries from these stations, or directly from the collection point and deliver them to wood processing plants. One such processing plant is in operation at

L'Espérance Trebuchet; more such units can be established across the island to process and convert the biomass into wood chips, together with temporary storage facilities.

The Ministry of Environment, Solid Waste Management and Climate Change has recently put in place three other sites for the deposition of all trees and branches after the cyclones. This biomass may also be stocked and processed for bioelectricity production.

- **Municipal Solid Waste – Refuse Derived Fuel**

  In 2018, the electricity export potential of Municipal Solid Waste (MSW) was evaluated by the MSIRI/MCIA and Solid Waste Recycle Limited (SWRL). For every 100 000 tonnes of Municipal Solid Waste (MSW), the amount of Refuse Derived Fuel (RDF) is around 36 000 tonnes, with a Net Calorific Value of around 12.55 MJ/kg. If burnt in a low pressure, waste incinerator with a low conversion efficiency of 22%, the net electricity export is around 25 GWh.

  Schemes and regulations for SMEs to produce RDF together with an appropriate pricing mechanism will promote the development of this 'filière'. The setting up of a regional composting and waste sorting plants and a Residue Derived Fuel (RDF) production plant as promoted by the Solid Waste Management Division of the Ministry of Environment will facilitate this development.

2.2.3 INDUSTRIAL WOODY WASTE

Similar to domestic woody wastes, a potential also exists at industries level. All imported items arriving in containers are placed on wooden pallets ('palettes') which once damaged need to be discarded. Wood poles used on construction sites together with demolition material, represent another source of collection of woody biomasses. Used and discarded paper or carton boxes or any cellulosic material may as well be collected and converted into biomass (wood chips).

Residues from the agricultural sector such as the remaining of plants after vegetables or fruit (e.g., pineapple) have been harvested, can also be collected as waste. This may include cane trash left behind in manually harvested fields or where baling would not be possible.

Regulations and pricing mechanisms will need to be approved for encouraging SMEs to develop in this field as well. It is estimated that 25 000 to 40 000 t (Dry Matter) of these wastes may be collected annually and sent to the same processing units. A minimum bio-electricity production of 25 GWh may be expected in the initial years.

2.2.4 QUALITY AND STANDARDS OF WOOD CHIPS DELIVERED AT IPP GATE

All the collected wood wastes would have to be further processed into wood chips before delivery to the IPP. It has been estimated that four such wood chippings stations to cover the whole island would be required to minimize on haulage cost.

It was also discussed that the biomass should meet quality standards, conforming with the requirements of the boilers. This has to be worked out between the suppliers and the IPPs'.

The types of wood species that would be accepted for use would have to undergo detailed chemical tests (ultimate analysis) characterising the Net Calorific Value to know its energy content, the alkali metals composition and chlorine content to determine its corrosive nature and the melting point of ash to predict its slagging and fouling properties. All these tests would determine how safe the biomass is for combustion in high pressure boilers. It was noted that no laboratory in Mauritius is fully equipped to carry out these tests. A single sample sent for analysis in certified laboratories in France may cost Rs 50,000. However, cost effective use of local resources would be made in existing laboratories in Mauritius and further requirements would be assessed.

3. BIOELECTRICITY POTENTIAL AND SUPPORT REQUIRED

The FIC has considered all the options to boost or explore potentials for local biomass production; Table 3 summarizes the proposals for the various sources and the support mechanisms which would be required to develop and materialize them.

The proposals, by the Framework, for the sugarcane sector are not only restoring the capacity of bioelectricity from bagasse but also increasing its total capacity to 538 GWh with the inclusion of trash and other measures suggested. These efforts are also vital for sustaining the sugar sector, together with the other by-products such as ethanol, vinasse (used as fertilizer) and rum. Furthermore, these steps will prevent land abandonment and the presence of sugarcane will control soil erosion and act as an important carbon sink.

Developing the woody biomass sector will produce a minimum of 235 GWh by 2030, thus contributing to achieve Government's objective of partial substituting coal. Other benefits of this new sector ('filière') include the setting-up of new SMEs and job creation, valorisation of our forest resources together with a more effective management of these lands. Some 125 000 t of coal (based on 1 574 kWh/t coal) will be substituted annually by exploiting locally available woody biomass in the energy mix.

The average amount of coal imported between 2015 and 2018 has been 712 000 t/yr; the potential of locally produced biomass (sugarcane and woody biomass) represents approximately 55% of the total amount of coal imported. Based on an average price of USD 125/t of coal (Prior Dec 2021), local production of woody biomass will represent an annual savings of nearly USD 61 M in foreign currency in 2030.

The total bioelectricity which may be produced and exported by 2030, through locally available biomass, is estimated to be 773 GWh by 2030. This will represent approximately 22.8% in the energy mix by 2030.

Table 3. Bioenergy potential (GWh) in Mauritius by 2030 & Support needed

Source of Biomass	Year 2030	Measures or Requirements	Support needed
Sugarcane			
To restore cane yield, and produce additional bagasse from 3.8 M t of cane + Efficient Boiler at Alteo (+60 GWh)	**443**	A Cane Replanting Revolving Fund for Large and Corporate Growers (1 300 ha /year)	A Cane Replanting Revolving Fund estimated at MUR 200 M yearly over 6 years
		A Biomass Land Rehabilitation Scheme for abandoned cane plantations	A Biomass Land Rehabilitation Scheme amounting to Rs 150 M, annually over four years
		Consolidation of the Accompanying Measures to Restore Abandoned Cane Lands Scheme (ALMS)	MUR 100 M/year (over 5 years)
		To legalize remuneration of bagasse with indexation	Bagasse remuneration of MUR 3.50/kWh to be maintained
		Irrigation network improvement and facilities by Irrigation Authority	Improvement of irrigation network and re-introduce irrigation electricity grant (Rs 50 M for 6 years)
		Long term Power Purchase Agreement. As per the mandate of the URA there will be competitive procurement.	
Bagasse Dryer	**25**	Long term contracts (20 years).	Grants & Green loans (USD 5.8 M) per system. Costs as provided by IPP's.
High Biomass Cane	**5**	Already in progress by MSIRI	
Trash collection	**65**	Investment to upscale trash collection and transport logistics (10 000 t to 65 000 t)	Estimated additional investment MUR 300 M
Woody Biomass			
Ex-Sugarcane Lands (3 500 ha)	**50**	R&D to develop new Eucalyptus varieties+ machines/ logistics for harvest, transport, processing & chemical analyses	MUR 20 M grant to finance R&D, analyses, and Capacity Building. A total of Rs 85 M over 9 years
		Capacity Building & Review of lease contracts with Growers Facilities to convert land and replant with Eucalyptus or other species	An Afforestation Scheme for Eucalyptus/Biomass with a loan of Rs 131 M, annually over 4 years

State Forest Lands (8 000 ha)	**100**	Ministry of Agro Industry/Forestry Service to facilitate coordination with Tenants of hunting grounds and modalities for this co-exploration	Revisit contracts with Tenants of hunting grounds
NPCS	**5**	MoAIFS/NPCS to work out the modalities and conditions for the collection of invasive species + Rent of 2 000 ha. Facilitate the creation of SMEs for biomass collection	
Domestic Woody Wastes	**40**	Support from Solid Waste Management Division (MoE), review of regulations and contracts for trimming by CEB, MT, etc.	
		Promotion of SMEs for collection	SME Chipping Stations loan of Rs 30 M annually over 4 years
		Pricing & incentives to boost this new sector	
Industrial Woody Wastes	**40**	Promotion of SMEs for collection	SME Chipping Stations loan of Rs 30 M annually over 4 years
		Pricing & incentives to boost this new sector	
Total	**773**	**GWh/year**	

4. PRICING OF BIOMASS

The overall cost of fuel, as delivered to a power plant, consists of the base price and logistics cost. In the absence of an operating and formal biomass market, regulators adopt different principles intending to establish the fair price of biomass for the determination of feed-in tariff.

In principle, three different methodologies can be considered for the determination of fair base prices of biomass, namely the price of fuel alternative, market price and the opportunity price of biomass. The merits and demerits of the alternatives are summarized in Table 4.

Table 4. Fuel pricing option evaluation

Alternative	*Merits*	*Demerits*
Price of Fuel alternative	Most transparent	Lowest or highest marginal cost and rationale Impact of volatility
Market price	Takes care of all factors Better social acceptability	Lack of transparency for informally traded biomass Higher cost of transactions
Opportunity price	Can be transparent if there is only one alternative	Practical difficulty as there is always more than one alternative

4.1 PRICING OF BAGASSE

4.1.1 HISTORICAL BACKGROUND OF BAGASSE PRICING IN MAURITIUS

In 1991, Mauritius pioneered a methodology for bagasse pricing.

The Government of Mauritius had formulated a bagasse energy development program in partnership with the private sector over a 6 - month period in 1991. The then Ministry of Energy set up a Technical Committee which developed an avoided cost model taking into account the cost of generation from a 22 MW diesel power plant proposed by the Central Electricity Board (CEB).

The World Bank provided support to the Committee to work out the principles and the guidelines. Bagasse was priced at Rs 100 (or USD 3.7) per ton and its impact was significant; within three years (1997-2000), almost all the sugar mills invested in cogeneration projects to export electricity to the grid.

A Bagasse Transfer Price Fund (BTF) was also created to compensate growers, for the price realization by the sugar mill for bagasse used for purposes other than the manufacture of sugar. This has been one of the most successful policy interventions on biomass prices considering the impact it had in expanding the bagasse cogeneration industry in the country. However, the bagasse price (BTPF) remained stagnant at Rs 100 per ton, which coupled with relatively lower sugar prices in recent years, has caused disinterest in the sugarcane growing business.

4.1.2 REVIEW OF BAGASSE PRICING BY GOVERNMENT IN 2021 FOR LONGER PERSPECTIVES

A study, conducted by the World Bank in 2020 on the competitiveness of the sugar sector, quotes,

> "*that price paid by CEB to IPP's for bagasse should be equal to the opportunity cost of using HFO."* It further stated that *"The third alternative was to add a 15% "green premium" to the HFO reference price in recognition of the renewable nature of bagasse and the benefits of clean energy. The 15% green premium is a solution proposed by members of the cane industry.*"

Other studies have recommended that bagasse be priced at the opportunity cost of coal, but this has not been endorsed by Government.

Applying HFO as an appropriate opportunity cost and a 15% premium, the price of bagasse as per Government policy is Rs 3.50 per kWh" (Table 5).

Table 5. Methodology of bagasse pricing

		Coal	***HFO***	***HFO + 15% Premium***
Reference price (2014 to 2018)	Rs/t	3,530	13,878	15,960
Bagasse Calorific Equivalent	%	33.0	11.4	11.4
Bagasse price	Rs/t	1,165	1, 582	1,819
Bagasse Price as per Government Policy	**Rs/kWh**	**3.50**		

Based on different options proposed to the Government of Mauritius in 2021, the latter decided that the price of bagasse be remunerated Rs 3.50 per kWh through the Sugar Cane Sustainability Fund and distributed at a calculated rate of Rs 3,300 per tonne sugar for crop 2021 to all planters and producers.

The above decision of the Government was announced in the Budget Speech 2021/22, and it was retained that the policy/vision of the Government was to:

- *Have a new economic growth pole: "The Green Energy Industry". It is an industry which will have a significant impact on our economy, boost our GDP growth and most importantly, create new job opportunities.*
- *Produce 60 percent of our country's energy needs from green sources by 2030.*
- *Phase out the use of coal totally before 2030.*
- *Exploit biomass as a major source of renewable energy and setting up of a National Biomass Framework.*

In order to give effect to this budget measure, relevant sections of the SIE (amendment) Act 2016 and MCIA Act 2011 were amended. The amendments and modalities of implementation of these measures are presented in Annexures 2 and 3.

With amendments brought to the SIE Act concerned with repeal of the Bagasse Transfer Price, there is a quid pro quo sort of arrangement for the IPP's to relinquish the BTP share in exchange of millers benefiting the Rs 3.50/ kWh.

During the discussions of the working group (WG3), the following were also highlighted:

- **Contracts between CEB and IPP's:**

  All issues concerning contractual terms that exist between CEB and IPP's would be addressed by the parties concerned. However, views/concerns were expressed on the product exchange agreement that exist between the miller and the IPP's, is summarized in Annex 4.

- **Funding of Bagasse proceeds for the longer perspectives**

  The representative from Ministry of Finance, Economic Planning and Development advised that funding of the Bagasse proceeds would be decided by Government in the light of financial status of the budget and that of the CEB on a yearly basis.

- **Indexation of the base price of Rs 3.50/kWh**

  Representative from Ministry of Finance, Economic Planning and Development explained that the tariff of electricity is not being indexed on a yearly basis. Electricity tariffs were increased eight or nine years ago and another tariff increase linked to COVID 19 and war between Russia/Ukraine is currently under study by Government. Therefore, the present price of Rs 3.50/kWh for bagasse will prevail until further Government decision.

- **Regulation of the base price of Rs 3.50/kWh**

  The base price of Rs 3.50/ kWh for bagasse combustible is funded by Government. Should this price be a pass on cost to the CEB, then a Committee comprising of the Ministry of Finance Economic Planning and Development, Ministry of Energy and Public Utilities, MCIA, URA, CEB, MARENA will determine and review the price and the indexation thereof since this bagasse price will be a component of the tariff determination under part IV of the Electricity Act 2005.

4.1.3 RECOMMENDATIONS FOR PRICING OF BAGASSE

Following discussions, the pricing committee (WG3) has recommended:

A. Keep the base price for bagasse at Rs 3.50/kWh for subsequent years. The bagasse proceeds would be based on Rs 3.50/kWh and the rate per sugar tonne basis for distribution to planters and producers would be calculated each year.

B. Rectifications be brought to the section 13A subsection (4) by changing from "effect payment to planters or producers" to "effect payment to planters and producers" in order to harmonise with Budgetary measures reflecting the vision of the Government.

C. Administrative arrangements would be made for CEB to submit appropriate returns to the MCIA such that a provisional payment for bagasse is carried out in November of the current year and a final in March of the following year.

D. The Rs 3.50/kWh is funded by Government. Should this price be a pass on cost to the CEB, then a Committee comprising of the Ministry of Finance Economic Planning and Development, Ministry of Energy and Public Utilities, MCIA, URA, CEB, MARENA will determine and review the price and the indexation thereof.

E. With amendments brought to the SIE Act concerned with repeal of the Bagasse Transfer Price, there is a quid pro quo sort of arrangement for the IPP's to relinquish the BTP share in exchange of millers benefiting the Rs 3.50/ kWh.

4.2 PRICING OF SUGARCANE TRASH

4.2.1 HISTORICAL BACKGROUND OF TRASH PRICING IN MAURITIUS

On 24 June 2019 in Parliament, the Deputy Prime Minister on sugar cane trash, quote:

"On 07 December 2018, the negotiating panel recommends that cane trash energy should be remunerated at the same tariff as bagasse energy. That is what the negotiating panel, on 07 December 2018, recommends: trash energy same as bagasse.

Don't forget, there is no yardstick to know how to remunerate trash energy. So, they use the next best, that is, bagasse.

Alteo informed CEB that there would be no incentive to use cane trash if cane trash is to be remunerated on the same basis as bagasse because when you burn your cane, the bagasse is in the mill and you use it to do energy whereas for cane trash, you have to collect it, you have to bale it and you have to transport it, and all this costs money. That is the argument of Alteo.

So, on 18 February, at my Ministry - but I am not present - there is a meeting chaired by the Director General of my Ministry, together with the General Manager of CEB, other technical staff as well as Alteo, and this is following a decision of the Board of CEB. Finally, the committee recommends to CEB a coal energy tariff of Rs 4.45 kilowatt-hour indexed on local inflation - that is important - and not indexed as before, and the CIF coal price.

A bagasse energy tariff of Rs 2.80 per kilowatt-hour indexed on local inflation at 2018 base price and it also recommends cane trash energy tariff of 4.45 for that experimental period of three years, that is, for these 3 GWh per year, 1.7% of the production.

And, for the first time, we will be able to see how cane trash behaves as biomass for electricity production and, if the experience is positive, then we are ahead for a bright future for ***la paille canne****. But, Madam Speaker, what is extraordinary in that deal is that, for the first time, the IPPs will pay the suppliers of trash Rs1 per kilowatt-hour."*

4.2.2 OVERVIEW

The electricity potential for cane trash is 65 GWh, equivalent to 40,000 t of coal, worth more than USD 13 M at the current spot price, end of April 2022.

The technologies and logistics to collect trash are well established since 2017, yet less than 15% of this potential is exploited. Unlike wood pellets, there is no reference "world market price" from which to compare and estimate the local price of trash, a conundrum for decision-makers. No wonder the World Bank (2020) breezed past this issue. Quote:

> *"Some of the overlooked policy changes include collecting and using cane trash from the fields to burn as biomass along with bagasse. This option indeed yields additional revenues but is costly to implement, leaving small net margins."*

At the very outset, the pricing committee acknowledged that trash is a renewable source of energy, which may justify a mix of opportunity cost and value-based pricing that includes a "green premium" of 15% compared to heavy fuel oil (HFO). This proposition, cited in the World Bank report (2020) for bagasse pricing offered a reasonable margin without being too costly to implement.

The WG 3 took cognizance that the price of sugarcane trash as fuel would include two distinct components, i.e., costs on the planters' side and trash processing fees at the power plant (IPP).

❑ Planters Side

1. The costs on the “Planters side” include trash price as a commodity (ownership price) and expenses associated with trash windrowing, baling, loading, and transport to the Power Plant (IPP) gate.
2. It was pointed out that the owner of trash currently receives a sum of around Rs 1,100/t trash, calculated in 2016/17. This price, indexed on coal is no more suitable since Mauritius, at the UN Climate Change Conference (COP26), pledged to phase out coal by 2030.
3. The committee acknowledges that the price of trash on the Planter’s side should be the price delivered at the IPP gate.

❑ Power Plant Side (IPP)

1. On the IPP side, the "trash processing fees" include, amongst others, costs of unloading trash bales, storage, bale breaking, shredding, lab analysis and mixing with bagasse, prior combustion in boiler furnaces.
2. On the IPP side, the "trash processing fee" is an expense agreed under a Power Purchase Agreement (PPA) contract between IPP and the utility (CEB). If requested by the negotiation parties, the MCIA, as a neutral faction may provide support to estimate this expense, based on verifiable inputs.

4.2.3 PRICING METHODOLOGY

Despite overlooking trash, World Bank's methodology on bagasse pricing was valuable, offering some clues on how to price it. Quote,

"Second was to estimate a price for bagasse with reference to heavy fuel oil (HFO), which is said to be a better reference material than coal, as HFO burns cleaner and is what the CEB uses in its own power plants. The third alternative was to add a 15% "green premium" to the HFO reference price in recognition of the renewable nature of bagasse and the benefits of clean energy."

4.2.3.1 PLANTERS SIDE – VALUE OF TRASH IN RS/KWH

The trash pricing calculation process is depicted in a schematic diagram, Annex 7, Fig. A7.1.

In the World Bank (2020) report, the value of bagasse was calculated by using bagasse calorific equivalent HFO with a "green premium" of 15%. Similarly, the price of sugar cane trash on the Planters' side will be based on trash calorific equivalent HFO.

Based on Statistics Mauritius (2021) the average import price of Fuel oil (c.i.f) was Rs 19,498/tonne in 2021. From CEB source (2021) HFO 380 CST1, the price was Rs 17,955/t.

If assumed Rs 20,000/t, taking into consideration generation efficiencies, the price of trash is simply:

Price of Trash at IPP gate (Rs/kWh) **= HFO (Rs/t) / kWh/t HFO**

= Rs 20,000/4,927

= Rs 4.06/kWh

- The HFO price of Rs 20,000/t is based on the past landing price of Fuel Oil at Port Louis harbour, with 15% green Premium, see Annex 5, Figure A5.1 & Table A5.1. It also takes into consideration the high and unpredictability of oil prices since the start of the year 2022. It is a rounded, HFO reference price meant to boost this sector while ensuring a reasonable revenue for the Planter.

- As shown in Annex 6, Table A6.1 the average electricity generated for the period 2008 to 2019 by the CEB was 4,927 kWh/t HFO.

- As per Statistics Mauritius, the average price of Fuel Oil in 2021 was Rs 19,498/t. The estimated price for the year 2021 would be **Rs 3.96/kWh** (19,498/4,927). With a 15% premium, it would be **Rs 4.55/kWh**.

- **Discussions were held on the estimated price versus CEB official reference price as submitted and the number of years to take for the average price.**

    - The estimated price for 2018 to 2021, excluding 2020 gave Rs 3.21/kWh (15,829/4,927) and with a premium of 26% gave Rs 4.06/kWh (20,000/4,927).

    - Five years (2017 to 2021) rolling average of CEB official reference prices, without premium gave Rs 2.91/ kWh (14, 355/ 4,927), and with a premium of 15% gave Rs 3.35/ kWh.

Year	CEB - HFO 380 CST1 Rs/t CEB official Ref price	HFO with 15% Premium (Rs/t)
2017	12,346	14,198
2018	15,338	17,639
2019	14,194	16,323
2020	11,941	13,732
2021	17,955	20,648
Average*	14,355/4,927 2.91/kWh	16,506/4927 3.35/kWh

- **There was an in-principle agreement that the price of trash and wood would be kept at par with bagasse, that is Rs 3.50/kWh as trash is mixed with bagasse and burnt in the same boiler and it is not possible to distinguish between trash energy and bagasse energy.**

- **Any additional green premium on top of the Rs 3.50/kWh would be a policy decision.**

4.2.3.2 PLANTERS SIDE – VALUE OF TRASH IN RS/TONNE

Depending on climatic conditions, the moisture content of chopped trash from mechanically harvested cane will drop to 15 - 25% after a few days. This moisture as well as ash content, impacts on Net Calorific Value (NCV) and Thermal Efficiency of a Power Plant. It directly impacts net electricity export to the grid, hence the proposal for a differentiated price for two categories, A & B. The calculations are shown in Annex 7, Table A7.1.

The proposed price (based on Rs 3.50/kWh) shown in Table 6 applies to Power Plants equipped with high-pressure boilers, i.e., 82 bars. The ash content averages 10%, the lower, the better.

Table 6. Value of trash at IPP gate (Based on Rs 3.50/kWh)

Ash ±10%	*Trash Moisture*	*Price (Rs/t)*
Category A	**~15% to 20%**	**3,175**
Category B	**>20% to 25%**	**2,888**

4.2.3.3 COST OF TRASH COLLECTION AND TRANSPORT TO IPP GATE

The planter's net revenue per tonne of trash is the price mentioned in Category A & B (Table 6), minus all the expenses incurred by trash collection and transport to the IPP gate. The estimation of trash collection and transport costs is solely meant to guide the Planter about the range of prices to be paid to the contractor.

Trash collection is influenced by the weather, terrain, and cane yield. The sunnier the region, the number of operating days is longer, reducing costs. In general, the flatter the terrain, the faster the collection rate, and the higher the cane yield, the more bales collected per hectare. All these factors as well as the distance from the field to the Power Plant impacts trash collection costs, an indication that the costs vary. This cost is to be mutually agreed upon between the trash owner and contractor, the lesser this expense, the revenue for the planter is higher.

Due to variations in the operating conditions in the field, the price was estimated with Monte Carlo simulations, instead of the commonly used "Normal, Worst, and Best" scenario model. The data used for calculations is based on past reports, machine capacity (baler), and field observations for a normal crop year, which excludes crop years 2020 & 2021. Key results are shown in Annex 7, Table A7.2.

For trash collection and transport to the IPP gate, the range of price with a margin of 12% is between Rs 1,708/t to Rs 2,155/t, offering some guidance to the trash owner.

- Mean price with 12% margin = Rs 1,708/t
- Maximum price with 12% margin = Rs 2,155/t

As for sugar cane harvest and transport, the price is not fixed but based on a mutual agreement (win-win situation) between the parties. It is up to the planter and the contractor collecting the trash to agree on the price. It is up to the planter to decide to pay more than Rs 2,155/t if the contractor is unwilling to collect the trash in very difficult regions.

4.3 WOODY BIOMASS

4.3.1 OVERVIEW

Woody biomass such as wood chips, pellets and sawdust are one of the most common types of biomass combusted to generate electricity. In Mauritius, this source of biomass has not been tapped up to now, despite some 40 000 ha of land under forest. From a commercial side, there have been some attempts to plant Eucalyptus on marginal sugarcane lands, particularly by Compagnie Sucrière de Beau-Vallon. Experimentation works to evaluate Eucalyptus varieties other than the local ones have started, together with conversion into wood chips and combusted in the existing boilers of the IPPs. These are mainly on a trial basis as there is no pricing mechanism. Additionally, existing power plants with low-pressure boilers might invest in higher pressure ones to gain efficiency; this is where a clear pricing mechanism is important for such investment.

It is unanimously agreed at the pricing committee (WG3) that wood biomass will play an important role in the phasing out of coal although it is true that locally produced biomass will not replace all the coal to be displaced. The electricity potential from woody biomass is estimated to be around 235 GWh which is equivalent to around 150 000 t of coal. The WG3 has worked out a price for the biomass in form of wood chips that will be supplied at the gate of the IPP.

4.3.2 PRICING METHODOLOGY

The methodology used has been based on the one used for trash which in turn was dependent on the one on bagasse from the World Bank report. The methodology used is as follows:

- The average price of HFO delivered at CEB (provided by CEB during the meeting) was taken for the 2018, 2019 and 2021. The price for 2020 was not taken as the price was unusually low due to the Covid-19 pandemic.

- A green premium of 15% was added to average price of HFO and the price of electricity per kWh was computed for HFO which is used for biomass.

4.3.3 PRICE OF WOODY BIOMASS IN RS/KWH

The average price of HFO for the three years is Rs 15,829/t and with the 15% of green premium, it amounts to Rs 18,203 per tonne. Given that it is the very first time this pricing mechanism is being set up and this initiative is in line with our NDC and Government policy to phase out coal, together with the increase in price of HFO globally, a reference price of Rs 20,000 per tonne of HFO was proposed.

Therefore, the price of biomass delivered at the IPP gate is:

Price of Trash at IPP gate (Rs/kWh) **= HFO (Rs/t) / kWh/t HFO**

= Rs 20,000/4,927

= Rs 4.06/kWh

The HFO price of Rs 20,000/t is based on the past landing price of HFO at Port Louis harbour, with 15% green Premium, see Annex 5, Fig. A5.1 & Table A5.1. It also takes into consideration the high and unpredictability of oil prices since the start of the year 2022. It is a rounded, HFO reference price meant to boost this sector while ensuring a reasonable revenue for the Planter.

As shown in Annex 5, the average electricity generated for the period 2008 to 2019 by the CEB was 4,927 kWh/t HFO.

- **There was an in-principle agreement that the price of local wood would be kept at par with bagasse, that is Rs 3.50/kWh.**
- **Any additional green premium on top of the Rs 3.50/kWh would be a policy decision.**

4.3.4 PRICE OF WOODY BIOMASS IN RS/TONNE

The electricity generated from biomass depends on several parameters namely calorific value, moisture content and efficiency of the power plant. The Gross Calorific Value (GCV) was taken as 19 000 kJ/kg from FAO (2015). This value is in line with what Terragen obtained and it was also agreed by the representative of MCA and IPP in the committee.

The Net Calorific Value (NCV) was computed for biomass at different moisture content mainly 15%, 20%, 25% and 30%. It was agreed to use an efficiency of power plant of 28%. Based on the price of biomass at Rs 3.50/kWh proposed is as follows:

Table 7. Value of woody biomass at different moisture content

	Moisture %			
	15	**20**	**25**	**30**
GCV kJ/kg	19 000	19 000	19 000	19 000
NCV kJ/kg	16 149.63	15 199.51	14 249.39	13 299.27
NCV kWh/kg	4.49	4.22	3.96	3.69
NCV kWh/t	4 486.01	4 222.09	3 958.16	3694.24
Power plant efficiency, %	28.00	28.00	28.00	28.00
Electricity Generated, kWh/t	1 256.08	1 182.18	1 108.29	1 034.39
Price of biomass, Rs/t based on Rs 3.50/kWh	**4,396**	**4,138**	**3,879**	**3,620**

It is important to note that the price of imported biomass is currently more than Rs 8,000/t FOB (Argus Biomass Markets). The proposed price for local woody biomass, ready for combustion in high-pressure boilers and delivered at the IPP gate is shown in Table 8.

Table 8. Price of woody biomass at different moisture content

	Moisture %			
	<20	**20 - 25**	**>25 - 30**	**>30 - 35**
Price of biomass, Rs/t on Rs 3.50/kWh	**4,396**	**4,138**	**3,879**	**3,620**

5. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

The Framework Implementation Committee (FIC), through three working groups, has investigated into the potential, opportunities and pricing of sugarcane (bagasse and cane trash) and woody (forest wood or plantations, domestic or industrial woody wastes) biomasses respectively.

❑ Sugar Cane Sector

i. The amount of electricity exported to the National grid from bagasse has declined from 381 GWh in 2015 to 246 GWh in 2021. This downward trend will continue in the absence of sweeping measures to boost sugarcane production. Higher amount of sugarcane will indirectly help to materialize the biofuel project.

ii. Government to revisit the regulations for land conversion with the objective to 'Lock' lands under sugarcane production (45 000 ha).

iii. The decline in sugarcane productivity, due to a higher ratio of ratoon crops older than seven years, has exceeded 40% in 2019 at the Corporate and Large-Planters levels. A Cane Replanting Revolving Fund, requiring a loan of MUR 200 M annually over six years and operating as a revolving fund, is being proposed to restore cane yields by 10-12 t/ha by replanting 1 300 ha annually.

iv. A Biomass Land Rehabilitation Scheme amounting to Rs 150 M (loan), annually over four years, will target Small and Medium Planters who have abandoned their cane plantations. Furthermore, sugarcane productivity will be boosted by the consolidation of ALMS Scheme with Rs 100 M (loan), annually over five years to cater for derocking, road mending, land preparation, and cane replantation for small and medium planters. An Electricity/Irrigation Network Improvement grant of Rs 50M, annually over six years will also boost cane productivity.

v. Capital investment in a more efficient power plant at Alteo will increase electricity production from 77 to 125 kWh/t cane, representing a gain of 60 GWh per annum. The installation of bagasse dryers will improve the thermal efficiency of power plants, boosting electricity production by 25 GWh per year.

vi. The collection of sugarcane trash on 60% of the area harvested mechanically over the island will generate 65 GWh per year.

vii. Some 3 500 ha of marginal lands with very low sugar cane yields have been identified for conversion into wood plantation (Eucalyptus) or other alternative species. Based on current yields from local Eucalyptus varieties at 15 t/ha/yr (dry

matter basis), electricity production may reach 50 GWh by the year 2030 from these lands.

❑ Forest Lands

Forest lands are an important source of biomass, representing an electricity export potential of 100 GWh per year. The main constraint remains that 11 200 ha, out of 12 000 ha available are already leased for hunting purposes. It has been highlighted that hunting activities and biomass production may be integrated as all the trees present on these grounds belong to the State. Furthermore, the collection of biomass (invasive species) from the National Parks on 2 000 ha can add another 5 GWh.

Private forest lands (25 000 ha) should be taken on board for biomass production; Identification of the landowners is necessary. Any potential of producing and collecting biomass for bioelectricity production in Rodrigues Island will similarly be assessed.

❑ Woody Biomass and Wastes

An Afforestation Scheme for Eucalyptus/Biomass with a loan of Rs 131 M, annually over 4 years at a low-interest rate is proposed for all planters willing to convert their marginal cane lands.

Two new 'Filières' have been identified for the collection of woody wastes from domestic and industrial sources. Development of SMEs for such collection is being recommended as well as the extension of wood processing and storage plants in different regions. SME's Chipping Stations loan of Rs 30 M, annually over 4 years at a low-interest rate is proposed; some 80 GWh of electricity can be produced.

❑ Price of Local Biomass

The prices proposed for the various sources of biomass are as follows:

- Bagasse at Rs 3.50/kWh (Government measures to be maintained until further change).
- With amendments brought to the SIE Act concerned with repeal of the Bagasse Transfer Price, there is a quid pro quo sort of arrangement for the IPP's to relinquish the BTP share in exchange of millers benefiting the Rs 3.50/ kWh.
- Baled trash from mechanically harvested cane and delivered at IPP gate (Rs 3.50/kWh):
    - Category A (Moisture ~15% - 20%) = Rs 3,175/t
    - Category B (Moisture >20% - 25%) = Rs 2,888/t
    - Planters' revenue equal Rs 3,175/t or Rs 2,888/t share minus collection and transport cost, estimated to range between Rs 1,708 – Rs 2,155/t.
- Woody Biomass ready for combustion and delivered at IPP gate (Rs 3.50/kWh):
    - Moisture <20% = Rs 4,396/t
    - Moisture 20 - 25%) = Rs 4,138/t
    - Moisture >25 - 30% = Rs 3,879/t
    - Moisture >30% - 35% = Rs 3,620/t

❑ To guarantee the sustainability of this sector, it is proposed to index the price of bagasse and trash with Heavy Fuel Oil (HFO) and local inflation. For woody biomass, the indexation will also include the FOB price of imported wood chips. The weightage is to be fine-tuned when the fuel prices stabilize on the world market.

- **A pricing committee will be set comprising of the Ministry of Finance Economic Planning and Development, Ministry of Energy and Public Utilities, MCIA, URA, CEB and MARENA to determine and review the price and the indexation thereof when the price will be a pass on cost to CEB.**

❑ It is also proposed that the pricing of biomasses for trial purposes will be similar to those applied at commercial scale.

❑ Bioelectricity Production Projection by 2030

The total production from local biomasses (sugarcane and woody) is summarized in Table 9; it is based on high pressure power plants with an island average potential of 116 kWh/t cane. Electricity production with sugarcane has been forecasted on a projection aiming at producing some 3.8 M tonnes of cane; the total amount of electricity that will be exported will reach 538 GWh by 2030.

Table 9. Bioenergy Production (2023 – 2030)

All data on a yearly basis			High Pressure Power Plants + Bagasse Dryers					
	2023	2024	2025	2026	2027	2028	2029	2030
Cane to be Harvested Area (ha) [1]	40 200	42 000	42 000	42 600	43 200	43 800	44 400	45 000
Cane Yield (t/ha) [2]	68	72	76	80	82	83	84	85
Cane Total (million t)	2.7	3.0	3.2	3.4	3.5	3.6	3.7	3.8
Cane to Electricity (kWh/t) [3]	90	90	116	116	116	116	116	116
Electricity Bagasse (GWh)	246	272	370	395	411	422	433	443
Bagasse Dryer (GWh) [4]	0	0	25	25	25	25	25	25
Higher Fibre Cane - HF(GWh) [5]	0	0	0	1	2	3	4	5
Elec. Bag + Dryer + HF (GWh)	246	272	395	421	438	450	462	473
Cane Trash (GWh) [6]	20	30	55	65	65	65	65	65
Electricity all Sugarcane (GWh)	266	302	450	486	503	515	527	538
State Forests (GWh)	0	10	50	75	100	100	100	100
National Parks, NPCS (GWh)	0	1	2	3	4	5	5	5
Eucalyptus (GWh)	0	0	5	10	20	30	40	50
Domestic Wood (GWh)	10	15	40	40	40	40	40	40
Industrial Wood (GWh)	10	15	40	40	40	40	40	40
Electricity Woody Biomass (GWh)	20	41	137	168	204	215	225	235
Electricity Local Biomass (GWh) [7]	286	343	587	654	707	730	752	773
Coal Equivalent (1,000 t) [8]	182	218	373	416	449	464	478	491
Coal Price (USD/t) [9]	>250	200	125	125	125	125	125	125
FOREX Savings (USD million)	>45	44	47	52	56	58	60	61
IPP Electricity Export (GWh) [10]	1 450	1 450	1 450	1 220	1 220	1 220	1 220	1 220
Electricity Island (GWh) [11]	2 787	2 910	3 076	3 138	3 199	3 261	3 233	3 384
Electricity from either Coal or RDF, Imported biomass & other sources (GWh) [12]	1 164	1 107	863	566	513	490	468	447 No Coal
Missing amount based on existing GWh output capacity (1,220) of IPP (sugar) – If Wood Pellets (1,000 t)								447

Footnote for Table 9.

[1] With "the "**lock**" on cane land and better prices on bagasse and trash, it is expected that land under sugarcane cultivation will rise.

[2] From 2009 to 2019 cane yield was around 74 t/ha. With the replantation scheme, cane yield is expected to start to rise significantly from the year 2025.

[3] It is expected that there will be one refinery in Mauritius. If no refinery, the cane to electricity ratio will be higher than 116 kWh/t cane.

[4] Bagasse Dryer is expected to add 25 kWh/t bagasse, or 8.5 kWh/t cane.

[5] It is expected that higher Fibre cane varieties will be introduced in the future.

[6] Sugar cane trash is readily available. Electricity production can be optimized if burnt as fuel in high pressure power plants.

[7] Electricity that can be produced from local biomass.

[8] It is the amount of coal equivalent to local biomass (bagasse, trash & wood). Electricity export assumed 1,574 kWh/t coal.

[9] In March 2021 coal price was around USD 100/t and started to rise. Spot coal price on 28 April 2022 was USD 325. It is assumed that prices will stabilize in the future (no war) at around USD 125/t based on the average 2010/21 which was around USD 100 - 125/t.

[10] The Power Plants will use bagasse, trash, and local wood, supplemented by imported wood during the off-crop season. IPP exported 1,460 GWh with 299.3 GWh from bagasse & 1,159 GWh from coal, respectively (Annual Report CEB, 2018/19). One unknown is the MW Capacity of a proposed New Alteo Plant. Also, The Union Saint Aubin Power plant (OTEOSA) is a coal stand-alone power plant and its contract will expire in 2025. As the policy of the Government is to phase out coal, at the expiry of the contract it will probably not launch a tender to procure energy from coal sources. Therefore, this plant is excluded from our scenario for 2030. The electricity export potential of power plants associated with the sugarcane industry will be assumed to be around 1,220 GWh in 2030.

[11] Source: Central Electricity Board, 2022. Base case.

[12] Power Plants (1,220 GWh output capacity) cannot remain idle during the off-crop season. Any missing GWh that bagasse, trash, or local wood cannot produce will come from coal, imported wood, or other sources like RDF (Item 10 - 7). In 2030, when coal will be phased out, 447 GWh of electricity will be produced mainly from RDF and other sources.

Bioelectricity produced from biomass represent up to a maximum of 36% of the energy mix by 2030, the forecasted electricity mix is shown in Figure 7.

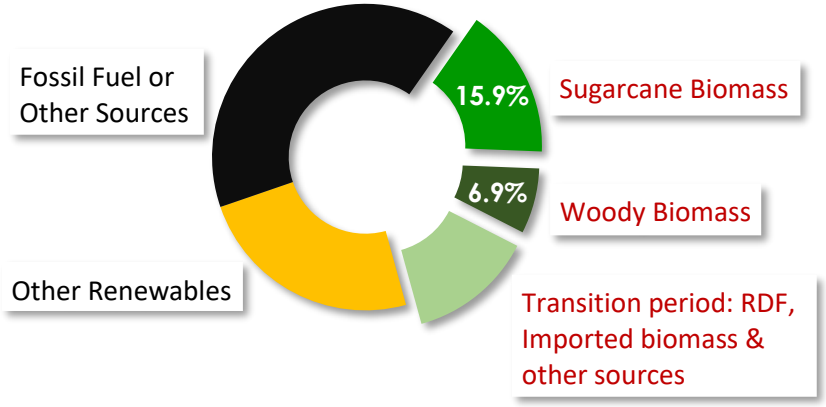


Figure 7. Electricity Mix year 2030

It has been stated that it is against GOM's policy to import biomass on account of a shortage in foreign currencies. The policy is to concentrate on local biomass as imported biomass costs more than locally available renewable sources. The representative of MOFEPD recommended concentrating on local biomass given the problem of foreign currency.

The existing IPPs (associated with sugar mills) output capacity may be maintained at 1,220 GWh/year in 2030 with projects in the pipeline on the use of Refuse Derived Fuel (RDF) and biomass from private forest lands.

It is expected that more local biomass will be available if some of the 25,000 ha of private forest, not accounted for in this report (only 10 000 ha State forest included), is involved in biomass production. Additionally, biomass type, RDF from 100 000 tonnes of Municipal Solid Waste (MSW) has an electricity export potential, estimated to be around 25 GWh.

Another potential source of biomass is the very high fibre "Energy Cane" not accounted in this report since the varieties have not yet been released by the MSIRI/MCIA.

❑ Financial Requirements to develop the Biomass Sector

The financial requirements to achieve the targets in the year 2030 are detailed in Table 10.

Cane Biomass - To consolidate the sugarcane sector for biomass production, several schemes have been recommended:

■ **Loans**

(i) A **Cane Replantation Scheme** amounting to Rs 200 M annually over six years, as a low-interest loan, renewable after seven years. This will be operated as a revolving fund and owned by the Government. The beneficiaries will be the Large and Corporate Growers.

(ii) A **Biomass Land Rehabilitation Scheme** amounting to Rs 150 M, annually over four years and disbursed as a low-interest loan. The beneficiaries will be all the planters who have abandoned their cane plantations.

■ **Grants**

Provision of an additional budget under the existing Accompanying Measures to Restore Abandoned Cane Lands

(iii) Provision of an additional budget under the existing "Accompanying Measures to restore abandoned Cane Lands/ALMS "Scheme of Rs 100 M, annually over five years to cater for derocking, road mending, land preparation and replanting. The beneficiaries will be small and medium planters.

(iv) An Electricity/Irrigation Network Improvement grant of Rs 50 M annually over six years to the Irrigation Authority to cater for technology improvement and electricity use in electric pumps for the irrigation of cane fields.

Woody Biomass - To start the development of the new economic green activity concerned with wood, the schemes proposed are:

■ **Loans**

(i) SME Chipping Stations loan of Rs 30 M annually over four years at a low-interest rate. The beneficiaries would be the Small and Medium Enterprises.

(ii) An **Afforestation Scheme** for Eucalyptus/Biomass with a loan of Rs 131 M, annually over four years at a low-interest rate. The beneficiaries would be all planters whose cane lands are marginal.

- **Grants**

  (iii) An increase in the MCIA budget, catering for Research & Development, Capacity Building, and Testing at the MSIRI Department. A grant of Rs 20 M annually would be required for the first two years, gradually decreasing to Rs 5 M as from 2026.

- **Private investments** – A total investment of Rs 1,150 M is required for the bagasse dryers, trash collection units, and SME wood processing units, to be financed by green loans.

- **Payment for trash and wood commodities delivered at IPP gate**

  - An amount of Rs 35.0 M is required in 2022 to remunerate planters for 10 GWh of electricity from trash sources; this amount will increase to Rs 227.5 M in 2030 with 65 GWh of electricity generated.

  - Similarly, an amount of Rs 7.0 M is needed in 2022 to remunerate SME's for 2 GWh of electricity from wood sources; this amount will increase to Rs 822.5 M in 2030 with 235 GWh of electricity generated.

  - A policy decision is required to statute whether these costs will be catered by the CEB or other sources of funding.

Table 10. Financial requirements to achieve targets (2023 – 2030)

All data on a yearly basis (Rs M/yr)			High-Pressure Power Plant + Bagasse Dryers					
	2023	2024	2025	2026	2027	2028	2029	2030
Cane to be Harvested Area (ha)	40 200	42 000	42 000	42 600	43 200	43 800	44 400	45 000
Electricity Local Biomass (GWh)	286	343	587	654	707	730	752	773
Coal Equivalent (1,000 t)	182	218	373	416	449	464	478	491
Coal Price (USD/t)	>250	200	125	125	125	125	125	125
FOREX Savings (USD million)	>45	44	47	52	56	58	60	61
Cane Replantation Scheme * *(Low-Interest Loan)*	200	200	200	200	200	200		
Biomass Land Rehabilitation Scheme (Low-interest Loan)	150	150	150	150				
Wood Chipping Stations (Low-interest loan)	30	30	30	30				
Afforestation Scheme for Eucalyptus/Biomass (Low-interest loan)	131	131	131	131				
Total Loan (Rs M/yr)	511	511	511	511	200	200		
Increase budget under existing Accompanying Measures to restore Abandoned Cane Lands/ ALMS Scheme	100	100	100	100	100			
Irrigation Electricity/Network Improvement Grant to Irrigation Authority	50	50	50	50	50	50		
Additional budget to MCIA - R&D and Capacity Building and Testing for Biomass	20	20	10	10	10	5	5	5
Total Grant (Rs M/yr)	170	170	160	160	160	55	5	5
Total Grant and Loan (Rs M/yr)	681	681	671	671	360	255	5	5
Payment for Cane Trash and Woody Biomass at IPP Gate								
Electricity Cane Trash (GWh)	20	30	55	65	65	65	65	65
Cane Trash Payment @ Rs 3.50/kWh (Rs M/yr)	70.0	105.0	192.5	227.5	227.5	227.5	227.5	227.5
Electricity Woody Biomass (GWh)	20	41	137	168	204	215	225	235
Wood Payment @ Rs 3.50/kWh (Rs M/yr)	70.0	143.5	479.5	588.0	714.0	752.5	787.5	822.5

Footnote for Table 10

* Cane Replantation Scheme is in the budget 2022-2023 while other schemes and grants are estimated projections.

❑ Environmental Impact of biomass utilisation

Electricity generation is the greatest emitter of CO_2 in Mauritius, representing 60% of total emissions, followed by the transport sector with 23%. The CO_2 emissions avoided from renewable energy sources account for 16% of the total CO_2 emissions. Bagasse and trash based on the current production level account for 47% of the CO_2 emissions from renewable sources.

With additional electricity generation from biomass sources, totalling 773 GWh in 2030, there will be a positive impact on the avoided CO_2. The level of its emission will be kept at 18%, despite significantly higher electricity demand in 2030. Furthermore, the planting of additional trees would increase the carbon sequestration potential.

REFERENCES

CSO (2020) Energy and Water Statistics, Statistics Mauritius.

CSO (2021) Energy and Water Statistics, Statistics Mauritius.

Energy Observatory Report (2020).

FAO (2015) Wood Fuels Handbook, Food and Agricultural Organization, krajnc N., Pristina.

Forest (2022) Forestry Services, Mauritius. [Accessed, 02 May 2022].

Resources and energy quarterly: December 2022, Australian Government.

World Bank (2020) Mauritius Sugar Sector Review, Competitiveness Analysis, Dec 2020.

ANNEXURES

Annex 1

TORS & COMPOSITION OF COMMITTEES UNDER BIOMASS FRAMEWORK

Steering Committee (SC):

The main objectives of the Steering Committee were:

- To align with the objectives of Government to enhance the use of renewable sources of energy for electricity production in particular biomass increase in the energy mix of the country
- To report to Government on milestones of targets achieved to increase use of biomass for bioelectricity and the timelines
- To develop and approve strategies, plans and policies that will facilitate the implementation of the biomass framework
- To oversee and monitor the activities of the Framework implementation Committee

SN	Composition	Designated Officer	Post Held
1	Ministry of Agro-Industry and Food Security	Mr Medha Gunputh (Chairperson)	Senior Chief Executive
		Mrs Indira Rugjee	Deputy Permanent Secretary
2	Mauritius Cane Industry Authority	Mr Satish Purmessur	Chief Executive Officer
3	Ministry of Finance, Economic Planning and Development	Mr Vikraj Ramkelawon (Firm)	Lead Analyst
		Mrs Sadhna Appanah/Mr Hemnish Urdhin (Alternate)	Lead Analyst
4	Ministry of Energy and Public Utilities	Dr Soonarane	Director Technical Services
		Mr A.Beetun	Lead Engineer
5	Ministry of Environment, Solid Waste and Climate Change	Mrs Aisha Golamaully (Firm)	Environment Officer/Senior Environment Officer
		Mrs Roufida Teemul (Alternate)	Environment Officer/Senior Environment Officer
6	Ministry of Commerce and Consumer Protection	Mrs Santah Umavassee	Deputy Director, Legal Metrology Services
7	State Law Office	Miss Purnima Dunputh	Assistant Parliamentary Counsel
8	Chamber of Agriculture	Mrs Jacqueline Sauzier G.C.S. K	General Secretary
9	University of Mauritius	Dr (Ms) Geeta Devi Somaroo	Senior Lecturer and Head of the Department of Chemical and Environmental Engineering

Framework Implementation Committee (FIC):

Under the guidance of the Steering Committee, the FIC will

- Liaise with different working groups, IPPs, promoters and investors to create a synergy.
- Analyse relevant information in the planning of targets for biomass production and supply in the short, medium and long term.
- Be responsible for overall reporting and monitoring of the progress of work of each working group on different sources of biomass.
- Benchmark and promote the potential sources of biomass for bio-electricity
- Create an enabling environment for investment to take place.
- Carry out ground proofing of biomass supply in the scenarios to reach targets set by the SC in the mix by 2030 and timelines.
- Set up and provide guidance to the working groups assigned with each different source of biomass.
- Plan and execute the scale-up biomass supply to power plants.
- Validate the cost of production of biomass on a commercial scale.
- Appraise projects geared towards biomass production and make recommendations to SC for approval.

SN	Composition	Designated Officer	Post Held
1	Mauritius Cane Industry Authority	Mr Satish Purmessur (Chairperson)	Chief Executive Officer
		Dr Asha Dookun -Saumtally	Director, MSIRI
		Dr Suman Seeruttun	Ag Principal Research Manager (Director MSIRI as from Sept. 2022).
		Mrs Kumari Cahoolessur	Ag Manager Policy & Planning Unit, MCIA (Manager, Policy & Planning Unit as from Jan. 2023).
2	Ministry of Agro-Industry and Food Security	Mr P. Khurun	Deputy Conservator of Forest
		Mrs C Cyparsade (Alt) Mrs Indranee Buldawoo	Ag Principal Scientific Officer
3	Ministry of Finance, Economic Planning and Development	Mr Vikraj Ramkelawon	Lead Analyst and SMST) Agro Industry
		Mr Ritesh Etwaroo(Alt)	Analyst / Senior Analyst
4	Ministry of Energy and Public Utilities	Mr Avisshal Beetun	Lead Engineer
5	Chamber of Agriculture	Mrs Jacqueline Sauzier G.C.S. K	General Secretary
6	University of Mauritius	Dr Dinesh Surroop	Associate Professor
7	Mauritius Renewable Energy Agency	Ms Mreedula Mungra	Chief Executive Officer
		Mr Naweed Bundhoo (Alt)	Research Development Officer
8	Central Electricity Board	Mr Pramod Kokil	Senior Engineer
		Mr Janesh Kistoo	Engineer
9	Ministry of Environment, Solid Waste and Climate Change	Mrs Aisha Golamaully	Environment Officer / Senior Environment Officer
10	Co Opt Rep Civil Society	Mr Shreedanand Cullychurn	Director WoodPro Ltd

Working Groups 1 & 2 on Cane and Woody Biomass:

The main objectives of the Working Group on Cane and Woody Biomass were:

a) To review the potential and explore opportunities from the respective sources.
b) To assess the constraints in realising these potentials.
c) To formulate the support needed to realise the potentials.

Composition of Working Group 1 on Cane Biomass

Name	Position / Organisation
Dr Dinesh Surroop	Associate Professor, University of Mauritius (Chairperson)
Mr Satish Purmessur	Chief Executive Officer, MCIA
Dr Asha Dookun-Saumtally	Director, MSIRI, MCIA
Dr Suman Seeruttun	Ag. Principal Research Manager, MSIRI, MCIA (Director MSIRI as from Sept. 2022).
Mrs Kumari Cahoolessur	Ag Manager, Policy & Planning Unit, MCIA (Manager, Policy & Planning Unit as from Jan. 2023).
Dr Goolam Badaloo	Scientific Officer, MSIRI, MCIA
Mr Ah Foon Lau Ah Wing CEng.	TO/STO (Research), MSIRI, MCIA (RO/SRO as from Nov. 2022).
Dr Deepack Santchurn	TO/STO (Research), MSIRI, MCIA
Mr Dineshrao Babajee	Chief Executive Director, Sugar Investment Trust
Mr Ramesh Moonshiram	HR Consultant, Rose Belle Sugar Estate
Mr Hem Prakash Dhotah	General Director, Rose Belle Sugar Estate
Mr Hansley Mooloo	Officer in Charge, Rose Belle Sugar Estate Board
Mr Denis Lavoipierre	Agricultural Development Manager, Alteo Limited
Mr Gregory Bathfield	Project Development Manager, Alteo Limited
Mr Sanjiv Parsan	Factory Manager, Alteo Limited
Mr Jean Michel Gerard	General Manager, Omnicane Thermal Energy
Miss Devina Mooloo	Representative, Omnicane Thermal Energy
Mr Jean Luc Caboche	General Manager, Milling & Logistics, Omnicane Limited
Mr Jean Marc Iweins	Power Plant Manager, Terragen Ltd
Mrs Laila Neuhausser	Biomass Engineer, Terragen Ltd
Mrs Patricia Laurent-Ragavan	Agronomist, Terragri Ltd
Mrs Farmeen Salamut	Area Manager, Terragri Ltd
Mr Sachin Sookna	Marketing Manager, MCAF Ltd
Mr Shyamdutsingh Ramdhary	Member, Board of Directors, MCAF
Mr Didier Charoux	Managing Director, Medine Agriculture
Mr Didier Langois	Land Development Coordinator, Constance La Gaiete Co Ltd
Mr Olivier Baissac	CEO, ENL Agri Limited

Composition of Working Group 2 on Woody Biomass

Name	Position / Organisation
INSTITUTIONS	
Dr Suman Seeruttun	Ag. Principal Research Manager, MSIRI, MCIA (Chairperson) (Director MSIRI as from Sept. 2022).
Mr Satish Purmessur	Chief Executive Officer, MCIA
Mr Yash Ramdharee	Director, Farmers Service Agency, MCIA
Dr Dinesh Suroop	Associate Professor, University of Mauritius
Mrs Kumari Cahoolessur	Ag Manager, Policy & Planning Unit, MCIA (Manager, Policy & Planning Unit as from Jan. 2023).
Mr Ah Foon Lau Ah Wing CEng.	TO/STO (Research), MSIRI, MCIA (RO/SRO as from Nov. 2022).
Mr Devadass Nursimulu	Financial Operations Officer/SFO, Policy & Planning Unit, MCIA
Mrs Pratimah Peerthum	Scientific Officer, National Plant Protection Office
PRIVATE FOREST	
Mr Thierry Merven	Group CEO,Cie De Beau Vallon Ltée
Mrs Kareen Theodore-Cotry	Group Agronomist and Diversification Manager, Cie De Beau Vallon Ltée
Mr Denis Lavoipierre	Agricultural Development Manager, Alteo Limited
Mr Jean Michel Gerard	General Manager, Omnicane Thermal Energy Operations Ltd
Mr Jean Marc Iweins	Power Plant Manager, Terragen Ltd
Mrs Laila Neuhausser	Biomass Engineer, Terragen Ltd
Mr Sachin Sookna	Director, Mauritius Cooperative Agricultural Federation
Mr Shyamduthsingh Ramdharry	Board Director, Mauritius Cooperative Agricultural Federation
STATE FOREST	
Mr Poojanraj Khurun	Deputy Conservator of Forest, Forestry Service
Mr Kersley Pynee	TO/STO, National Parks and Conservation Service
Mr Hemprakash Dhotah	General Director, Rose Belle Sugar Estate
Mr Hansley Mooloo	Field Superintendent, Rose Belle Sugar Estate Board
Mr Dineshrao Babajee	Chief Executive Director, Sugar Investment Trust
SME	
Mr Shreedanand Callychurn	Director, Woodpro Ltd

■ Working Groups 3 on Biomass Pricing:

Terms of Reference for the Working Group 3 on Biomass Pricing

a) To identify the different methods of valuation of biomass resources (e.g production costs, opportunity cost, etc).
b) To justify the method of valuation to be retained for the biomass resources.
c) To validate the costs in the valuation of biomass resources.
d) To work out the indexation formula for the different biomass resources.
e) To propose the financing mechanism for the biomass resources.
f) Any other related exercise as decided by the Framework Implementation Committee.

Composition of Working Group 3 on Biomass Pricing

Name	Position / Organisation
Mr S. Purmessur	Chief Executive Officer, MCIA (Chairperson)
Dr D. Surroop	Associate Professor, University of Mauritius
Mrs K. Cahoolessur	Ag. Manager, Policy & Planning Unit, MCIA (Manager, Policy & Planning Unit as from Jan. 2023).
Mr Ah Foon Lau Ah Wing CEng.	TO/STO (Research), MSIRI, MCIA (RO/SRO as from Nov. 2022).
Mr D. Nursimulu	Financial Operations Officer/Senior Financial Operations Officer, Policy & Planning Unit, MCIA
Mr P. Kokil	Senior Engineer, Central Electricity Board (CEB)
Mrs C. Ahon	Senior Professional, CEB
Mr J. Jaen	Group Chief Operations Officer, Omnicane (Representative of IPPs)
Mr G. Bathfield	Representative of Mauritius Chamber of Agriculture (MCA)
Mrs N. Suburn-Sobhun	Engineer/Senior Engineer, Ministry of Energy & Public Utility (MEPU
Mr P. Khurun	Deputy Conservator. Forest Services
Mrs V.V Ramiah	Representative of Ministry of Industrial Development, MSE's and Cooperatives
Mr N.Bundhoo	Representative of MARENA
Mr V.Ramkelawon	Representative of Ministry of Finance, Economic Planning and Development (MoFEPD)
Mr H.Urdhin	Representative of Ministry of Finance, Economic Planning and Development (MoFEPD)

SUMMARY OF AMENDMENTS BROUGHT TO THE LAW WITH RESPECT TO BIOMASS

SIE Act-Sections amended	Amendments	Full text after amendment
Section 13	Repealing completely section 13 and sixth Schedule concerned with Bagasse Transfer Price Fund.	
Section 13A	(i) in subsection (1), by deleting the words "sugar cane and bagasse" and replacing them by the words "biomass from such sources as may be prescribed";	"There shall be a Sugar Cane Sustainability Fund for the purpose of fostering the production of biomass from such sources as may be prescribed"
	(ii) in subsection (3) –	"Any contribution made on a yearly basis by such bodies as may be prescribed and the proceeds from any trash commodity shall be credited to the Sugar Cane Sustainability Fund and operated and managed under different portfolios for the different types of biomass."
	(A) in paragraph (a) –	
	(I) by inserting, after the words "as may be prescribed", the words "and the proceeds from any trash commodity";	
	(II) by inserting, after the words "Sugar Cane Sustainability Fund", the words "and operated and managed under different portfolios for different types of biomass."	"' Any contribution referred to in paragraph(a) shall be made on or before 1 March of every year and in such amount as shall be prescribed for the different types of biomass."
	(B) in paragraph (b), by deleting the words "may be prescribed" and replacing them by the words "shall be prescribed for the different types of biomass";	"Subject to subsection (6), the Mauritius Cane Industry shall on such terms and conditions as may be prescribed, effect payment to planters or producers, as the case may be on or before 31 March of every year."
	(iii) in subsection (4), by inserting, after the word "planters", the words "or producers, as the case may be";	In this section - "planter " means a planter registered with the Sugar Insurance Fund on or before 31 May 2015 or any planter producing biomass from such sources as may be prescribed"
	(iv) in subsection (7), in the definition of "planter", by deleting, the words "31 May 2015" and replacing them by the words "31 May 2015 or any planter producing biomass from such sources as may be prescribed"	
Section 13B	(i) in the heading, by deleting the words "Sugar Cane Industry Based" and replacing them by the word "National"	"National Biomass Framework"
	(ii) in subsection (1) –	
	(A) by deleting the words "Renewable	"The Mauritius Cane Industry Authority shall

	Sugar Cane Industry Based Biomass Framework" and "from biomass" and replacing them by the words "Renewable National Biomass Framework" and "from such sources of biomass as may be prescribed", respectively;	develop and monitor a framework to be known as the Renewable National Biomass Framework to promote production of energy from such sources of biomass as may be prescribed, including sugar cane, cane trash, high fiber cane, fuel canes, Gramineae and other related biomass,"
	(B) by deleting the words ", generated by the sugar cane industry";	

MCIA Act -Sections amended	**Amendments**	**Full text after amendment**
	in section 2 –	
Section 2	(i)in the definition of "co-product", in paragraph (a), by deleting the words "or sugar'' and replacing them by the words ", sugar, bagasse or molasses"	"co-products"-means a product of cane, sugar, bagasse or molasses
	(ii) by inserting, in the appropriate alphabetical order, the following new definitions – "biomass" means organic material from plants or animals; "producer" has the same meaning as in the Sugar Industry Efficiency Act	"biomass"- means organic material from plants or animals. "producer" has the same meaning as in the Sugar Industry Efficiency Act*
Section 4	in section 4, in paragraph (q), by deleting the words "the use of biomass" and replacing them by the words" the use of such sources of biomass as may be prescribed"	(q) foster the use of such sources of biomass as may be prescribed, including sugar cane, cane trash, high fiber cane, fuel canes, gramineae and other related biomass, in the production of electricity and biofuels for transport;
Section 5(1)	in section 5(1), by repealing paragraph (rc) and replacing it by the following paragraph – (rc) promote the production of energy from such sources of biomass as may be prescribed, including biomass generated by the sugar cane industry, develop and monitor the Renewable Sugar Cane Industry Based Biomass Framework referred to in the Sugar Industry Efficiency Act	(rc) promote the production of energy from such sources of biomass as may be prescribed, including biomass generated by the sugar cane industry, develop and monitor the Renewable Sugar Cane Industry Based Biomass Framework referred to in the Sugar Industry Efficiency Act;
Section 17(1)	in section 17(1)(c), by inserting, after the words "as the Minister may approve", the words "and such sources of biomass as may be prescribed"	(c) conduct research programmes on such other crops as the Minister may approve and such sources of biomass as may be prescribed;
Section 39	in section 39 – (i) in subsection (3), by deleting the words "every planter, shall, in addition, be entitled to receive out of the value of the bagasse so sold, transferred or utilised, an amount equivalent to the fraction represented by the quantity of canes supplied by him over the quantity of canes	(3) Where any bagasse produced at a factory in a crop year, other than bagasse used for the specific purpose of manufacturing sugar at that factory, is sold or otherwise transferred or is utilised in the production of any goods, every planter or producer, as the case may be, shall, in addition, be entitled to receive out of the

	milled at the factory in that crop year" and replacing them by the words "every planter or producer, as the case may be, shall, in addition, be entitled to receive out of the contribution made to the Sugar Cane Sustainability Fund in respect of the proceeds of bagasse an amount equivalent to his sugar entitlement";	contribution made to the Sugar Cane Sustainability Fund in respect of the proceeds of bagasse an amount equivalent to his sugar entitlement.
	(ii) in subsection (4), by inserting, after the word "planter", the words "or producer".	(4) The quantity of sugar, scums, molasses or bagasse to which a planter or producer is entitled under this section shall be determined by the Control and Arbitration Committee.

Note: * PART III of the SIE Act - Meaning of producer: **'producer'** means any of the producers listed in paragraph 2 below and includes any entity engaged in sugar cane growing or sugar milling activities which would result from the setting up of public sugar milling companies.

IMPLEMENTATION OF BAGASSE PRICE

Implementation of Rs 3.50/kWh for Crop 2021

For crop 2021 exceptionally bagasse proceeds were based on rate, Rs 3,300/t sugar as announced in budget 2021/2022.

Example:

Proceeds = 3,300 * 257,154.807 t sugar @98.5 %pol = Rs 848,610,863.10

Planters were distributed some 78% of proceeds= 0.7814*848,610,863.10 = Rs 663.1 M and;

Millers were distributed some 22% of proceeds = 0.2186 *848,610,863.10 = Rs 185.4 M

Implementation of Rs 3.50/kWh for the longer perspectives

The implementation of Rs 3.50/kWh for the longer perspectives would be based on Rs 3.50/ kWh rather than Rs 3,300/t sugar. The rate per tonne of sugar would be derived each year.

The rationale for this is that the energy needs to be remunerated and not the sugar. The proportion of fibre and sugar is inversely proportional and it makes sense to base bagasse proceeds on electricity export and distribution can be converted on a per tonne sugar basis as bagasse for each planter is not weighed at a factory.

Example:

Proceeds = Rs 3.50/kWh * 249,677,928 = Rs 873,872,748

Planters were distributed some 78% of proceeds:

= 0.7814 * 873,872,748 = Rs 682.8 M,

Millers were distributed some 22% of proceeds:

= 0.2186 * 873,872,748= Rs 191 M

The converted rate per tonne sugar basis is:

Rs 873,872,748 / 257,154.807 = Rs 3,398 / tonne sugar

Administrative arrangements

a. CEB will submit to the MCIA a statement on kWh export from bagasse: Provisional in November and a final in March of the following year
b. MCIA will work the proceeds and submit its claim to the Ministry of Finance, Economic Planning and Development for disbursement of funds in Sugar Cane Sustainability Fund: Provisional in December of the Crop Year and Final in March of the following year.
c. MSS will make payment to planters: A provisional in December of the Crop year and final in March of the following year.

PRODUCT EXCHANGE AGREEMENT

❑ Views of CEB

The commodity price of bagasse is presently remunerated by the CEB under the PPA's in consideration of the concept of the Product Exchange Agreement, i.e, the sugar mill supplies bagasse to the power plant in exchange of the investment made by the power plant to produce steam and electricity to manufacture sugar. The CEB is paying to the IPP's the sugar mill share of the fixed investment and the operational costs to produce steam and to generate electricity used to manufacture sugar. With the remuneration of bagasse at Rs 3.50/kWh to planters and producers as from crop 2021 in addition to the price payable to existing IPP's for bagasse energy under the concept of the Product Exchange Agreement, the same bagasse would be remunerated twice and would be passed through to both the taxpayers and the electricity consumers. To ensure that the price of bagasse energy is cost reflective and to minimize the financial impact on taxpayers and electricity consumers, the concept of the Product Exchange Agreement under the PPA's will have to be discontinued.

❑ Views of Millers

The miller expressed that if it has to pay for investment in a power plant and steam it would in turn pass on that cost to the planters and would claim a ratio higher than 22% as its entitlement for sugar. In that case, Government would have to review the sugar entitlement ratio of 78:22 between planter and miller.

The planters'' and millers'' entitlement are clearly defined under section 39 of the MCIA Act. It is clear that only excess bagasse that is obtained after manufacture of sugar and burnt to produce electricity for supply to the national grid has an economic value.

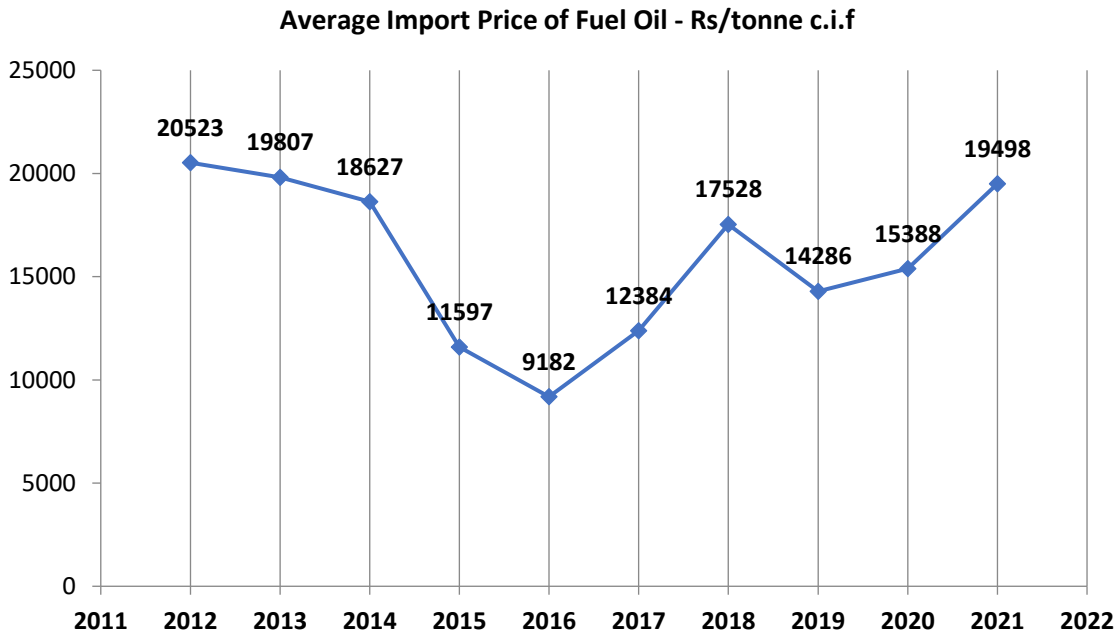
The Biomass framework, therefore recommends to Government and the negotiating parties (CEB and IPP's) to assess the merit of the statement made by the World Bank and all the efforts made by the Government to keep the sector afloat.

> *"The sugarcane sector incurs losses of approximately Rs1.35 billion annually. On a subsector level, nearly all the losses are borne by planters Rs 1,379 M, followed by millers Rs 629.4 M annually."*

Any changes to be brought through negotiations between parties or through a Government policy should not adversely affect the condition of the planters and the millers.

REFERENCE PRICE OF HFO

An assumed price of HFO of Rs 20,000/t was initially used to described the methodology. It takes into consideration past prices and the high price of oil in 2022, green premium and incentives to Planters.



Source: Adapted from CSO (2021) Energy and Water Statistics

Fig. A5.1 Average import price of fuel oil c.i.f

Table A5.1. HFO Price - CEB

Year	CEB - HFO 380 CST1 Rs/t CEB official Ref price	HFO with 15% Premium (Rs/t)	CEB - HFO 380 CST1 Rs/t CSO
2017	12,346	14,198	
2018	15,338	17,639	15,338
2019	14,194	16,323	14,194
2020	11,941	13,732	
2021	17,955	20,648	17,955
Average	14,355/4,927 2.91/kWh	16,506/4927 3.35/kWh	15,829/4,927 3.21/kWh

Source: Central Electricity Board

ELECTRICITY GENERATED BY THE CEB DURING THE PERIOD 2008 TO 2019

Table A6.1 Fuel input and generation output (Statistics Mauritius)

Year	Diesel + HFO Electricity Generated (GWh)	Fuel input for Electricity Generation (Tonne)			Calculated (kWh/t HFO)
		HFO	Diesel	Diesel + HFO	
2008	796.4	160359	1721	162080	4,914
2009	907.8	183678	2558	186236	4,874
2010	947.0	190108	1875	191983	4,933
2011	1028.4	207576	1354	208930	4,922
2012	1027.0	206146	1728	207874	4,940
2013	1044.1	208865	1190	210055	4,971
2014	1045.2	213588	1125	214713	4,868
2015	1094.5	221116	979	222095	4,928
2016	1072.9	215794	924	216718	4,951
2017	1142.3	230543	1181	231724	4,930
2018	1181.4	238222	753	238975	4,944
2019	1307.4	263801	558	264359	4,946
				Average	**4,927**

The year 2020 and 2021 were ignored due to the lockdown impact on electricity generation efficiencies.
A small percentage of diesel is used by the generators, assumed HFO.
Source: Adapted from CSO (2020)

NET POWER EXPORTED PER TONNE OF CANE TRASH

Power Plants in Mauritius can only mix a maximum of 15 % trash with bagasse before combustion in boiler furnaces. Hence, to estimate the value of trash, a spreadsheet model was developed to estimate net electricity export from trash, if 100% of trash is burnt as fuel.

The model is based on high-pressure boilers, 82 bar, 525^{o}C currently using bagasse as fuel. Since trash (15 – 25% moisture) is drier than bagasse (48% moisture), the gain in thermal efficiency is taken into consideration to calculate net electricity export to the grid.

The price of two categories of trash is shown in table A7.1. Ash content averages 10% or less, but not higher than 13%, and moisture not higher than 25%, which may be rejected by the Power Plant.

- Category A for moisture content ~15% to 20%, Rs 3,175/t.
- Category B for moisture >20% to 25%, Rs 2,888/t.

Table A7.1 Electricity export and value of trash

Moisture (%)	Electricity Export (kWh/t trash)	Trash Payment for 2 Categories
15	948.39	**Category A** Average Power Output between 15% to 20% moisture = 907 kWh/t **At Rs 3.50/kWh, Value of trash** **Rs 3,175/t**
16	931.94	
17	915.50	
18	899.07	
19	882.65	
20	866.23	
21	849.82	**Category B** Average Power Output between 20% to 25% moisture = 825 kWh/t **At Rs 3.50/kWh, Value of trash** **Rs 2,888/t**
22	833.42	
23	817.02	
24	800.64	
25	784.26	

Cost of trash collection and transport to the IPP gate

The price of trash collection and transport to the IPP gate is shown in Table A7.2.

Table A7.2 Monte Carlo simulation (5 x 100,000 scenarios)

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5
Std	130	130	130	130	130
Min	1,350	1,361	1,370	1,362	1,340
Mean	1,708	1,707	1,708	1,707	1,708
Max	2,154	2,155	2,153	2,139	2,135

Trash at IPP gate

1. Planters' registration number
2. Weight of trash on the weighbridge
3. Sample collected to test moisture and ash content

Power Plant Limitations and Quality of Trash

1. Ash content on average is 10%. The Power Plant may reject trash bales suspected to contain a higher amount of ash, visible by the heavy presence of soil, mud, or rocks.
2. If trash baling operations are carried out by a third party, the Power Plant must be able to check baling operations to ensure the quality of the biomass.

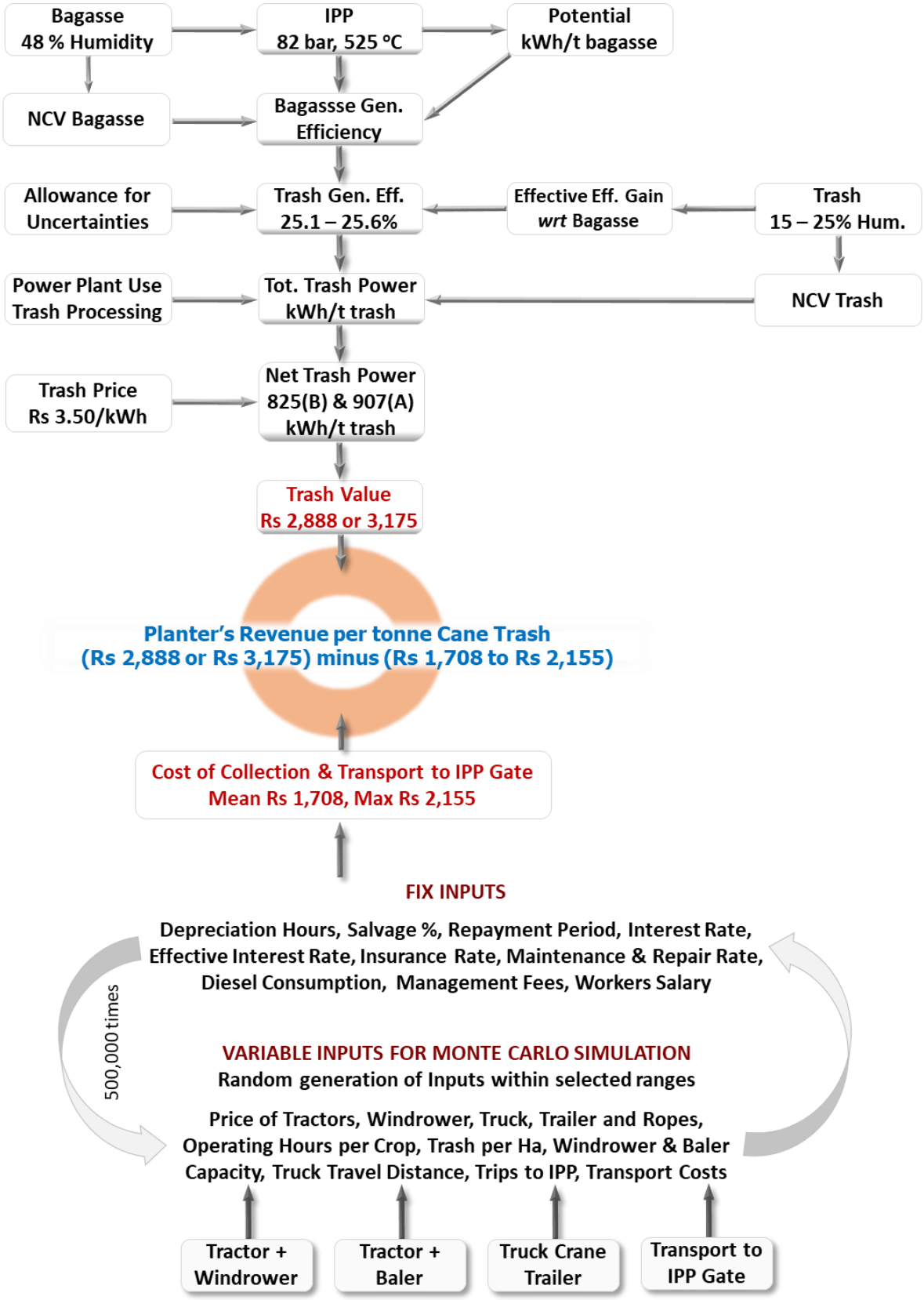


Fig. A7.1 The calculation process for trash pricing