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.

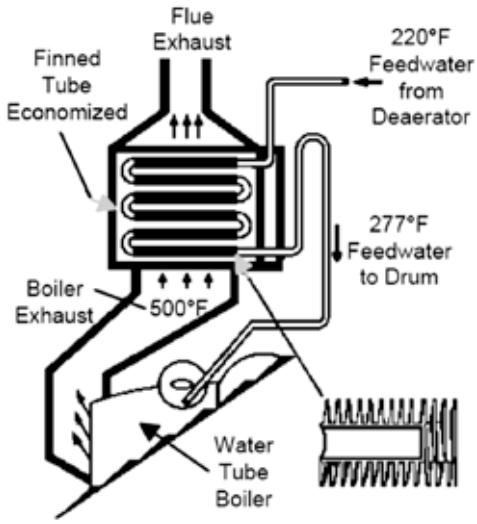

Figure 5. Finned-tube boiler economizer (US Department of Energy, 2008).

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.