Republic of Mauritius

TECHNOLOGY NEEDS ASSESSMENT

TECHNOLOGY ACTION PLAN & PROJECT IDEA REPORT FOR MITIGATION

ENERGY INDUSTRIES
TNA REPORT III & IV

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TNA REPORT III

TECHNOLOGY ACTION PLAN (ENERGY INDUSTRIES)

(March 2013)

Disclaimer

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Acknowledgements

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1. Ministry of Energy and Public Utilities (Central Electricity Board, Water Resources Unit, Wastewater Management Authority, Central Water Authority)
2. Ministry of Finance & Economic Development (Statistics Mauritius)
3. Ministry of Public Infrastructure, National Development Unit, Land Transport and Shipping (Land Transport Division, National Development Unit)
4. Ministry of Environment and Sustainable Development
5. Ministry of Industry, Commerce and Consumer Protection
6. Central Electricity Board
7. Enterprise Mauritius
8. University of Mauritius
9. Omnicane Management and Consultancy Limited
10. Energy Consulting IPA London
11. ECO-Bio-Tech
12. Mauritius Chamber of Commerce and Industry

List of Acronyms

BCR	Benefit-Cost Ratio
CDM	Clean Development Mechanism
CEB	Central Electricity Board
CER	Certified Emission Reduction
CF	Capacity Factor
CLD	Causal Loop Diagram
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent
EE	Energy Efficiency
EIA	Environmental Impact Assessment
EPA	Energy Purchase Agreement
ER	Emission Reduction
FDI	Foreign Direct Investment
FI	Financial Institution
FiT	Feed-in Tariff
GEF	Global Environment Facility
IPP	Independent Power Producer
IRR	Internal Rate of Return
kW	Kilowatt
kWh	Kilowatt hour
LC	Local Currency
LEMS	Leasing Equipment Modernisation Scheme
LPA	Logical Problem Analysis
LPG	Liquefied Petroleum Gas
MoEPU	Ministry of Energy and Public Utilities
MoFED	Ministry of Finance and Economic Development
MRV	Measuring, Reporting and Verification
MW	Megawatt
MWh	Megawatt hour

NAMA	Nationally Appropriate Mitigation Action
NGO	Non-Governmental Organisation
NPV	Net Present Value
OT	Objective Tree
PBT	Pay Back Time
PDD	Project Design Document
PPA	Power Purchase Agreement
PT	Problem Tree
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
RET	Renewable Energy Technology
Rs	Rupee (Mauritian)
SIPP	Small Independent Power Producer
SSDG	Small-Scale Distributed Generation
TAP	Technology Action Plan
TNA	Technology Needs Assessment
VAT	Value-Added Tax
WACC	Weighted Average Cost of Capital
WHR	Waste Heat Recovery

Executive Summary

This Technology Action Plan (TAP) Report is the synthesis of the two reports, namely: (1) Technology Needs Assessment (TNA) Report; and (2) Barrier Analysis and Enabling Framework Report that have been developed under the TNA project for Mauritius. It is the product of broad multi-stakeholder collaborative action. The leaning-by-doing methodology has been used throughout the duration of the TNA project, whereby training on the tools and methodologies developed in the project were provided to all stakeholders. These methodologies and tools can be used for developing Nationally Appropriate Mitigation Actions (NAMAs) for Mauritius using an evidence-based approach.

This report has presented an overview of the power sector of Mauritius, along with its associated GHG emission levels and trends, broken down per sector. In 2010, energy industries accounted to 60% of total emissions, the highest contributor before transport with 24.8%. The National Energy Strategy targets for the electricity mix to 2025 places the use of renewable fuel sources at 25% of the total, notably with the share of wind power increasing from 0% in 2010 to 8% in 2025. Energy Efficiency (EE) target for the stationary combustion of fossil fuels (e.g. boilers in commercial and industrial settings) does not exist. In this report, one Renewable Energy Technology (RET) and one EE measure have been prioritized for climate change mitigation, namely utility scale wind energy and energy efficient boilers, respectively.

The TNA project has not discussed the wind farms or installation of economizers as stand-alone projects. Instead, it has considered the cumulative installed wind energy capacity to 2025, and that of economizers to 2020, which is analogous to the programmatic approach for scaling-up emission reductions. This programmatic approach is aligned with the development of sectoral Nationally Appropriate Mitigation Actions (NAMAs) for Mauritius. The Technology Action Plan (TAP) has also discussed the use of performance-based emission reduction finance instrument for accessing multilateral and bilateral sources of funding, along with domestic funding to support the implementation of measures. Hence, the action plans for the energy industries may be used for attracting funding for supported NAMAs.

Barriers for technology diffusion are for the most part financial: (1) wind technology investment is capital intensive, can be financially un-viable depending on tariffs for the sale of electricity, (2) initial investment in boiler economizers is high. In the case of boiler economizer, the non-financial barriers have been valued. This report therefore proposes the following measures and enabling framework for overcoming barriers and generating attractive investment opportunities:

Wind Technology	Energy Efficient Boilers
Measures	
A cost-reflective dynamic Feed-in Tariff (FiT) as a financial support scheme, supported by a wind-energy resource map that permits to determine the electricity generation capacity of wind-farms at different locations.	Support the uptake of economizers through the provision of energy audits, a rebate scheme on capital investment, and training of energy managers.
Enabling framework	
Guaranteed access to the grid supported by a Utility Regulatory Authority (URA), business permit facilitation, provision of financial and banking services	Provision of financial and banking services, EE promotion services, consulting services

The TAP for utility-scale wind energy is summarised below. The penetration of wind technology is aligned with the Long-Term Energy Strategy 2009-2025 with a total installed wind capacity equal to 100MW in 2023. The provision of financial incentive in the form of a Feed-in-Tariff (FiT) is recognized as a policy instrument for de-risking investment in renewable energy technologies. The benefit-cost ratio is a high 4.84 showing the net worth of investing in the financial incentive. The benefits of wind technology have been taken as: (1) CO2 emission reductions; (2) jobs created; and (3) savings on national energy bill. The cumulated emission reduction to 2025 has been calculated as 1,640,856 tCO2. The table identifies the main stakeholders, time frame for implementation of action plan, selected indicators of success and the main risks associated with the implementation of the action plan.

Barrier Category	Barriers	Potential measures, cost and capitalization	Concerned Institutions	Time Frame
Economic & Financial (wind technology is financially not viable)	High Cost Capital Inappropriate financial incentives	Provide financial incentive in the form of cost-reflective FiT for de-risking investment in wind energy technology. **Cost of action:** Rs 937,695,079 (NPV) **Benefit –cost ratio:** CBR = 4.84 **Sources of funding:** • Public financing through carbon tax on fossil fuels; • Multi-lateral or bilateral funds for implementing FiT as a supported NAMA	Ministry of Finance and Economic Development; CEB, Ministry of Energy and Public Utilities; Ministry of Environment and Sustainable Development. The roles and functions of these institutions are	0-13 years

Indicators of success (selected):
- Installed capacity (MW)
- % penetration of wind in the national grid
- Wind electricity generated annually (MWh/yr)
- Grid emission factor
- Annual emission reduction by wind (tCO2/yr)
- Number of jobs created
- Monetary value of fossil fuel import substitution (Rs/yr)
- Annual value of financial incentive disbursed for each project (Rs/yr)

Risks associated with action plan:

Regulatory risk: The setting up of the URA may be further delayed that would slow down the penetration of wind energy due to lack of transparency in the setting of electricity tariffs and contract negotiations;

Financial risk: The FiT scheme is predicated upon the availability of substantial amount of funding, and funding on a regular and timely basis. This is important in the context that guaranteed access to the grid will be granted for 15 years;

Wind potential risk: There is a risk that wind energy potential assessment is not completed or delayed in its implementation that would jeopardize site selection for wind farms;

Social risk: Mauritius is a small island and there is a high likelihood that suitable wind farm sites may be close to communities, environmentally sensitive areas, have detrimental impacts on bird life; be seen to be aesthetically unpleasant, among others. Wide-scale communication campaigns will be necessary and communities must be engaged at the early stage of wind project development;

Technical risk: There is a low risk that the technologies adopted by promoters do not respond well in the cyclonic conditions that may prevail over Mauritius periodically; and
Operational risk: The penetration of wind energy is predicated upon the increase in base load power production in the network. The targets set for the penetration of wind energy to 2025 is therefore dependent upon the timely commissioning of other power generation units detailed in the Long-Term Energy Strategy 2009-2025.

The action plan for economizer seeks to retrofit a total of 115 economizers on boilers burning either diesel (61) or LPG (54) between 2013 and 2020. The annual CO2 emission reduction in the Mauritian context has been calculated at 54.2 tCO2 and 18.3 tCO2 for retrofitted boilers running on diesel and LPG, respectively. The main financial measure seeks to provide a 20% rebate on the capital cost of an economizer. The net Present Value (NOV) of the three measures proposed here is Rs 33,190,975, which also takes into account the cost of operation and maintenance (O&M). The benefits consist of: (1) CO2

Barrier Category	Barriers	Potential measures, cost and sources of funding	Concerned Institutions	Time Frame
Economic & Financial	High Cost Capital Inappropriate financial incentives and disincentives	Government to provide financial incentives in the form of a rebate scheme on capital investment implementing rebate scheme as a supported NAMA	Ministry of Finance and Economic Development; Ministry of Industry. Please see Annex 2 for	0-7 years

Indicators of success (selected):
- Number of economizers installed (with full specification)
- Quantity of fuel saved annually for by each economizer (tonne fuel / year)
- Annual emission reduction by each economizer (tCO2/yr)
- Number of jobs created
- Monetary value of energy saved (Rs/year)
- Annual value of financial incentive disbursed for each project (Rs/yr)
- Number of energy managers trained (number per year)
- Number of audits carried out

Risks associated with action plan:

Financial risk: The action plan is predicated upon the availability of substantial amount of funding on a regular and timely basis. There is a low risk that sufficient funding may not be available;

Operational risk: There is a low-to-medium risk that the technologies adopted by promoters are not operated and maintained adequately leading to premature failure and reduced confidence in technology; and

Human capacity risk: Since qualified energy auditors and energy managers are in short supply in Mauritius, there may be a high turn-over of such skilled staff once they have been trained;

1. Technology Action Plan for Energy Industries

1.1 Actions at sectoral level

1.1.1 Short sector description

1.1.1.1 Introduction

The generation of electricity has grown by 4-5% annually over the past decade in order to match demand (see Figure 1), reaching 2,687.7 GWh in 2010. Thermal energy currently generates 96.2% of this electricity and primary sources like hydro and wind the remaining 3.8%.

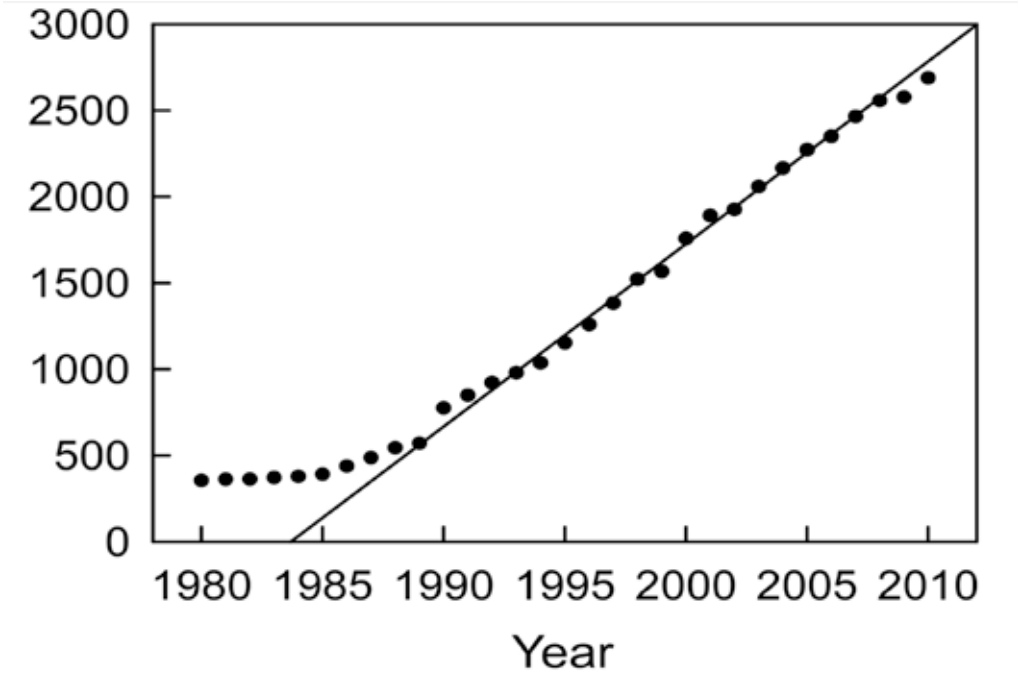

Figure 1: Electricity generation in Mauritius, 1980-2010 (Source: CSO – Digest of Energy and Water Statistics – various, Energy and Water Statistics – 2009 and 2010).

In 2010, bagasse, a renewable source of biomass obtained after sugar cane is crushed to extract its juice, accounted for 20.5% of total electricity generation (and 21.3% of all thermal generation). Fossil fuels, such as coal (38.7%), and diesel & heavy fuel oil (36.3%), accounted for 75% of electricity generation. The combination of hydro and bagasse meant that the share of renewable energy in the electricity mix of Mauritius (island) was 24.3% in 2010. The renewable component of the electricity mix is vulnerable to the impacts of climate variability, especially during periods of drought when reduced precipitation has adverse impacts on hydro-electric generation, as well as reducing the yield of sugar cane, and hence, bagasse. In such circumstances, demand for electricity is met by adding more fossil fuels in the electricity mix.

Public and private generation of electricity

Electricity is produced both by CEB and IPPs. In 2010, the CEB and IPPs generated 44.9% and 55.1%, respectively, of all electricity on the island of Mauritius. In fact, IPPs have generated more than 50% of total electricity needs of the country since 2007. This breakdown shows the prominent role of both the public utility and private producers in addressing emission reductions in the power sector.

Final electricity consumption

Since the generation of electricity is the main source of CO2 emissions, a better understanding of the end uses of electricity can assist in identifying mitigation technologies for demand-side management. Figure 2 shows the breakdown in final electricity use in 2010. Three activities – domestic, commercial and industrial – account for over 98% of electricity use, and each activity uses approximately one third of total electricity. In terms of identifying mitigation technologies in the power sector, it would then be worthwhile investigating the potential of demand-side management in these three sectors.

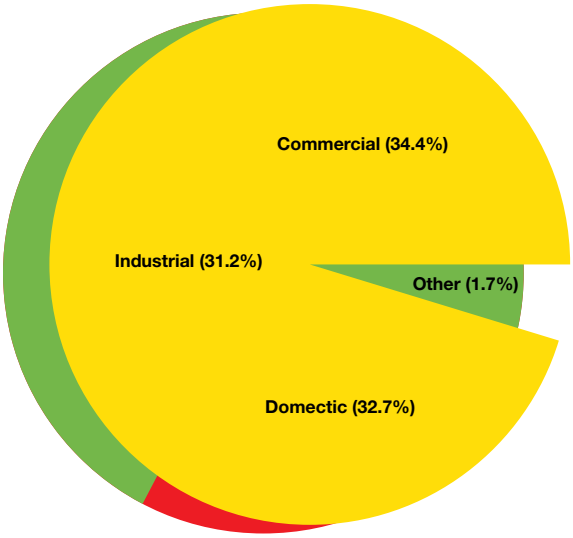

Figure 2: Breakdown of final electricity use, 2010 (Source: CSO, Energy and Water Statistics – 2010).

National CO2 Emissions

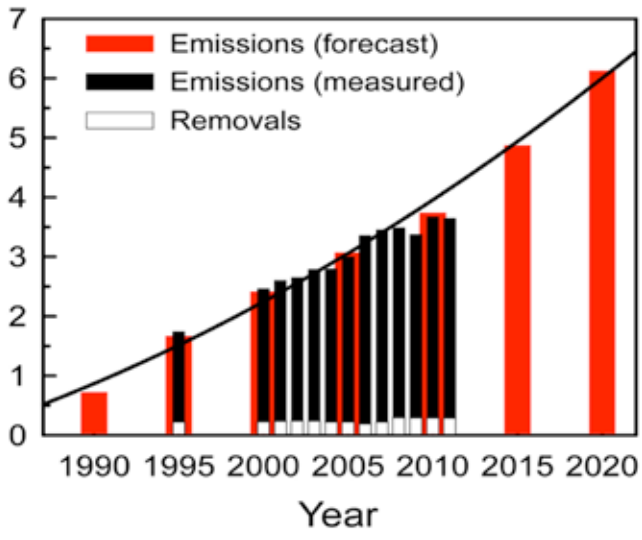

Figure 3: Projected (red) and measured (black) emissions of carbon dioxide (Sources: CSO, Energy and Water Statistics (annual indicators); Initial National Communication under the UNFCC, 1999).

The red bars in Figure 3 show the Business-As-Usual (BAU) emission scenario until 2020 reported in the Initial National Communication under the UNFCCC for Mauritius (GOM, 1999). The solid bars are the measured national emissions, while the open solid bars relate to removal by sinks. It can be seen that the emissions forecast in 1998 are still relevant, baring the dip in emissions in 2009 which followed the global trend due to the global financial crisis. Two pertinent observations can be made from Figure 3: (1) the trend in past emissions closely matches the BAU scenario. If this trend continues, per capita emissions may reach ~4.5 tCO2 in 2020, and if extrapolated to 2050 will lead to a per capita emission equal to 10.25 tCO2; and (2) there is limited scope in Mauritius for the sequestration of CO2 by sinks. This means that emission reductions at source will be the predominant means of future reductions in CO2 in Mauritius.

Sectoral breakdown of CO2 emissions

Table 1 summarises CO2 emissions in five sectors for the past 3 years both in absolute terms and as percentages. The largest source of CO2 emissions is from the burning of fossil fuels to produce electricity – i.e. Energy Industries. This sector accounts for around 60% of national CO2 emissions.

Table 1: Sectoral CO2 emissions from fuel combustion activities, Republic of Mauritius, 2008-2010

Sector	2008		2009		2010[1]	
	Quantity (1000 t)	%	Quantity (1000 t)	%	Quantity (1000 t)	%
Energy industries (electricity)	2,032.0	58.3	1,997.0	59.3	2,158.3	60.3
Manufacturing industries	456.0	13.1	351.6	10.4	360.4	10.1
Transport	813.0	23.3	844.8	25.1	887.0	24.8
Residential	131.0	3.8	122.8	3.6	135.6	3.8
Other (incl. Agriculture and Trade)	53.8	1.5	49.1	1.5	39.7	1.1
Total	**3485.8**	**100.0**	**3,365.3**	**100.0**	**3,581.0**	**100.0**

2009 by the author). [1] *Provisional.*

1.1.1.2 Preliminary targets for technology transfer and diffusion

The Long-Term Energy Strategy 2009 – 2025 provides the blueprint for the development of the energy sector in Mauritius (Ministry of Renewable Energy & Public Utilities, 2009). Further, the Energy Strategy 2011-2025 Action Plan (please see Annex 2 of TNA Report) provides the future orientations of Mauritius concerning GHG emission reductions from a combination of energy efficiency measures and renewable energy technologies. There are no economy wide energy targets, but targets for RETs and EE do exist for electricity generation and consumption. These targets are summarised in Table 2 and Table 3, respectively. Table 2 shows the electricity mix between 2010 and 2025, while Table 3 shows the cumulative EE target in the electricity sector relative to the 2008 baseline year.

Table 2: Electricity mix targets, 2010-2025.

Fuel Source		Percentage of Total Electricity Generated			
Renewable		**2010**	**2015**	**2020**	**2025**
	Bagasse	16	13	14	17
	Hydro	4	3	3	2
	Waste-to-Energy	0	5	4	4
	Wind	0	2	6	8
	Solar PV	0	1	1	2
	Geothermal	0	0	0	2
Sub-total		20	24	28	35
Non-renewable	Fuel oil	37	31	28	25
	Coal	43	45	44	40
Sub-total		80	76	72	65
TOTAL		**100**	**100**	**100**	**100**

Table 3. Energy efficiency targets in the electricity sector, 2010-2025.

Year	2010	2015	2020	2025
Target (%)	2	4	6	10

1 The Energy Strategy 2011 – 2025 Action Plan can be downloaded at http://www.gov.mu/portal/site/mpusite - accessed 5 February 2012.

EE targets for the stationary combustion of fossil fuels (e.g. boilers in commercial and industrial settings) do not exist. The updated Energy Strategy Action Plan 2011-2025 mentions that guidelines for energy management in industry would be developed in 2012, and for mandatory energy audits to be carried out in industry as from 2013. Further, the Action Plan states that EE programmes based on voluntary agreements would be created for industry between 2011 and 2014.

1.1.2 General barriers and proposed measures

General barriers are for the most part financial barriers – (1) wind technology investment is capital intensive, can be financially un-viable depending on tariffs for the sale of electricity, (2) initial investment in boiler economizers is high and can present some technical difficulties which often discourages operators from implementing the measure. Regulatory, operational and technical barriers also exist which limit the diffusion of the RET and EE technologies. These are often related to institutional and human capacity barriers.

Selected technologies

It is pointed out that several mitigation technologies are not applicable in Mauritius because of a combination of context (e.g. climatic conditions implying no need for heating; topography that limits hydro-electricity; feed-in-tariffs to promote micro-generation of renewable energy technologies in place); technology already adopted (e.g. CFL and solar water heating for household and industrial applications); low socio-cultural acceptability (e.g. solar cook stoves); and/or the stage of development of Mauritius (e.g. use of modern fuels like LPG for cooking automatically excludes biomass/coal/kerosene cook stoves). Since barriers for the uptake and diffusion of utility-scale PV in Mauritius are currently being addressed , the TAP will focus only on utility-scale wind energy technology and waste heat recovery in boilers.

Proposed measures:

A range of generic policy instruments are available for the promotion of RETs including utility-scale wind energy (REN21, 2008). A brief description of the main policy instruments is summarized in Table 4.

Table 4. Renewable energy promotion policies.

Policy instrument	Brief description
Feed-in Tariff (FiT)	A policy that sets a fixed guaranteed price at which power producers can sell renewable power into the electric power network. Some policies provide a fixed tariff while others provide fixed premiums added to market- or cost-related tariffs
(RPS)	Also called renewables obligations or quota policies. A standard requiring that a minimum percentage of generation sold or capacity installed be provided by renewable energy. Obligated utilities are required to ensure that the target is met
Capital subsidies, grants, or rebates	One-time payments by the government or utility to cover a percentage of the capital cost of an investment, such as a solar hot water system or rooftop solar PV system
Investment or other tax credits	Allows investments in renewable energy to be fully or partially deducted from tax obligations or income
Sales tax, energy tax, excise tax, or VAT reduction	Various forms of indirect fiscal incentives given to investors on procurement of RET equipment and parts, and tax incentive on energy used to develop RET project
Tradable renewable energy certificates	Each certificate represents the certified generation of one unit of renewable energy (typically one megawatt-hour). Certificates provide a tool for trading and meeting renewable energy obligations among consumers and/or producers, and also a means for voluntary green power purchases

Energy production payments or tax credits	Provides the investor or owner of qualifying property with an annual tax credit based on the amount of electricity generated by that facility
Net metering	Allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. The customer pays only for the net electricity used
Public investment, loans, or financing	Capital financing provided by the public sector either directly in a project or as a loan
Public competitive bidding	Open and transparent public procurement processes that promotes competitive bidding for renewable energy projects. This is part of providing an environment conducive for capital investment in RETs

As the two technologies retained pertain to two different types of mitigation measures, namely RET with wind technology and EE with boiler heat recovery, no one policy instrument can be entirely applicable to both. However, they both require substantial investment. FiTs are more suited for attracting investors and diffusing a RET with appropriate tariff setting as discussed in section 1.2.3.2. A rebate scheme (financial incentive) is fitting for the EE measure since upfront investments often discourage implementation of the measure – in the case of boiler economizers (heat recovery), a 20% rebate scheme on the capital investment is recommended as a rebate scheme (see section 1.3.4.1). This rebate scheme will be complementary to the Leasing Equipment Modernisation Scheme (LEMS) that is operated by the DBM. Details of the LEMS can be found at Annex 1.

Important non-financial measures exist to support the diffusion of RET and EE within the power sector of Mauritius which apply to both: reinforcing regulatory frameworks, institutional and human capacity can lead to better penetration and lift technical and operational barriers.

1.2 Action Plan for Wind Technology

1.2.1 About the technology

A utility-scale wind turbine primarily consists of a main supporting tower upon which sits a nacelle (the structure containing the mechanical to electrical conversion equipment). Extending from the nacelle is the large rotor (three blades attached to a central hub) that acts to turn a main shaft, which in turn drives a gearbox and subsequently an electrical generator (see Figure 4). In addition to this there will be a control system, an emergency brake (to shut down the turbine in the event of a major fault) and various other ancillary systems that act to maintain or monitor the wind turbine.

Modern turbines reach a conversion efficiency of approximately 50 percent, close to the theoretical limit (59%) and very close to the practical limit that is imposed by the drag of the blades. Nevertheless there is a significant body of on-going global R&D into construction methods/materials for larger turbines, conversion efficiency refinements, lower cost components and improved reliability. The energy

used and GHG emissions produced in the direct manufacture, transport, installation, operation and decommissioning of wind turbines are small compared to the energy generated and emissions avoided over the lifetime of wind power plants: the GHG emissions intensity of wind energy is estimated to range from 8 to 20 g CO2/kWh in most instances, whereas energy payback times are between 3.4 to 8.5 months (Wiser, et al., 2011).

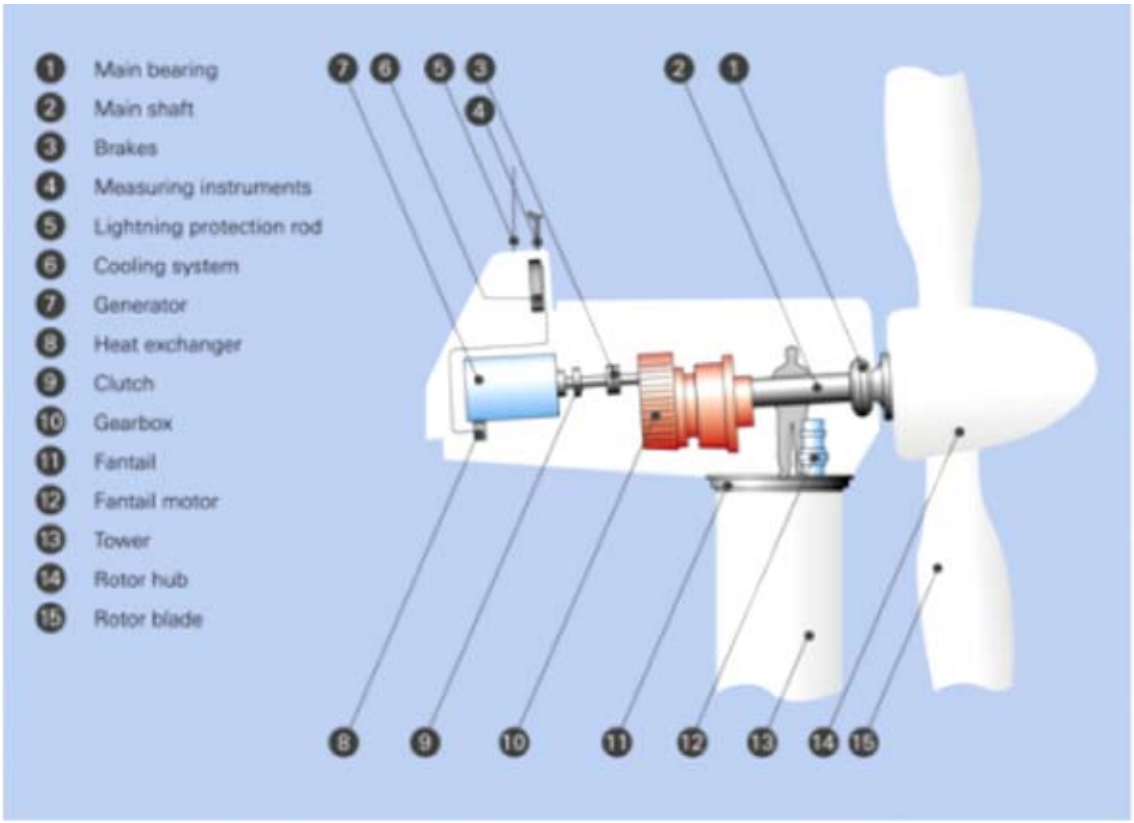

Figure 4. Transverse view of a typical wind turbine (source ZF, 2010).

The main issue related to applicability of wind technology in Mauritius is its suitability to operate in cyclonic conditions, when wind gusts exceeding 250 km/hr can be experienced. This is a serious issue since wind energy demonstration projects in the 1980s were damaged by cyclones (Palanichamy, Sundar Babu, & Nadarajan, 2004). Hence, turbines with wind Class II ratings would be needed for weather conditions of Mauritius. One example is the newly designed 1 MW GEV HP wind turbine by Vergnet that is proposed to be installed in Mauritius at Plaine des Roches that can withstand Category 5 hurricanes (i.e. wind speeds up to 300 km/hr). Suzlon's Class IIa S95-2.1MW generator is also expected to be used at Plaine Sophie. The 2-blade rotor is designed such that it can be lowered with minimum effort during cyclones.

1.2.2 Target for technology transfer and diffusion

For wind energy, the updated Energy Strategy Action Plan 2011 – 2025 provides a timeline for installed capacity, as summarized in Table 5. The target proposed for the diffusion of utility-scale wind energy in this report is aligned with that shown in Table 5. It is pointed out here that the TNA project has not discussed the different wind farms as stand-alone projects. Instead, the TNA project has considered the cumulative installed wind energy capacity to 2025 that is analogous to the programmatic approach for scaling-up emission reductions. This programmatic approach may also be seen as a sectoral NAMA for Mauritius.

Table 5. Installed wind capacity to 2025, MW.

Year	2013	2014	2017	2020	2023	Total
(MW)	22	18	20	20	20	100

1.2.3 Barriers and enabling framework for wind technology diffusion

This section provides a short description of the barriers and an extensive discussion of the enabling framework that would help to overcome them. Sections 1.2.3.1 and 1.2.3.2 discuss in brief the financial and non-financial barriers, respectively, while section 1.2.3.3 discusses the enabling framework that is required to overcome the barriers. Detailed barrier analysis for wind technology can found in section 1.2.2 of RII – Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012).

1.2.3.1 Economic and financial barriers for wind technology

Investing in utility-scale wind energy is capital intensive and an investor's perspective is rather on ROI (defined in IRR terms) that is intricately linked with the issue of differential tariff that would be proposed to prospective investors for the sale of electricity to the CEB. The need for financial instruments to address barriers and reduce investment risks are already recognized by policy makers (DB Climate Change Advisors, 2011). Further, the updated Energy Strategy Action Plan 2011 – 2025 proposes two supporting initiatives, namely: (1) the setting of cost-reflective electricity tariffs and financial support schemes for renewables over the 2012-2013 timeframe, and (2) introducing preferential FiTs for electricity generation from renewable energy sources for plants above 50 kW. Lessons learned from the FiT scheme for SSDGs can be used to inform a FiT for utility-scale wind energy.

3 The differential tariff would be compared against the cheapest alternative to provide an equivalent amount of electricity. In the case of Mauritius, the cheapest option would be coal. It should be noted that the updated Energy Strategy Action Plan 2011 – 2025 (http://www.gov.mu/portal/goc/mpu/file/plan2806.doc or Annex 2 of TNA Report) already makes provision for increased coal-fired power plant capacity by 100 MW by 2015.

1.2.3.2 Non-financial barriers for wind technology

The main non-financial barriers have been identified as either the lack of or low-level of: (1) a regulatory framework; and (2) a detailed wind atlas. It has been argued in RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012) that the use of the PPP modality for developing wind farms in Mauritius is a useful one to overcome shortcomings in human and institutional capacity. Operational barriers are not expected to pose a problem for the diffusion of utility-scale wind energy with the proposed increase in base load power generation, and as long as grid stability is closely monitored with the increasing penetration of wind energy.

Regulatory framework: Currently, Mauritius lacks a strong, independent regulator. The Utility Regulatory Authority Act 2004 (No. 42 of 2004) provides for the establishment and management of a Utility Regulatory Authority (URA) that would act as an independent regulator. Despite the presence of supportive legal and policy frameworks, the URA is yet to be set up.

Wind energy resources assessment: The lack of a wind energy resources atlas has two consequences: (1) potential investors do not have a good understanding of practical wind-energy development in Mauritius; and (2) it makes it difficult to set up a dynamic FiT for wind energy for Mauritius.

1.2.3.3 Enabling framework for overcoming the barriers for wind technology

The enabling framework encompasses the set of resources and conditions within which the technologies and target beneficiaries operate. In particular, it is those resources and conditions that are generated by structures and institutions that are beyond the immediate control of the beneficiaries that are relevant here. In ideal situations, the enabling framework should provide the environment conducive for the transfer and diffusion of mitigation technologies. This section discusses the vital elements of the enabling framework that should be improved to enhance the diffusion of wind technology. More details can be found in section 1.5.1 of RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012).

Characterization of the technology supply chain shows that wind technology is not anticipated to be manufactured in Mauritius, and nor would there be any need for intermediaries in supplying the technology. Utility-scale wind technology requires state-of-the-art fabrication technology and know-how that is unlikely to be acquired locally by 2025. It is, therefore, assumed that the technology will be imported from major manufacturers, most probably through the PPP modality. Under this modality, the entire suit of engineering solution required for the installation, commissioning, operation and maintenance of utility-scale wind farms will be transferred to Mauritius.

Since the technology would be transferred from overseas, there would be the requirement for business facilitation. The BOI, as per its mandate, is identified as the first point of contact for potential investors that can provide this business and extension service. In Mauritius, any foreign investor would require a business permit for setting up its operations in Mauritius, and this permit is delivered by the BOI.

4 http://www.ecolex.org/ecolex/ledge/view/RecordDetails;jsessionid=6460735005F01E25DADDE93E5FD35A84?id=LEX-FAOC062183&index=documents – accessed 10 December 2012.

Another service provided by the BOI is the marketing of Mauritius as a destination for foreign investment. Consequently, the BOI must be fully capacitated to market investment in wind energy in Mauritius, and work in close collaboration with the key stakeholders identified in Annex 2 to issue business permits. The latter is not an issue since as discussed in section 1.2.2 in RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012) two wind farms are already considered under the PPP modality.

Market information is required in order to lower the transaction costs of wind energy developers to a minimum. The type of information that would be required are: (1) wind energy resources potential in Mauritius – i.e. wind atlas – that would allow identification of most promising sites for wind energy development and allow potential project developers to develop their financial model based on practicable wind electricity generation capacity. This service should be provided by the Ministry of energy and Public Utilities, which is the parent ministry for overseeing the implementation of the Long-Term Energy Strategy 2009-2025 of Mauritius (Ministry of Renewable Energy & Public Utilities, 2009). Other institutions that can be involved in developing a wind atlas are the Mauritius Research Council (MRC) and the University of Mauritius (UoM). The geographical spread of wind energy potential is constrained by topography, land use plans, interference with civil aviation and other telecommunication systems, and proximity to sub-stations and HV transmission lines for grid interconnection. Hence, information about these constraints is required to inform the market development of utility-scale wind energy.

Awareness and information about wind technology would also be targeted at local communities for enhancing the social acceptability of this new technology. Such awareness would be crucial at the stage of public consultations that are mandatory during the process of obtaining an EIA. Training and capacity building will be targeted mainly to provide skilled technician for the maintenance of wind technology. The banking sector is well-developed in Mauritius, and commercial banks are expected to provide financial and banking services. This service is not anticipated to be an issue once the de-risking policy instrument – i.e. FiT – has been established, and long-term grid access is provided to developers. Annex 2 shows how different stakeholders can provide business and extension services for the development of utility-scale wind energy in Mauritius.

The main enabling framework for removal of barriers to promote utility-scale wind technology is composed of: (i) providing financial incentives to operators, and (ii) contract management for guaranteed access to the national grid and other legal and commercial clauses as stipulated in an EPA. These are the two components of a de-risking methodology that was discussed in section 1.2.3 of RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012). The financial incentive is further discussed in section 4.2.4. Monetary policy will influence both the exchange rate of the local currency relative to major currencies. This would be a critical issue in tariff pricing in circumstances when investors would contract loans in foreign currency, whereas payments on electricity produced would be paid in LC. Also, monetary policy will influence the inflation rate that would affect the long-term pricing of wind-generated electricity. Fiscal policies in terms of corporate tax, VAT and import duties will also influence investment and return on investment. Corporate tax is applied at a flat rate of 15% in Mauritius and is unlikely to change considering that it is already low. It has been assumed here that since utility-scale wind technology will benefit from a FiT, the technology will operate under the existing VAT and import duty regime.

1.2.4 Proposed action plans for Wind Technology

The action plan for the diffusion of utility-scale wind energy is derived from to the measures that are discussed in section 1.2.3 of RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012). For each action or measure, the following information has been provided: (1) why the measure/action is needed; (2) who is responsible for the measure (government agency, private sector etc.); (3) timeframe for implementation (0-5 years, 5-10 years, or 10-20 years); (4) cost of the action, and how can it be funded (domestic funding, or international funding); and (5) indicators of success, and risks.
The measures that were identified for wind technology are:

1. Financial incentive in the form of FiT that would cover the incremental cost of the preferential tariff;
2. URA is set up as an independent energy regulator and it is fully functional and capacitated to fulfil its mandate ; and
3. Establish a wind energy resources atlas that will provide the multiple benefits of: (i) providing visibility to potential investors; (ii) forming the basis for establishing a dynamic FiT scheme; and (iii) allow the determination of the threshold wind energy potential needed for the technology to be financially viable.

As discussed in section 1.2.2.2 of RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012), the regulatory framework for setting up the URA has been in place for several years. The setting up of the URA will take place through a political process, and it was decided by stakeholders that this was beyond the scope of this study. The representative of the Ministry of Energy and Public Utilities highlighted that the Government of India is currently assisting the MoEPU to carry out wind energy resources assessment and to develop the wind atlas for Mauritius. Hence, the cost of this measure has not been accounted for in order to avoid duplication.

So the action plan for utility-scale wind energy will cover the financial incentive that would be required for de-risking the investment environment, which is arguably the most significant barrier for the technology diffusion and up-scaling.

1.2.4.1 Why is financial incentive needed for wind technology

A commercially unattractive investment opportunity can be converted into a commercially attractive one through two actions: (i) reducing the risk of the activity through say a regulatory policy – e.g. guaranteed access to the grid for IPPs; and (ii) increasing the ROI by creating financial incentives – e.g. FiT for renewable energy (Glemarec, Rickerson, & Waissbein, 2012). The FiT proposed here will overcome the investment barrier for wind energy technology. It is pointed out that the financial implication of a guaranteed access to the grid is the cumulative cost of the incentive over the duration of the guaranteed access, and hence it does not carry any incremental costs.

1.2.4.2 Who is responsible for the incentive needed for wind technology

The national electricity is owned and managed by CEB. The contract for the sale of wind electricity will be between the wind farm owner and the CEB. Since the mandate of CEB is to offer reliable electricity at the lowest cost, it is unlikely that CEB will pay the incremental cost of the FiT, as is the case for SSDG installations. The Ministry of Finance and Economic Empowerment will be responsible for paying the incremental cost of wind electricity

1.2.4.3 Timeframe for the implementation of FiT for wind technology

The timeframe used in the TNA project for the energy industries is aligned with the time period of the Long-Term Energy Strategy 2009-2025 (Ministry of Renewable Energy & Public Utilities, 2009). Hence, the timeframe for the implementation of the FiT scheme is aligned with the targets set in Table 5, and would therefore cover the period 2013 to 2025.

1.2.4.4 Cost of FiT for wind technology

The detailed benefit-cost analysis of the proposed FiT is given in section 1.2.3.1 of RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012). The cost of this measure is the incremental cost of the preferential tariff or FiT for a total of 100MW installed capacity by 2023 as shown in Table 5. Hence, the cost of the measure is taken as Rs1.5/kWh (i.e. Rs6/kWh – Rs4.5/kWh). Based on a cumulative electricity generation between 2013 and 2025 equal to 1,656,621 MWh, and using a discount rate of 14%, the NPV of the cost of the measure has been calculated as Rs 937,695,079. This cost excludes the effect of inflation and learning curve of wind energy technology that would lead to cost parity over the long-term. It has also assumed that a FiT of at least 15 years would be provided to investors, while the period studied here is 13 years.

Benefit-cost ratio

By considering the benefits of: (1) global environmental benefit from GHG emission reduction using the long-term price of CO2e; (2) incremental job creation; and (3) reduction in energy bill through import substitution, the financial measures gives a benefit-cost ratio equal to 4.84. This shows that the benefits of the financial measures far outweigh its direct costs. The benefit-cost ratio can be expected to be higher since it would be reasonable to expect that both the price of emission reduction and imported fossil fuels would increase in the future, thereby increasing the monetary value of benefits.

Capitalization is of key importance for the financial sustainability of any FiT initiative. So, an integral part of the measure should be to identify clearly utility cost-recovery processes (DB Climate Change Advisors, 2011). This constitutes an important aspect of providing security, and hence confidence, to investors. In the present case, several sources of funding can be considered:

- The FiT scheme can be capitalized using carbon taxation on all fossil fuels as is presently the case for the MID Fund. Where appropriate the taxation level may be increased to increase the revenues to cross-subsidize the FiT scheme;
- The FiT scheme can also be funded as a policy NAMA. In this case, the evidence provided by the TNA project may be used to seek multi-lateral and/or bilateral funding for implementing the FiT scheme(partially or fully) as a supported NAMA. What should also be explored is to set up a performance-based emission reduction finance mechanism for the release of funding. In this case, the programmatic approach adopted here would require a stringent MRV system, the elements of which are discussed in the next section.

1.2.4.5 Indicators of success for wind technology and risks

Indicators are required to monitor and evaluate the implementation of the action plan. Although, the measure considered above was financial incentive in the form of a FiT, the indicators of success summarised in Table 6 coves all the aspects of the enabling framework discussed in section 1.2.3. For the MRV system that is linked to the performance-based finance instrument, details about emission reductions are required. It is proposed that the tried-and-tested methodologies of the CDM for calculating emission reduction be adopted.

Table 6 also summarizes the risks associated with the wind technology action plan.

Table 6. Indicators of success and risks for wind technology action plan.

Project component	Objectively Verifiable Indicators
Set up contract management for guaranteed access to the national grid and other legal and commercial clauses as stipulated in an EPA	• Number of enquiries • Number of contracts • % utilisation of grid by wind power
Market information (mainly in terms of wind energy resources potential in Mauritius and other constraints)	• Rate of information consultation • % utilisation of onshore wind energy potential • Installed capacity • Monetary value of import substitution of fossil fuel • Number of jobs created
Provide financial incentives to operators	• Number of enquiries • Tariff setting indicators (annual value of incentive disbursed) • Amount of MWh produced
Enable business permit facilitation (Board of Investment)	• Number of enquiries • Number of permits allocated
Provision of financial and banking services (commercial banks)	• Services provided by type • Services provided by scale
Awareness and information about wind technology mostly targeted at local communities	• Information campaigns by type • Number of stakeholders reached by type
Emission reduction	• Grid emission factor • Quantity of CO2 reduced (tCO2)

Risks associated with action plan

Regulatory risk: The setting up of the URA may be further delayed that would slow down the penetration of wind energy due to lack of transparency in the setting of electricity tariffs and contract negotiations;

Financial risk: The FiT scheme is predicated upon the availability of substantial amount of funding, and funding on a regular and timely basis. This is important in the context that guaranteed access to the grid will be granted for 15 years;

Wind potential risk: There is a risk that wind energy potential assessment is not completed or delayed in its implementation that would jeopardize site selection for wind farms;

Social risk: Mauritius is a small island and there is a high likelihood that suitable wind farm sites may be close to communities, environmentally sensitive areas, have detrimental impacts on bird life; be seen to be aesthetically unpleasant, among others. Wide-scale communication campaigns will be necessary and communities must be engaged at the early stage of wind project development;

Technical risk: There is a low risk that the technologies adopted by promoters do not respond well in the cyclonic conditions that may prevail over Mauritius periodically; and

Operational risk: The penetration of wind energy is predicated upon the increase in base load power production in the network. The targets set for the penetration of wind energy to 2025 is therefore dependent upon the timely commissioning of other power generation units detailed in the Long-Term Energy Strategy 2009-2025.

1.2.4.6 Summary of wind technology action plan

The action plan for utility-scale wind energy is summarised in Table 7.

Table 7. Summary of action plan for wind technology.

Barrier Category	Barriers	Potential measures, cost of funding	Concerned Institutions	Time Frame
Economic & Financial (wind technology is not financially viable)	High Cost Capital Inappropriate financial incentives	Provide financial incentive in the form of cost-reflective FiT for de-risking investment in wind energy technology. Cost of measure: Rs 937,695,079 (NPV) Cost-benefit ratio of action: CBR = 4.84 Sources of funding: • Public financing through carbon tax on fossil fuels; • Multi-lateral or bilateral funds for implementing FiT as a supported NAMA	Ministry of Finance and Economic Development; CEB, Ministry of Energy and Public Utilities; Ministry of Environment and Sustainable Development. The roles and functions of these institutions are discussed in Annex 2.	0-13 years
Indicators of success (selected): - Installed capacity (MW) - % penetration of wind in the national grid - Wind electricity generated annually (MWh/yr) - Grid emission factor - Annual emission reduction by wind (tCO2/yr) - Number of jobs created - Monetary value of fossil fuel import substitution (Rs/year) - Annual value of financial incentive disbursed for each project (Rs/yr)				

1.3 Action Plan for Energy Efficient Boilers

1.3.1 About the technology

An economizer is a gas-water heat exchanger that allows the recovery of part of the heat contained in the boiler's flue gases, heating the water fed to the boiler. The hot waste flue gases give up the heat and are then vented to the atmosphere. The economizer consists of a shell, which is installed in the flue line, inside which there is a bundle of finned tubes through which the water to be heated circulates, and outside which gases circulate. Thus, the temperature of the flue gas is reduced and boiler efficiency is increased. Most boilers, particularly fire-tube boilers, are not sold with an economizer, unless the user so requires, which is not generally the case in Mauritius.

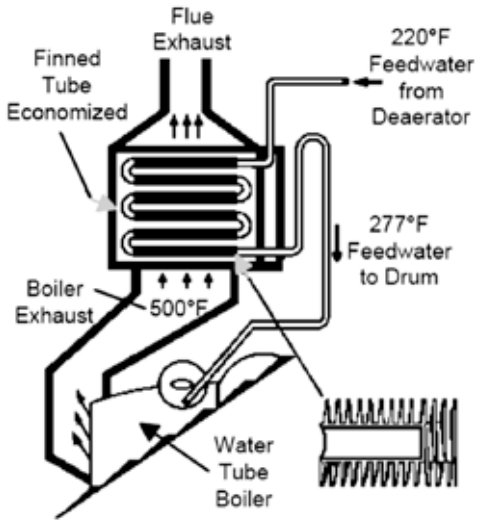

Figure 5. Finned-tube boiler economizer (US Department of Energy, 2008).

The cost of the economizer depends on the size of the boiler in which it is installed, since a larger economizer is required for a greater flow of gases. In general, its installation is justified for boilers with a capacity of more than 300 BHP (diesel) or 700 BHP (residual) and with a continuous operation of more than 5000 h/year. The energy saving usually achieved is up to 3% ((Institute for Applied Ecology, 2003)). A significant advantage of an economizer is that it can be designed and retrofitted onto an existing boiler. The lifetime of a typical industrial boiler is between 10-20 years. The capital cost of a typical boiler has been assumed to vary between Rs 1.64 million to Rs 2.5 million. The annual CO2 emission reduction in the Mauritian context has been calculated at 54.2 tCO2 and 18.3 tCO2 for retrofitted boilers running on diesel and LPG, respectively.

5 The lifetime can be as long as 20 years in local operating and maintenance conditions when the boiler is run on LPG. When run on diesel, the lifetime is reduced because of the sulphur content in the fuel, albeit at around 40-50 ppm. Communication with Mr Bernard Domingue, Vivo Energy – 19 December 2012.

1.3.2 Target for technology transfer and diffusion

EE targets for the stationary combustion of fossil fuels (e.g. boilers in commercial and industrial settings) do not exist. The updated Energy Strategy Action Plan 2011-2025 mentions that guidelines for energy management in industry would be developed in 2012, and for mandatory energy audits to be carried out in industry as from 2013. Further, the Action Plan states that EE programmes based on voluntary agreements would be created for industry between 2011 and 2014. Table 8 lists the total number of boilers in operation in Mauritius along energy source and geographical distribution. The numbers in brackets correspond to the total number of enterprises housing the boilers. This study has targeted boilers using LPG and diesel as primary energy sources – i.e. a total of 143 boilers representing 24.3% of all boilers used in industrial and commercial applications.

Table 8. List of boilers installed in Mauritius at March 2012.

	Diesel	LPG	Electricity‡	HFO	Coal	Paper/wood
Grand Port	2 (2)	1 (1)	16 (7)	3 (3)	0	0
Black River	0	0	0	2 (2)	0	0
Pamplemousses	10 (9)	9 (7)	59 (36)	23 (14)	4 (3)	1 (1)
Port Louis	2 (1)	0	5 (4)	4 (3)	0	0
P Wilhems	28 (22)	16 (12)	126 (69)	57 (37)	6 (5)	1 (1)
Flacq	10 (5)	16 (11)	36 (17)	1 (1)	1 (1)	
Moka	15 (11)	14 (11)	44 (29)	8 (8)	0	1 (1)
Savanne	8 (6)	8 (2)	29 (10)	8 (4)	1 (1)	0
R du Rempart	1 (1)	3 (2)	7 (6)	2 (2)	0	0
Total No. boilers	**76**	**67**	**322**	**108**	**12**	**3**
Total No. enterprises	**57**	**46**	**178**	**74**	**10**	**3**
% of total number of boilers	***12.9***	***11.4***	***54.8***	***18.4***	***2.0***	***0.5***

‡ These are electric geysers of less than 100L capacity that offer marginal incremental efficiency gain. Members of sectoral working group agreed that electric heaters would be left out of the analysis.

1.3.3 Barriers and enabling environment to the diffusion of boiler economizer

This section provides a short description of the barriers and an extensive discussion of the enabling framework that would help to overcome them. Sections 1.3.3.1 and 1.3.3.2 discuss in brief the financial and non-financial barriers, respectively, while section 1.3.3.3 discusses the enabling framework that is required to overcome the barriers. Detailed barrier analysis for wind technology can found in section 1.3.2 of RII – Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012).

1.3.3.1. Economic and financial barriers for boiler economizer

All the key stakeholders have singled out the high upfront capital cost of the equipment as the main impediment for the widespread diffusion of boiler economizers. One supplier also mentioned that the cost of installation is also very high since retrofitting economizers on existing boilers requires substantial modifications. So far it is not economical for boilers run on HFO because of the high sulphur content leading to corrosion due to the formation of highly concentrated sulphuric acid. One way to mitigate this constraint is to use high grade stainless steel that can resist corrosion from acids. This measure would increase the capital, and O&M costs, and therefore make the use of economizer non-economical at the end due to much longer payback periods. This was also confirmed by other technology suppliers and end-users. In order to avoid these barriers, the TNA project has targeted boilers that run on LPG and diesel only (please see Table 8).

1.3.3.2. Non-financial barriers for boiler economizer

Low awareness of the technology: Facilities that do not employ engineers may not be aware and show any interest unless being approached by consultants that are already scarce on the local market. This lack of awareness of the benefits of EE and use of LCA imply that capital budgeting excludes investment in EE measures and focuses on operations;

Lack of technical expertise: There is a lack of consultants who would conduct detailed engineering studies (with accurate measurements) to evaluate energy savings opportunities from flue gas within defined precision levels and provide guarantee of savings. This is an important factor necessary to convince Top Management to show interest and confidence in energy efficiency projects. Very often it is production that takes the lead and not energy efficiency.

1.3.3.3 Enabling framework for overcoming the barriers for boiler economizer

Since the technology does not find widespread uptake under the prevailing practices, the market supply chain for economiser is relatively simple. Usually, economizers are not built in Mauritius but there are agents and representatives of large overseas suppliers, and the technology is supplied on a needs basis. There are about 4 suppliers of the technology in Mauritius and they liaise directly with the end-users without the need for intermediaries.

The main business and extension services are:

1. The provision of financial and banking services predominantly by commercial banks or leasing companies in the case of LEMS discussed in section 1.1.2;
2. EE promotion services (EEMO, Enterprise Mauritius, Ministry of Industry, etc.); and
3. Consulting firms.

The roles and functions of these service providers are given in Annex 2.

There are also engineering companies that provide ancillary services during installation and maintenance of the equipment. Training and capacity building for energy managers and industrial auditors will be carried out under the GEF-UNDP-EEMO project for the removal of barriers to promote EE in industry.

The enabling environment is fairly similar to that of utility-scale wind energy with the exception of support provided to local suppliers. In fact, stakeholder consultations have revealed that the government is putting in place mechanisms to increase the number of local suppliers of economizers to support the up-scaling of the technology in commercial applications, namely the hotel and leisure service sector.

1.3.4 Proposed action plans for Boiler Economizer

The action plan for the diffusion of boiler economizer is derived from to the measures that are discussed in section 1.3.3 of RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012). For each action or measure, the same outline as for utility-scale wind technology has been followed.

Based on the barrier analysis given in the previous section, the measures that were identified for boiler economiser are:

1. Financial incentive in the form of a 20% rebate on the capital cost of an economiser;
2. Free energy audit prior to installing each economiser in order to optimise performance of the retrofitted WHR equipment; and
3. Training provided to one person (energy manager) per enterprise hosting an economiser.

1.3.4.1 Why are the measures needed for boiler economizer

The single most significant barrier for the diffusion of economizers in industry is high upfront capital cost. In order to alleviate this financial burden, a 20% grant on the capital cost has been proposed. Further, enterprises lack the in-house capacity to carry out energy audits, and, very often, there are no dedicated personnel to deal with energy management. These lead management to overlook investment in energy efficiency. In order to overcome these barriers, the action plan proposes to offer one free energy audit per retrofitted boiler and to provide dedicated EE training to one person per enterprise.

1.3.4.2 Who is responsible for the measures identified for boiler economizer

Different institutions or stakeholders will be responsible for implementing the three measures.

Financial incentive: The rebate scheme will be coordinated by the Ministry of Industry. The sources of funding are discussed in section 1.3.4.4.

Energy audit: Audits will be carried out by certified auditors. The cost of audits may be covered by the Ministry of Industry or a related institution like EEMO and Enterprise Mauritius.

Training on energy manager: Specialized agencies, such as EEMO and/or the Ministry of Industry, would provide training to energy managers at the level of 1 person per enterprise. Training and capacity building for energy managers and industrial auditors will be carried out under the GEF-UNDP-EEMO project for the removal of barriers to promote EE in industry. The training is assumed to be a one-off training delivered over a 3 weeks' period.

1.3.4.3 Timeframe for the implementation of the measures for boiler economizer

The timeframe used in the TNA project for the energy industries is aligned with the time period of the Long-Term Energy Strategy 2009-2025 (Ministry of Renewable Energy & Public Utilities, 2009). Hence, the timeframe for the implementation of the measures will cover the period 2013 to 2020 as per the schedule summarised in Table 9.

In the barrier analysis, it has been assumed that 20% of commercial entities using boilers would opt for pre-heating of water using SWH as a means to reduce energy bill (Ministry of Environment & Sustainable Development, 2012).

6 Response provided by Dr Dinesh Surroop, Senior Lecturer, University of Mauritius, and Mr Soorianan Narsiah, Director, Energy Concept, Canada. Private communication through email on 6 December 2012; Mr Bernard Domingue, Vivo Energy,

Mauritius. Phone communication on 18 December 2012; Ms Shyama Buctowar, RTKnits, Phone Communication on 19 December 2012.

7 Communications with Mr Fargy Romaly, Rey & Lenferna – 19 December 2012.

8 Response provided by Dr Dinesh Surroop, Senior Lecturer, University of Mauritius, and Mr Soorianan Narsiah, Director, Energy Concept, Canada. Private communication through email on 6 December 2012.

9 Communication by email with Dr Khalil Elahee, University of Mauritius and Chairperson of EEMO – 30 November 2012.

Table 9. Schedule for the installation of boiler economizers.

Year	2013	2014	2015	2016	2017	2018	2019	2020
Economizer (diesel)	3	8	8	8	8	8	8	10
Economizer (LPG)	3	8	8	8	8	8	8	3
Total economizers	6	16	16	16	16	16	16	13

1.3.4.4 Cost of measures for boiler economizer

The cost of measures is discussed in details in section 1.3.3 of RII - Barrier Analysis and Enabling Framework Report (Ministry of Environment & Sustainable Development, 2012). The total cost per unit of the three measures amounts to Rs 343,388.7. The total cost of measures between 2013 and 2020 has been calculated as Rs 33,190,975 in terms of NPV.

Benefit-cost analysis

Benefit-cost analysis was carried out along with a sensitivity analysis for different capital costs of economizer and efficiency gains. In addition to the cost of measures, the analysis also included the incremental O&M cost of economizers. The benefits that were considered are: (1) global environmental benefit from GHG emission reduction using the long-term price of CO2e; (2) incremental job creation; and (3) cost of fuel saved. The BCR was calculated as 3.05 revealing the overall positive benefits of the proposed measures. The results of the sensitivity analysis are summarized in Table 10. Even at the higher capital cost and lower energy efficiency gain investigated here, the benefit-cost ratio is a relatively high value of 2.42 that would justify the application of the measures proposed. The capital cost that would yield a benefit-cost ratio of 1.3 (rule of thumb for investing in measures) for an efficiency gain of 3% has been calculated as close to Rs 6,100,000 per economizer.

Table 10. Sensitivity analysis of benefit-cost ratio as a function of capital cost and efficiency gain.

Benefit-Cost Ratio	Capital cost (Rs1,640,000/unit)	Capital cost (Rs2,500,000/unit)
Efficiency gain (3%)	3.05	2.42
Efficiency gain (10%)	10.12	8.06

Capitalization is of key importance for the financial sustainability of the measures. So, an integral part of the measure should be to identify clearly utility cost-recovery processes (DB Climate Change Advisors, 2011). In the present case, several sources of funding can be considered:

- The measures can be funded using carbon taxation on all fossil fuels as is presently the case for the MID Fund. Where appropriate the taxation level may be increased to increase the revenues to cross-subsidize the measures;
- The cost of training of energy managers and energy audits can be covered (at least partially) by the current GEF-UNDP-EEMO project for the removal of barriers to promote EE in industry;
- The rebate scheme can also be funded as a policy NAMA. In this case, the evidence provided by the TNA project may be used to seek multi-lateral and/or bilateral funding for implementing the rebate scheme(partially or fully) as a supported NAMA. What should also be explored is to set up a performance-based emission reduction finance mechanism for the release of funding. In this case, the programmatic approach adopted here would require a stringent MRV system, the elements of which are discussed in the next section.

1.3.4.5 Indicators of success for boiler economizer and risks

Indicators are required to monitor and evaluate the implementation of the action plan. In addition to covering the measures discussed above, the indicators of success summarised in Table 11 also cover the components of the enabling framework discussed in section 1.3.3. For the MRV system that is linked to the performance-based finance instrument, details about emission reductions are required. It is proposed that the tried-and-tested methodologies of the CDM for calculating emission reduction be adopted. Table 11 also summarizes the risks associated with the boiler economizer action plan.

Table 11. Indicators of success and risks for boiler economizer action plan.

Project component	Objectively Verifiable Indicators
EE Promotion services	• Number of economizers installed by type and energy savings • Number of audits carried out (with full reporting) • Number of energy managers trained
Mechanisms for increasing the number of local EE consultants and suppliers of economizers	• Number of suppliers & consultants • Number of enquiries made • Number of products and services provided
Provide incentives for enterprises	• Number of purchases benefitting from the rebate scheme • Amount disbursed on rebate • Number of new jobs created
Provision of financial and banking services (commercial banks)	• Number of enquiries • Services provided by scale
Emission reduction	• Quantity of fuel (diesel and LPG) saved (tonne/yr) • Quantity of CO2 reduced (tCO2/yr)

Risks associated with action plan

Financial risk: The action plan is predicated upon the availability of substantial amount of funding on a regular and timely basis. There is a low risk that sufficient funding may not be available;

Operational risk: There is a low-to-medium risk that the technologies adopted by promoters are not operated and maintained adequately leading to premature failure and reduced confidence in technology; and

Human capacity risk: Since qualified energy auditors and energy managers are in short supply in Mauritius, there may be a high turn-over of such skilled staff once they have been trained;

1.3.4.6 Summary of boiler economizer action plan

Table 12 summarizes the proposed technology action plan for boiler economizer.

Table 12. Summary of action plan for boiler economizer.

Barrier Category	Barriers	Potential measures, cost and sources of funding	Concerned Institutions	Time Frame
Economic & Financial	High Cost Capital Inappropriate financial incentives and disincentives	Government to provide financial incentives in the form of a rebate scheme on capital investment	Ministry of Finance and Economic Development; Ministry of Industry. Please see Annex 2 for more details.	0-7 years
Market Failures/ Imperfection	Low awareness of the technology Lack of consulting services	Energy audit for each boiler for retrofitting an economizer by a professional auditor, as incentive for associated capital investment	Ministry of Industry, Commerce and EEMO. Please see Annex 2 for more details.	0-7 years
Social, cultural and behavioural	Traditions and habits Lack of trained energy managers	Promote EE interventions through training of energy managers (1 person per enterprise)	EEMO and/or the Ministry of Industry, Commerce. Please see Annex 2 for more details.	0-7 years
		Cost of measures: Rs 33,190,975 (NPV) **Cost-benefit ratio of action:** CBR = 2.42 – 10.2 **Sources of funding:** • Public financing through carbon tax on fossil fuels; • GEF-UNDP-EEMO project for the removal of barriers to promote EE in industry; • Multi-lateral or bilateral funds for implementing rebate scheme as a supported NAMA		
Indicators of success (selected): - Number of economizers installed (with full specification) - Quantity of fuel saved annually for by each economizer (tonne fuel / year) - Annual emission reduction by each economizer (tCO2/yr) - Number of jobs created - Monetary value of energy saved (Rs/year) - Annual value of financial incentive disbursed for each project (Rs/yr) - Number of energy managers trained (number per year) - Number of audits carried out				

1.4 Cross cutting issues

The main and common barrier to the transfer and diffusion of utility-scale wind energy and boiler economizers was the high upfront capital investment, and the lack of economic and financial incentives to promote the technologies. Institutional and human capacity are also lacking for regulation, operation and technical aspects.

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Annex 1 – Leasing Equipment Modernisation Scheme.

	Turnover per annum (MUR)	Eligible Sectors	Ceiling per beneficiary client* (MUR)	Minimum contribution of Beneficiary client	Annual Interest Rate (Fixed)
LEMS I	Up to 50.0 M	All sectors including Trading	10.0 M	10% Cost of Asset	7.25%
LEMS II	> 50.0 M but less than 150.0 M	All sectors excluding trading	25.0 M	15% Cost of Asset	7.25%
LEMS III	> 150.0 M	All sectors excluding trading	75.0 M	20% Cost of Asset	7.25%

* Beneficiary client may be a company or 'societe' registered in the Republic of Mauritius and operating for at least one year.

All applications are made at the leasing companies for onward submission to the RWG Committee for consideration.

The eligible leasing companies include Finlease Co Ltd, Dolberg Asset Finance Ltd, Mauritian Eagle Leasing Co Ltd, La Prudence Leasing Finance Co Ltd, CIM Finance Ltd and AXYS Leasing Ltd.

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Annex 2 – List of Stakeholders Involved and their Contacts.

Utility Scale Wind Energy

The stakeholder mapping was carried out by participants at the TNA Report Validation and TAP Inception Workshop that was held on 26 and 27 July 2012. The table also gives the roles and functions of the stakeholders.

Stakeholders	Contact details	Roles and Functions
Ministry of Energy and Public Utilities (MoEPU)	Mr. O. Seewootohul Level 10, Air Mauritius Centre, John Kennedy Street, Port Louis Tel: 405 6700 Fax: 208 6497 Email: mpu@mail.gov.mu	Responsible for developing Energy Policy and Strategy of Mauritius and to put in place policy instruments to support EE and RETs
CEB	Head Office, Royal Road, Curepipe Mauritius Tel: (230) 601-1100 Fax: (230) 675-7958 Email: ceb@intnet.mu	Responsible for power generation, transmission and supply, and sale of electricity. CEB has plans to invest in utility-scale wind energy in the future.
Financial Institutions	There are several banking institutions.	Provider of finance for investment in wind energy projects.
Ministry of Finance and Economic Empowerment (MoFEM)	Ground Floor, Government House, Port-Louis, Mauritius Tel: (230) 201-1146 Fax: (230) 211-0096 Email: mof@mail.gov.mu	The ministry responsible for budgeting and has the role to develop financial instruments to fund the incremental cost of electricity produced from RETs.
Community Groups, NGOs,	Site specific and are usually identified during EIA stage.	Protect the interest of communities located geographically close to wind farms, as well as related to issues of biodiversity.
Mauritian Wildlife Foundation	Mauritian Wildlife Foundation, Grannum Road, Vacoas, Mauritius Tel: (230) 697-6097 Fax: (230) 697-6512 Email: executive@mauritian-wildlife.org (http://www.mauritian-wildlife.org)	MWF endeavours to protect biodiversity, especially endemic plants, animals and mammals.
Board of Investment	10th Floor, One Cathedral Square Building, 16, Jules Koenig Street, Port Louis, Mauritius Tel: (230) 203 3800 Fax : (230) 208 2924 Email : contact@investmauritius.com	Institution responsible for attracting FDI in Mauritius.

Department of Civil Aviation	SSR International Airport, Plaisance, Plaine Magnien, Mauritius Tel: (230) 603-2000 Fax: (230) 637-3164 Email: civil-aviation@mail.gov.mu	Responsible for providing clearance for wind farms siting so that farms do not interfere with the flights in the Mauritian air space.
Ministry of Housing and Lands	Level 7, Ebène Tower, Cybercity, Mauritius Tel: (230) 403 4086 Fax: (230) 454 6397	Responsible for providing land development permits for wind farms.
Ministry of Environment and Sustainable Development	Ken Lee Tower, Cnr Barracks & St Georges Streets, Port-Louis, Mauritius Tel: (230) 203 6200 - 6210 Fax: (230) 211 9524; (230) 212 8324 Email: menv@mail.gov.mu	Responsible for providing EIA license for wind farm development.
Mauritius Research Council	Dr Vickram Bissoonauth 6th Floor, Ebene Heights, Cybercity, Mauritius Tel: (230) 465 1235 Email: v.bissonauth@mrc.intnet.mu	The MRC has been involved in measuring the potential for wind and solar energy resources in several places in Mauritius since 2007. It uses the information for assisting decision-making on energy on policy.
University of Mauritius	Dr Dinesh Surroop Department of Chemical Engineering, Faculty of Engineering, University of Mauritius Email: d.surroop@uom.ac.mu	Active in the fields of research for the promotion of RETs and energy efficiency.

Heat Recovery (EE boilers)

Stakeholders	Contact details	Roles and Functions
Ministry of Energy and Public Utilities (MoEPU)	Mr O. Seewootohul Level 10, Air Mauritius Centre, John Kennedy Street, Port Louis Tel: 405 6700 Fax: 208 6497 Email: mpu@mail.gov.mu	Responsible for developing Energy Policy and Strategy of Mauritius and to put in place policy instruments to support EE and RETs.
EEMO	8th Floor, C&R Court, 49, Labourdonnais Street, Port-Louis Tel: (230) 210 7143, (230) 210 7345 Fax: (230) 210 6978 (http://publicutilities.gov.mu)	Facilitates the promotion of EE in all sectors of the economy, including industry and commercial activities. It also carries out capacity building and training on energy auditing.
Ministry of Industry, Commerce and Consumer Protection	Industry Division, Level 7, Air Mauritius Building, Port Louis Tel : 210-7100 Fax: 211 0855 Email: mind@mail.gov.mu	An objective of the ministry is to support green, socially responsible and quality initiatives in enterprises. In this context, the ministry teams up with other institutions to support EE in industries.
Financial Institutions	There are several banking institutions.	Provider of finance for investment in wind energy projects.
Enterprise Mauritius		Provides energy audit services through funding schemes for industry.
Ministry of Finance and Economic Empowerment (MoFEM)	Ground Floor, Government House, Port-Louis, Mauritius Tel: (230) 201-1146 Fax: (230) 211-0096 Email: mof@mail.gov.mu	The ministry responsible for budgeting and has the role to develop financial instruments to fund the incremental cost of electricity produced from RETs.
Mr Sharma Buctowar (Chemical & Environmental Engineer)	Peupliers Ave SLDC New Industrial Estate Pte Aux Sables Tel : 206 8888 Mob: 251 5793 Email: sharma.b@rtkshare.com	End-user on textiles sector.
Mr Bernard Domingue	Vivo Energy - 941 1226	Service provider (consulting, maintenance)
Mr Fargy Romaly	Rey & Lenferna - 422 5382	technology supplier
Research institutions	There are several institutions such as: MITD, UoM, MRC, UTM etc …	Active in the fields of research for the promotion of RETs. Activities include renewable energy resources mapping, development of energy futures, etc …

TNA REPORT IV

PROJECT IDEA REPORT (ENERGY INDUSTRIES)

(March 2013)

Disclaimer

This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP Risoe Centre (URC) in collaboration with the Regional Centre ENDA for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the Ministry of Environment and Sustainable Development.

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List of Acronyms

BHP	Boiler Horsepower: 1 boiler horsepower = 9.81055407 kilowatts
CDM	Clean Development Mechanism
CEB	Central Electricity Board
CER	Certified Emission Reduction
CF	Capacity Factor
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent
EE	Energy Efficiency
EIA	Environmental Impact Assessment
EPA	Energy Purchase Agreement
ER	Emission Reduction
FDI	Foreign Direct Investment
FI	Financial Institution
FiT	Feed-in Tariff
GEF	Global Environment Facility
HFO	Heavy Fuel Oil
IPP	Independent Power Producer
IRR	Internal Rate of Return
kW	Kilowatt
kWh	Kilowatt hour
LC	Local Currency
LPA	Logical Problem Analysis
LPG	Liquefied Petroleum Gas
MoEPU	Ministry of Energy and Public Utilities
MoFED	Ministry of Finance and Economic Development
MUR	Mauritius Rupee
MW	Megawatt
MWh	Megawatt hour
NGO	Non-Governmental Organisation
NPV	Net Present Value
R&D	Research and Development
RE	Renewable Energy
RET	Renewable Energy Technology
ROI	Return on investment
Rs	Rupee (Mauritian)
SIPP	Small Independent Power Producer
TAP	Technology Action Plan
TNA	Technology Needs Assessment
URA	Utility Regulatory Authority
VAT	Value-Added Tax
WHR	Waste Heat Recovery

1 Project Ideas for Energy Industries

1.1 Brief summary of the Project Ideas for Energy Industries

This project ideas report presents concrete actions supporting the realisation of the overall target indicated in the Technology Action Plans for the Energy Industries sector, namely mitigation of climate change by scaling up the diffusion of wind energy technology (a Renewable Energy Technology – RET) and energy efficient boilers (an Energy Efficiency technology – EE).

These two technologies were selected as a result of a broad multi-stakeholder collaborative action, analysing different climate change mitigation technologies and their degree of applicability and effectiveness for Mauritius. Indeed, the project ideas build upon three reports: (1) RI - Technology Needs Assessment (TNA) Report, (2) RII - Barrier Analysis and Enabling Framework (BAEF) Report, and (3) RIII - Technology Action Plan (TAP) Report which is the synthesis of the two previous.

The TNA project has not discussed the wind farms or installation of economizers as stand-alone projects. Instead, it has considered the cumulative installed wind energy capacity to 2025, and that of economizers to 2020, which is analogous to the programmatic approach for scaling-up emission reductions. This programmatic approach is aligned with the development of sectoral Nationally Appropriate Mitigation Actions (NAMAs) for Mauritius. The Technology Action Plan (TAP) has also discussed the use of performance-based emission reduction finance instrument for accessing multilateral and bilateral sources of funding, along with domestic funding to support the implementation of measures. Hence, the action plans for the energy industries may be used for attracting funding for supported NAMAs.

For each technology, a specific financial incentive scheme is recommended, along with the necessary business and extension services required and appropriate enabling conditions in order to integrate their financial, technical, operating and regulatory aspects in the country's existing frameworks. All of these consist of:

- For wind energy technology:
    - Set up contract management for guaranteed access to the national grid and other legal and commercial clauses as stipulated in an EPA;
    - Market information (mainly in terms of wind energy resources potential in Mauritius and other constraints);
    - Provide financial incentives to operators in the form of a Feed-in Tariff;
    - Enable business permit facilitation;
    - Provision of financial and banking services; and
    - Awareness and information about wind technology mostly targeted at local communities
- For energy efficient boilers:
    - Free energy audit for each boiler, including technical assistance for identifying the design and type of economizer;
    - Rebate scheme on capital investment;
    - Covering incremental cost of training of operational staff on energy management; and
    - Covering incremental O&M costs.

Such measures have been devised to overcome the barriers identified in RII - BAEF report and are supported by the cost-benefit analyses performed for the same. The following sections provide summarised background for each project idea, justification and action plans including objective, scope, time lines, roles and responsibilities as well as deliverables and expected impacts.

1.2 Specific Project Ideas

1.2.1 Project Idea for wind energy

1.2.1.1 Summary sheet for wind energy

ENERGY INDUSTRIES SAMPLE PROJECT SHEET: Utility Scale Wind Energy		
Brief Project description The renewable nature of wind energy, the large available resource and the relatively advanced nature of the technology mean that it has the potential to make a significant contribution to climate change mitigation.		
Results Oriented Framework		
Overall Goal i. Creating an attractive environment for investment in- and use of- wind energy ii. Diffusion of utility-scale wind turbines	**Development Objectives** Removal of barriers for the uptake of wind turbines using financial incentives and an appropriate enabling framework	
Inputs i. Setting up of a Utility Regulatory Authority ii. Establishing financial incentives (FiT) iii.Business and extension services	**Outputs** i. Opportunity is created for investment in wind energy ii. Awareness of the national benefit is raised	**Impacts** Long term impacts include ease of exploitation of wind energy potential and contribution to energy independence.
Estimated costs MUR 1500 /MWh over 13 years: MUR 937,695,079 (NPV) Funding will be largely allocated for the provision of financial incentives between 2013 and 2023. The need for an independent regulator is already provided for under current legislation, but its setting up remains a political decision that is beyond the scope of this project.		
Proposed timeframe 10-20 years	**Executive bodies** Ministry of Energy and Public Utilities	
Cost-benefit analysis The NPV of benefits over 13 years equals MUR 4,537,237,725.88 – hence the Benefit/Cost ratio is 4.84.	**Risks** Delays in setting up the enabling framework, thus lost opportunity in the short and medium term	
Expertise required		
Profile Local expertise by CEB in interconnecting and managing wind energy and PV to the national grid. Local expertise for contract management and financial incentives. Foreign expertise is required for technical wind farm aspects.	**Key tasks** • Create enabling conditions for access to grid • Establish Feed-in Tariff • Support development of business and extension services	
Identification of key stakeholders Ministry of Energy and Public Utilities (MoEPU), CEB, Financial Institutions (Banks), Ministry of Finance and Economic Empowerment (MoFEM), Community Groups, NGOs, Board of Investment, Department of Civil Aviation, Ministry of Housing and Lands, Ministry of Environment and sustainable development, Research Institutions.		

1.2.1.2 Project overview

Project scope:

It is proposed that a price premium of MUR 6/kWh is paid to investors to generate renewable electricity from wind from 2013 through to 2025. This is a preferential tariff of FiT through which the public authority pays a price premium to investors above the baseline cost of electricity production. It is pointed out that Capacity Factors (CF) are site specific, and in the absence of knowledge of sites where future wind farms will be installed, a threshold Capacity Factor (CF) of 20% has been used. It is assumed that wind farms with the highest CF are built first and that future wind farms would have decreasing CF. Two critical requirements for the FiT scheme are long-term duration and guaranteed access to the grid, to minimise risk and thus create a commercially attractive investment opportunity. The enabling framework that is conducive for technology transfer and diffusion needs to be in place and is captured in the following project components:

1. Set up contract management for guaranteed access to the national grid and other legal and commercial clauses as stipulated in an EPA
2. Market information (mainly in terms of wind energy resources potential in Mauritius and other constraints)
3. Provide financial incentives to operators
4. Enable business permit facilitation (Board of Investment)
5. Provision of financial and banking services (commercial banks)
6. Awareness and information about wind technology mostly targeted at local communities

Project timeline:

With respect to the targets presented below, it is recommended that the project be implemented alongside the planned installations for 2013. “Fine tuning” for tariff setting, contract management and other components of the enabling framework can be conducted between 2013 and 2017. The project timeline is aligned with the Long-Term Energy Strategy 2009-2025.

Year	2013	2014	2017	2020	2023
Installed capacity (MW)	22	18	20	20	20
CF (%)	25	20.7	20.5	20	20
Electricity generated (MWh/yr)	48,180	32,640	35,916	35,040	35,040

Budget:

The cost of this measure is the incremental cost of the preferential tariff or FiT. Hence, the cost of the measure is taken as Rs1.5/kWh (i.e. Rs6/kWh – Rs4.5/kWh), or Rs1,500/MWh. The cost of the project given in section 1.2.1.1 is for the total cost of FiT for the cumulative wind-generated electricity to 2025.

10 The updated Energy Strategy Action plan 2011 – 2025 mentions that a Utility Regulatory Authority (URA) would be established in 2011/2012. Despite the presence of supportive legal and policy frameworks, the URA is yet to be set up, and the lack of such a body continues to be a regulatory barrier. Unfortunately, the setting up of the URA will take place through a political process that is beyond the scope of this study.

1.2.1.3 Project framework

It is pointed out that the National Energy Strategy targets for the electricity mix to 2025 places the use of renewable fuel sources at 25% of the total, notably with the share of wind power increasing from 0% in 2010 to 8% in 2025. This project is therefore well aligned with the current sustainable development priorities and should support the achievement of current national objectives.

Project Goal: Mitigate climate change through the use of wind energy technology as a substitute for carbon intensive technologies							
Development objectives: Removal of barriers for the uptake of wind turbines using financial incentives and an appropriate enabling framework							
Project Component	Expected Outcomes	Expected Inputs	Expected Outputs	Responsibility	Objectively Verifiable Indicators	Expected Impacts	Time frame
1.Set up contract management for guaranteed access to the national grid and other legal and commercial clauses as stipulated in an EPA	Attracting investment and project development	Setting up of the Utility Regulatory Authority	The Utility Regulatory Authority is operational and is able to implement the regulatory measure	- Ministry of Energy and Public Utilities (MoEPU) - CEB	- Number of enquiries - Number of contracts - % utilisation of grid by wind power	Ease of access and accurate management of grid capacity and stability.	Year 1 - 13
2. Market information (mainly in terms of wind energy resources potential in Mauritius and other constraints)	Attracting investment and project development	e.g. Wind atlas; topography, land use plans, interference with civil aviation and other telecommunication systems, and proximity to sub-stations and HV transmission lines for grid interconnection	Information is available to investors and other stakeholders such as the public authority in order to plan project developments.	- Board of investment - Ministry of Energy and Public Utilities (MoEPU) - CEB - Ministry of Housing and Lands	- Rate of information consultation - % utilisation of onshore wind energy potential - nstalled capacity - Monetary value of import substitution of fossil fuel - Number of jobs created	The wind atlas will be (i) providing visibility to potential investors; (ii) forming the basis for establishing a dynamic FiT scheme; and (iii) allow the determination of the threshold wind energy potential needed for the technology to be financially viable.	Year 1-3
3. Provide financial incentives to operators	Attracting investment and project development	Establish tariffs, policies and conditions of the FiT	Tariffs, policies and conditions are visible to investors and other stakeholders	- Ministry of Finance and Economic Empowerment (MoFEM)	- Number of enquiries - Tariff setting indicators (annual value of incentive disbursed) - Amount of MWh produced	Attractive investment opportunities exist	Year 1 - 13
4. Enable business permit facilitation	Attracting investment and project development	Establish guidelines for permit facilitation for wind energy investors, capacity building.	Business permit processes are clear visible	- Board of Investment, - Ministry of Housing and Lands	- Number of enquiries - Number of permits allocated	Ease of access to the market and to wind resources	Year 1 - 13
5. Provision of financial and banking services	Attracting investment and project development	Create collaborative frameworks with- and guidelines for- financial and banking services to facilitate wind energy investments, capacity building.	Financial and banking services are available to facilitate project design and implementation	- Financial Institutions (commercial banks) - Ministry of Finance and Economic Empowerment (MoFEM)	- Services provided by type - Services provided by scale	Ease of access to finance and services	Year 1 - 13
6. Awareness and information about wind technology mostly targeted at local communities	Enhancing the social acceptability of this new technology	A pool of specialised facilitators is identified or created for stakeholder information, engagement and dialogue	Capacity for stakeholder engagement is available	- Ministry of Energy and Public Utilities (MoEPU) - Community Groups, NGOs, - Ministry of Environment and Sustainable Development	- Information campaigns by type - Number of stakeholders reached by type	Security of stakeholder engagement capacity	Ongoing

1.2.1.4 Project Justification

Sustainable development priorities:

This project is aligned with the wider Maurice Ile Durable project and will support the attainment of Wind Energy targets set in the Long-Term Energy Strategy, as well as its objectives of Climate Change mitigation, market transformation, advancing industrial competitiveness and energy security.

Year	2013	2014	2017	2020	2023	Total
Installed capacity (MW)	22	18	20	20	20	100

Benefit-cost analysis:

The following benefits have been quantified to 2025:

1. Global environmental benefit from GHG emission reduction using the long-term price of CO2e (the cumulated emission reduction to 2025 has been calculated as 1,640,856 tCO2);
2. Incremental job creation; and
3. Reduction in energy bill through import substitution. Although this will change depending on the price of imported oil and price volatility, potential future increases in the price of oil have not been taken into account here. The analysis has used a weighted average of fossil fuels used to generate electricity over the past 3 years.

The calculations of NPV of costs and benefits of the financial measures give a benefit-cost ratio equal to 4.84 (NPV cost: MUR 937,695,079 and NPV benefits: 4,537,237,725). This shows that the benefits of the financial measures far outweigh its direct costs. The benefit-cost ratio can be expected to be higher since it would be reasonable to expect that both the price of CERs and imported fossil fuels would increase in the future, thereby increasing the monetary value of benefits.

In terms of other ecological effects related to the installation, the turbines have a relatively small environmental footprint and are often constructed on agricultural or brown-field sites, which limit their impact on local habitats or ecosystems. In instances where they are being installed in more pristine environments, a more rigorous environmental impact assessment may be required.

1.2.1.5 Monitoring and Evaluation (M&E)

Monitoring and evaluation frameworks will evolve as the project is implemented, to reflect the specificities of Mauritius in terms of contracts, installations, operation patterns and other factors. The project framework (section 1.2.1.3.) provides an indicative monitoring and evaluation indicators.

1.2.1.6 Risks

Risk	Level (Low, Medium, High	Response
Absence of regulatory authority	Medium	The regulatory framework for setting up the URA has been in place for several years. The setting up of the URA will take place through a political process that is beyond the scope of this study
Lack of grid capacity for intermittent power sources	Low	A grid-stability mapping exercise carried out by CEB has shown that the current grid could accommodate up to 30 MW of RET of intermittent source without modifications to the network
Identified sites prove to have low capacity factors	Low	Additional sites can be identified through a wind-resource map
Low visibility for investors	Low	Institutions such as the board of investment will promote the project, and visibility will be given via the Maurice Ile Durable project
Low initial performance of business and extension services	Low	Appropriate capacity building activities will be encouraged and facilitated
Wind turbines are damaged by cyclonic winds	Low	Only adequate wind turbine models will be selected to either withstand cyclonic winds or be lowered

1.2.1.7 Stakeholder mapping

Stakeholder	Roles and responsibilities
Ministry of Energy and Public Utilities (MoEPU)	Responsible for developing Energy Policy and Strategy of Mauritius and to put in place policy instruments to support EE and RETs
CEB	Responsible for power generation, transmission and supply, and sale of electricity. CEB has plans to invest in utility-scale wind energy in the future.
Financial Institutions	Provider of finance for investment in wind energy projects.
Ministry of Finance and Economic Empowerment (MoFEM)	The ministry responsible for budgeting and has the role to develop financial instruments to fund the incremental cost of electricity produced from RETs.
Community Groups, NGOs,	Protect the interest of communities located geographically close to wind farms, as well as related to issues of biodiversity.
Mauritian Wildlife Foundation	MWF endeavours to protect biodiversity, especially endemic plants, animals and mammals.
Board of Investment	Institution responsible for attracting FDI in Mauritius.
Department of Civil Aviation	Responsible for providing clearance for wind farms siting so that farms do not interfere with the flights in the Mauritian air space.
Ministry of Housing and Lands	Responsible for providing land development permits for wind farms.
Ministry of Environment and Sustainable Development	Responsible for providing EIA license for wind farm development.
Research institutions	Active in the fields of research for the promotion of RETs. Activities include renewable energy resources mapping, development of energy futures, etc …

1.2.2 Project Idea for boiler economizer

1.2.2.1 Summary sheet for boiler economizer

ENERGY INDUSTRIES PROJECT SHEET: Boiler Economizer

Brief Project description
The undertaking of three complementary actions are proposed (1) offering a free energy audit of Rs 10,000 per unit and (2) providing 20% of the capital investment rebate scheme of Rs328,000 per unit, and (3) a measure to provide training to selected staff (1 per company) on energy management and energy auditing at the estimated cost of Rs5,402 per person. Implementation will be between 2013 and 2020.

Results Oriented Framework

Overall Goal	Development Objectives
Mitigate climate change through the use of energy efficient boilers in industry and commercial operations	Removal of barriers for the uptake of boiler economisers using financial incentives and capacity building throughout the industry

Inputs	Outputs	Impacts
i. Capacity building and support mechanisms ii. Establishing rebate scheme on capital investment iii. Business and extension services	i. Opportunity is created for investment in economisers ii. Awareness of the benefit to the industry is raised	Long term impacts include reduction of industry energy and carbon intensity

Estimated costs
The total cost of measures is MUR 22,114,482 over 8 years (NPV). The breakdown (NPV) is as follows:
- Rebate scheme – MUR 21,122,615
- Energy audits – MUR 643,982
- Cost of training – 347,885

Proposed timeframe	Executive bodies
2013 - 2020	Ministry of Industry, Commerce and Consumer Protection

Cost-benefit analysis	Risks
The NPV of benefits over 13 years equals MUR 42,355,220 – hence the benefit/cost ration is 3.05. Sensitivity analysis for efficiency gain and cost of economizer unit places the benefit/cost ratio in the 2.41 – 10.12 range. The analysis also includes the cost of operation & maintenance of economizers.	Lack of visibility and trust in the measure, low efficiency gains, undesirable modifications

Expertise required

Profile	Key tasks
• Professional Energy Auditor • Trainers for energy managers • Engineers	• Carrying out Energy audit • Training of enterprise staff in energy management • Establishing rebate scheme on capital investment

Identification of key stakeholders
Ministry of Energy and Public Utilities (MoEPU), EEMO, Ministry of Industry, Commerce and Consumer Protection, Financial Institutions, Enterprise Mauritius, Ministry of Finance and Economic Empowerment (MoFEM), Mr Sharma Buctowar (Chemical & Environmental Engineer), Mr Bernard Domingue (Vivo Energy), Mr Fargy Romaly and Research Institutions such as MITD, UoM, MRC, UTM.

1.2.2.2 Project overview

Project scope

The undertaking of three complementary actions are proposed (1) offering a free energy audit of Rs 10,000 per unit and (2) providing 20% of the capital investment rebate scheme of Rs327,987 per unit, and (3) a measure to provide training to selected staff (1 per company) on energy management and energy auditing at the estimated cost of Rs5,402 per person.

The enabling framework that is conducive for technology transfer and diffusion needs to be in place: There are about 4 suppliers of the technology in Mauritius and they liaise directly with the end-users without the need of intermediaries. Government is currently putting in place mechanisms to increase the number of local suppliers of economizers to support the up-scaling of the technology in commercial applications, The main business and extension services are: (1) provision of financial and banking services (commercial banks); (2) EE promotion services (EEMO, Enterprise Mauritius, Ministry of Industry, etc.); and (3) consulting firms. There are also engineering companies that provide ancillary services during installation and maintenance of the equipment. Training and capacity building for energy managers and industrial auditors will be carried out under the GEF-UNDP-EEMO project for the removal of barriers to promote EE in industry.

Project timeline:

The timeframe used in the TNA project for the energy industries is aligned with the time period of the Long-Term Energy Strategy 2009-2025 (Ministry of Renewable Energy & Public Utilities, 2009). Hence, the timeframe for the implementation of the measures will cover the period 2013 to 2020 as per the schedule summarised in the following table.

In the barrier analysis, it has been assumed that 20% of commercial entities using boilers would opt for pre-heating of water using SWH as a means to reduce energy bill (Ministry of Environment & Sustainable Development, 2012).

Year	2013	2014	2015	2016	2017	2018	2019	2020
Economizer (diesel)	3	8	8	8	8	8	8	10
Economizer (LPG)	3	8	8	8	8	8	8	3
Total economizers	**6**	**16**	**16**	**16**	**16**	**16**	**16**	**13**

Implementation can be planned in the short to medium term in cost effective ways. For new projects, design, procurement and installation can utilize the new technology potential. For existing operations, implementation can be planned to coincide with major equipment replacements and/or retrofitting operations. This project has targeted boilers using LPG and diesel as primary energy sources – i.e. a total of 143 boilers representing 24.3% of all boilers used in industrial and commercial applications.

Budget:

The following table provides a summary of the cost of economic and financial measures for a typical economizer. The total cost to 2025 was calculated at MUR 99,798,428.

Measure	Cost (Rs)	Remarks
Energy audit	10,000 / unit	It is assumed that one energy audit will be carried out for each boiler for retrofitting an economizer. Each energy audit would require one day's work by a professional auditor. It is assumed that this would be carried out for free as an incentive for associated capital investment.
Rebate scheme on capital investment	327,986.7 / unit	20% of the capital investment will be provided as a rebate scheme (financial incentive). The capital cost is taken as Rs 1, 640, 000 for one unit.
Training of energy manager	5,402 / unit	Specialized agencies, such as EEMO and/or the Ministry of Industry, would provide training to energy managers at the level of 1 person per enterprise.
O&M	54,000 per unit per year	Once installed, it is assumed that O&M expenses would be negligible to 2025.

1.2.2.3 Project framework

It should be noted that Energy Efficiency (EE) target for the stationary combustion of fossil fuels (e.g. boilers in commercial and industrial settings) does not exist; however the National Energy Strategy does indicate that EE measures are to be taken (see section 1.2.2.4). This project can therefore advance the national agenda and provide an example as guidance for future EE programmes.

Project Goal: Mitigate climate change through the use of energy efficient boilers in industry and commercial operations

Development objectives: Removal of barriers for the uptake of boiler economisers using financial incentives and capacity building throughout the industry

Project Component	Expected Outcomes	Expected Inputs	Expected Outputs	Responsi-bility	Objectively Verifiable Indicators	Expected Impacts	Timeframe
EE Promotion services	Realising the benefits of installing and retrofitting boilers with economizers	Training and capacity building for energy managers and industrial auditors (under the GEF-UNDP-EEMO project for the removal of barriers to promote EE in industry)	Increased capacity of personnel.	- Ministry of Industry, Commerce and EEMO.	- Number of economizers installed by type and energy savings - Number of audits carried out (with full reporting) - Number of energy managers trained	Reduction in electric-ity and fuel consump-tion	Year 1-2
Mechanisms for increasing the number of local EE consul-tants and suppliers of economizers	Supports the up-scaling of the technology in commercial applications.	Consultations with industry stakeholders	Increased number of suppliers and consultants, creation of a competitive market	- Ministry of Finance and Economic Development; Ministry of Industry	- Number of suppliers & consultants - Number of enquiries made - Number of products and services provided	Customers have a wider range of choice to suit their needs and adopt the measure more easily	Year 1-3

Provide incentives for enterprises	Attracting investment in economisers and EE measures	Energy audits, rebate scheme on capital investment and covering O&M costs	Indentified specific needs, Rebate scheme on capital investment, O&M costs covered	- Ministry of Finance and Economic Development; Ministry of Industry	- Number of purchases benefitting from the rebate scheme - Amount disbursed on rebate - Number of new jobs created	Higher number of economiser purchases	Year 1-8
Provision of financial and banking services (commercial banks)	Being able to cover their own capital investment and ongoing maintenance costs	Information on benefits and rebate scheme to facilitate financing	Awareness and cooperation of financial and banking services to help promote the measure	- Financial institutions and Ministry of Industry, Commerce	- Number of enquiries - Services provided by scale	Ease of access to finance and services	Year 1-8

1.2.2.4 Project Justification

Sustainable development priorities:

EE targets for the stationary combustion of fossil fuels (e.g. boilers in commercial and industrial settings) do not exist. The updated Energy Strategy Action Plan 2011-2025 mentions that guidelines for energy management in industry would be developed in 2012, and for mandatory energy audits to be carried out in industry as from 2013. Further, the Action Plan states that EE programmes based on voluntary agreements would be created for industry between 2011 and 2014.

The free energy audit and capital investment rebate scheme directly address the key economical, financial and other barriers to the widespread diffusion of boiler economizers as noted TNA BAEF report. All the key stakeholders have singled out the high upfront capital cost of the equipment as the main impediment for the widespread diffusion of boiler economizers. Other barriers include low awareness of the technology and lack of consultants who would conduct detailed engineering studies (with accurate measurements) to evaluate energy savings opportunities – an important factor necessary to convince Top Management of pursuing energy efficiency projects.

Benefit-cost analysis:

Calculations to estimate the quantity of fossil fuels used for heating in industry and commercial applications were made using a top-down approach (macro socio-economic and environmental level for country-level aggregate) , resulting in a benefit-cost ratio is found to be 3.05 (NPV cost: MUR 99,798,428 and NPV benefits: MUR 129,226,461), which shows the net benefit accruing from the measures identified. Other than savings from increased efficiency, benefits can be multiple:

- Reduced health and safety hazards due to heat losses
- Marketing potential
- Reduced operational expenses
- Profit increase potential
- Potential to attract investments

The annual CO2 emission reduction in the Mauritian context has been calculated at 54.2 tCO2 and 18.3 tCO2 for retrofitted boilers running on diesel and LPG, respectively.

11 It wasn't possible to apply a bottom-up approach (namely operational level of industrial and commercial users of boilers) to estimate the quantity of fossil fuels used for heating in industry and commercial applications.

1.2.2.5 Monitoring and Evaluation (M&E)

The results-oriented framework will be used for M&E of project implementation. More specifically, the progress made against the Objectively Verifiable indicators (OVIs) will be monitored and reported under the governance structure of the project

1.2.2.6 Risks

Risk	Level (Low, Medium, High	Response
Lack of visibility of the project	Low	The relevant authorities and stakeholders will be solicited and engaged in the project
Energy audits reveal that energy efficiency gains from economizers are small	Low	Higher energy efficiency gains may be identified with alternative techniques or technologies thanks to energy audits and capacity building.
Enterprises may not have resources for hiring an energy manager	Medium	The training and support provided by the project can support existing staff to take on the role of energy manager.
Electricity use associated with the boiler auxiliaries (e.g., fans, pumps, conveyors) may change as a result of the new boiler.	Low	Risk is limited with appropriate commissioning of the entire boiler system.
A change of boiler system requires modification of operation and maintenance schedules.	Low	Industry operation and maintenance schedules change regularly as a result of increased capacity, new equipment and optimization measures.
The technologies adopted are not operated and maintained adequately leading to premature failure and reduced confidence in the technology	Low-Medium	The training and support provided should ensure that management pays attention to the new technology to achieve its potential benefits.

1.2.2.7 Stakeholder mapping

Stakeholder	Roles and responsibilities
Ministry of Energy and Public Utilities (MoEPU)	Responsible for developing Energy Policy and Strategy of Mauritius and to put in place policy instruments to support EE and RETs
EEMO	Facilitates the promotion of EE in all sectors of the economy, including industry and commercial activities. It also carries out capacity building and training on energy auditing.
Financial Institutions	Provider of finance for investment in wind energy projects.
Ministry of Finance and Economic Empowerment (MoFEM)	The ministry responsible for budgeting and has the role to develop financial instruments to fund the incremental cost of electricity produced from RETs.
Enterprise Mauritius	Provides energy audit services through funding schemes for industry.
Ministry of Environment and Sustainable Development	Responsible for providing EIA license for wind farm development.
Research institutions	Active in the fields of research for the promotion of RETs. Activities include renewable energy resources mapping, development of energy futures, etc …

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