Technical Assistance Closure Report:

Request ID No. 2015000025

Closure Report for CTCN Technical Assistance

1. Basic information

Title of response plan	Assessment and identification of technology needs and best practices for reducing the GHG emitting potential of the energy sector in Mauritius
Technical assistance reference number	Request ID No. 2015000025
Country / countries	Mauritius
NDE focal point and organisation	Mrs Sin Lan NG YUN WING Director of Department of Environment Ministry of Environment, Sustainable Development, and Disaster and Beach Management
Proponent focal point and organisation	Mrs Sin Lan NG YUN WING Director of Department of Environment Ministry of Environment, Sustainable Development, and Disaster and Beach Management
Designer of the response plan	Jukka Uosukainen, CTCN Director
Implementer(s) of technical assistance	Council for Scientific and Industrial Research (CSIR) of South Africa
Beneficiaries	Government of Mauritius
Sector(s) addressed	Power Sector, Independent Power Producers (IPPs)
Technologies supported	• **Sector:** Industry. **Technology Group**: Conventional power plant efficiency. **Technology**: Higher efficiency steam boiler and Large-scale Combined Heat and Power • **Sector**: Agriculture. **Technology Group**: Biomass carbon measurement and monitoring.
Implementation period and total duration in months	July 2018 to December 2019 (18 Months) Original response plan term – 6 months
Total budget for implementation	USD 44 071 + USD 10 935 (Adj) = USD 55 006
Description of delivered outputs and products as well as the activities undertaken to achieve them. In doing so, review the log frame of the original response plan and refer to it as appropriate	**Output 1:** Desktop report on environmental performance requirements for thermal power plants **Output 2:** Baseline study of existing power plants **Output 3:** Report on technology and operational recommendations to improve environmental and energy performance **Output 4:** Capacity building of local and national officials in monitoring and assessment of energy and environmental performance as well as the delivery of a final and nationally consolidated report
Methodologies applied to produce outputs and products	• Data and information gathering through surveys and interviews. • In Plant Measurements of key system parameters. • Validated information through modelling the systems and applied best practise systems optimisation techniques.
Deviations	• Deviation occurred in terms of timelines, the project was implemented over a period of 18 months compared to the plan of 6 months. The original budget included only one mission, this

	was expanded to include a second mission and an extended periods for outputs 3 and 4. • Incomplete data and a lack of response from Omnicane St Aubin prevented finalisation and quantification of study findings. • The absence of water supply and effluent measurements prevented thorough analysis of these aspects at both facilities (Omnicane St Aubin and Terragen).
Anticipated follow-up activities and next steps	None. To promote a serious consideration and possible implementation of recommendations, we propose a follow-up mission to: • Facilitate the implementation of no- and low-cost projects • Develop a measurement plan and remote monitoring of key parameter performance • Extend the study into reduction of Bagasse moisture levels in pursuit of appropriate measures • Support the Cane Field Residue (CFR) project in pursuit of optimum blend CFR, Bagasse and Coal • Conduct a more thorough investigation into the high levels of unburnt Carbon in fly ash and bottom ash • Introduce innovative coal power plant technologies • Expand the capacity of steam systems and performance measurement training to the Mauritian textile and sugar sectors All of the above to achieve international boiler best practise and to reduce greenhouse gasses emissions from power plants.

2. Lessons learned

	Lessons learned	**Recommendations**
Lessons learned from the CTCN TA process	• The importance of the quality of data collection is critical. • A representative training group affirms the importance of strategic selection of candidates to training workshops. • The importance of ministerial leadership cannot be overestimated.	*Recommendations include* • Data quality affects the overall outcomes and should be checked and confirmed before a mission is conducted • Strategic selection of candidates (that could benefit from the presented training) to workshops • Industry buy-in should be confirmed before consultants conduct surveys.
Lessons learned related to climate technology transfer	• Measurement and Monitoring is critical • Reporting using the data and information • Quality of water testing facilities • Existing technology in some cases were not being adequately maintained and prevents the	*Recommendations include* • Measurements should evolve from only installing measurement to reporting the right information to relevant managers within the business • Environmental measurement and monitoring can be improved • Access to data and information can be expanded

	implementation of newer technology.	• Measurement and Verification of savings as a result of projects can be improved

3. Illustration of the TA and photos

See Appendix 1 (Omnicane) & Appendix 2 (Terragen)

4. Impact Statement

Challenge	Mauritius is determined to reduce its national GHG emissions. The current energy challenge in Mauritius is to provide reliable affordable energy while transitioning towards more renewable sources thereby meeting the energy needs of its growing economy with the minimum environmental and climatic impact. Whilst renewable energy is expected to form an increasing proportion of the energy mix, it will still be necessary to utilise coal in the national energy mix. Conventional power production using coal will need to abide by environmental end energy related safeguards. These safeguards will, among other benefits, help to decrease the CO_2 emissions of the country. However, the national authorities and operational managers at the power plants are facing technical constraints and assistance will be required to: • Monitor and evaluate the environmental and related performance of the coal based power plants using international best practices, • Assess the existing coal based boiler technologies and advise on international best practices and best available techniques to reduce local pollution and GHG emissions from the power plants.
CTCN Assistance	The CTCN Technical Assistance to the Government of Mauritius assisted national priorities for enhancing national monitoring environmental performance of the country's five thermal power plants. Current steam and power generation practices, processes and technologies were evaluated and recommendations made. Environmental practices were evaluated where information was available. Capacity building was provided on performance measurement in energy systems that is also applicable in water and other environmental systems. Recommendations for improvement were not only made on a site level but also in the consolidated report on a strategic/country level.
Anticipated impact	As a result of the Technical assistance that included detailed reports with analysis and recommendations; the potential impact of these activities would include: • Improvement in energy and GHG emissions monitoring by the ministry officials and other relevant institutions as well as enhancing the environmental performance of the power plants. • Reinforcing of Environmental Impact Assessment processes and capacities related to energy production. • Increased mainstreaming of climate mitigation in national policies, increase in solutions for reducing GHG emissions and improvement in environmental performance of the energy sector.
Co-benefits: Achieved or anticipated co-benefits from the TA	Anticipated co-benefits include:

	• Enhanced capacities in environmental performance is likely to be scalable and replicable and can be rolled out to other sectors. • Better environmental performance is expected as a result of better environmental performance management by the energy sector.
Gender aspects of the TA	Reporting in terms of number of women and men trained is shown in Annex 1 of this report. Training and assessment were conducted by a team that consisted of two women and one man during the first mission (Omnicane visit) and during the second mission (Terragen) the team consisted of two women and two men. Women were encouraged to participate inthe scheduled training and all candidates were assisted in completing exercises as a practical component of capacity building.
Anticipated contribution to NDC	Mauritius' Intended Nationally Determined Contribution was submitted to the UNFCCC in September 2015 and included an increase in biomass energy production as a national mitigation action. This TA will assist in promoting the increase in Biomass and provide information on the best international practices and available technologies for energy efficiency.
The narrative story	Mauritius is determined to reduce their national GHG emissions. When the mix of energy sources for electricity generation are considered it is very interesting to see the magnitude of electricity being generated from Fuel oil and Diesel (36.5% in 2016 and 37.4% in 2017) compared to electricity generated from Coal (41.6% in 2016 and 2017). Bagasse as a source of energy for electricity generation decreased from 16.3% in 2016 to 14.7% in 2017. These three sources of energy are the main contributors to electricity generation while Hydro electricity generation contributed 3.3% in 2016 and 2.8% in 2017 and Photovoltaic electricity generation contributed 1% in 2016 and 2.4% in 2017. Mauritius is therefore still heavily reliant on fossil fuels for electricity generation. Even though renewable energy is expected to form an increasing proportion of the future energy mix, the existing coal and bagasse will have to abide by energy and environmental related safeguards. The safeguards will (amongst other benefits) help decrease the CO_2 emissions. The CSIR was contracted by the Climate Technology Centre and Network (CTCN) to consult on the Technical Response Plan and provide assessments and identification of technology needs and best practices for reducing the GHG emitting potential of the energy sector in Mauritius. The first mission was conducted in November 2018 to Omnicane St Aubin and the second mission was conducted in July 2019 to the Terragen Plant at Plaine Des Papayes. Both of these plants were assessed and reports delivered to plant personnel and the Mauritian Ministry of Environment. The following recommendations and observations were made: ***Output 2: Baseline study*** Mauritian thermal power plants compare well with global small scale power plants. There are technology improvements that can be applied but this should be viewed in the context of replacement timelines, available funding and the relatively stagnant national power demand.

	Thermal plant effiencies range between 33-37% with global best practice efficiencies exceeding 40%. The Terragen efficiency was 30.2% for the period June 2017 – June 2018 highlighting an area for improvement but is should however be qualified, noting the rate and scale of Mauritian power grid fluctuations that influence this metric. Newer technologies would include: small scale fluidised bed coal plants, small scale coal gasification combined cycle (CGCC) plants with the ability to discard coal fines more effectively than larger plants. Flue gas treatment measures essentially comprising of electrostatic precipitator are minimal and we suggest that a denitrification (deNox) unit and fluegas desulphurisation plant should be mandated in coal fired power plants. ***Output 3: Technical, Process and Operational Related Recommendations*** Recommendations regarding opportunities at the different plants included: • Boiler control and monitoring upgrades • Turbine efficiency issues that may have been caused by deposits, corrosion or erosion on turbine blades • VFD controls on cooling tower fans that could improve their performance • Check the feasibility of a bagasse dryers that could significantly improve the efficiency during crop season • Development and implementation (tracking performance) of energy baselines and water baselines Assuming all 5 thermal power plants in this study represent similar savings opportunities the cumulative energy and cost savings could conservatively be greater than **MUR 554M annually**. Other key parameters included the fuel and energy mix where the following recommendations were made regarding renewable energy: • Optimisation and maximising bagasse use. • Offshore wind power generation. • Pyrolysis of rubber tyres (latest technologies with low temperature pyrolysis). • Waste to energy in the form of biogas can be investigated at waste water treatment facilities. Coal Ash recommendations included, in order of execution: • Improve boiler combustion efficiencies with more effective air:fuel ratio controls, • Install, maintain and operate fly-ash refeeding systems to reduce the unburnt carbon levels in both fly- and bottom ash to levels below 10.0%, and ideally target 5.0% and Thereby obviate the need for a costly CBO unit and directly use final fly-ash residues in the building construction brick manufacturing process. Business risk to the IPPs were also discussed as a Key parameter. The reported delays and uncertainty around the renewal of power supply contracts by CEB for Mauritian IPP thermal power plants, especially in the case of the Terragen

	and Alteo plants, serves to delay critical decision making relating to plant upgrades and funding arrangements. ***Output 4: Capacity Building of National and Local Officials on Monitoring and Assessment of Environmental and Energy Related Performance.*** Capacity building was provided to 34 delegates in total. The training constituted a course on steam systems and a course on energy performance measurement. These courses were selected based on two distinct delegate groups as identified in the training needs assessment conducted together with the Mauritian Ministry of Environment (Government Officials and Independent Power Plant Personnel) and the courses were adapted to suit the stakeholder needs.
Contribution to SDGs	**SDG 2**: This TA supports SDG2 in that it sustainable agriculture is promoted in the use of Bagasse and Cane Field Residue as fuel o the power plant boilers. **SDG 4**: Education and lifelong learning opportunities were supported in the training component of this TA. **SDG 6**: The sustainable management of water was supported in the environmental assessment and certain pertinent issues were highlighted by the study. **SDG 7**: Access to sustainable and modern energy was promoted in the assessment and technology opportunities were highlighted. **SDG 9**: The resilience of the Mauritian infrastructure and sustainable industrialisation was fostered. **SDG 12**: Sustainable consumption and production patterns in industry was supported through this initiative. **SDG 13**: Combating climate change and its impacts was one of the main drivers of this assistance to the Mauritian authorities. **SDG 16**: Building on the accountability of the government institutions of Mauritius was promoted and improved through the Technical Assistance. **SDG 17**: The partnership in sustainability between South Africa and Mauritius was strengthened and hopefully implementation of opportunities could follow.

Annex 1 Technical assistance data collection

A. Output and outcome indicators

Indicator Please note indicators below highlighted as **anticipated**	**Quantitative value** Value and unit	**Qualitative description** List the various elements corresponding to the quantitative value as well as timelines and responsible institutions
Number of communication and outreach activities conducted by proponents and implementing partners to showcase CTCN support	• *Four (4) briefing and debriefing sessions to Ministry officials and thermal plant management prior and post on-site audits.* • *Six (6) progress and audit reports submitted, including this closure report, to the Ministry, thermal plant management and the primary contractor (NRE).* • *We are not aware of communication and outreach activities by the Ministry and Thermal plants.* • *This is not a subcontracted output.*	*Two (2) presentations on the results of the TA*
Number of participants in the events above	*Omnicane -16* *Terragen – 28* *NRE – 7* *Total = 41 (tbc)*	
a) Number of men	*36*	
b) Number of women	*5*	
Number of training sessions and capacity strengthening activities	4	• *2-Day End User Steam System Optimisation (SSO) training* • *2-Day End User Steam System Optimisation (SSO) training* • *2-Day Energy Management Performance Management and Indicators (EnPMI) training.*

Number of people who received the training	68 delegates over 4 workshops	
a) Number of men	40	
b) Number of women	28	
Total number of institutions trained	*9*	
a) Number of research organisations, laboratories and universities		*Omnicane St. Aubin* *Omnicane La Baraque Ltd* *Terragen Thermal Power Plant* *Alteo Energy Ltd* *Alteo Milling Ltd* *Central Energy Board* *Ministry of Environment and Sustainable Development* *Ministry of Energy and Public Utilities* *National Environmental Laboratory (NEL)*
b) Number of private companies	0	
c) Number of cities and local government	0	
d) Number of communities	0	
e) Number of ministries	2	*Ministry of Environment and Sustainable Development* *Ministry of Energy and Public Utilities*
f) Number of specialised governmental institutions	2	*Central Energy Board* *National Environmental Laboratory (NEL)*
g) Number of non-profit organisations	0	
Percentage of participants reporting satisfaction with CTCN training (from CTCN training feedback form)		*Omnicane 1-Day SSO: Content – 60%, Delivery – 70%* *Omnicane 2-Day EnPMI: Content – 80%, Delivery – 80%* *Terragen 2-Day SSO: Content – 90%, Delivery 100%* *Terragen 2-Day EnPMI: Content – 90%, Delivery – 90%*
Percentage of participants reporting increased knowledge, capacity and/or understanding as a result of CTCN training (from CTCN training feedback form)		*Omnicane 1-Day SSO: 50%* *Omnicane 2-Day EnPMI: 85%* *Terragen 2-Day SSO: 80%* *Terragen 2-Day EnPMI: 100%*
a) Number of men	36	
b) Number of women	20	
Total number of deliverables produced during the assistance (excluding mission, progress and internal reports)	*9 Outputs and Output Activities*	
a) Number of tools and technical documents strengthened, revised or developed	5 software and modelling tools demonstrated and applied during the training workshops	• ***SSST:*** *Steam System Scoping Tool* • ***SSAT****: Steam System Assessment Tool*

		• ***SSMT**: Steam System Modeler Tool* • ***3E-Plus**: Insulation Software Tool* • ***Excel Regression** Analysis*
b) Number of other information materials strengthened, revised or created (For example training and workshop reports, Power Points, exercise docs etc.)	Developed and adapted UNIDO / NCPC-SA training material for Mauritius training	• *1-Day SSO training power point material* • *2-Day SSO training power point material* • *2-Day EnPMI training power point material*
Total number of policies, strategies, plans, laws, agreements or regulations supported by the assistance	*0*	
a) Adaptation related		
b) Mitigation related		
c) Both adaptation- and mitigation related		
Anticipated number of policies, strategies, plans, laws, agreements or regulations proposed, adopted or implemented as a result of the TA	0	
a) Adaptation related		
b) Mitigation related		
c) Both adaptation- and mitigation related		
Anticipated number of technologies transferred or deployed as a result of CTCN support	0	
Number of South-South collaborations enabled during or through CTCN TA support	2	• *NCPC-SA* • *CSIR*
Number of climate technology RD&D related outreach activities	0	
Number of participants in climate technology RD&D related workshops and events	0	
a) Number of men		
b) Number of women		
Anticipated number of cooperative research, development, and demonstration programmes facilitated as a result of CTCN TA	0	
Number of countries with strengthened National System of Innovation as a result of CTCN support	0	
Number of organisations engaged through CTCN support	3	• *NCPC-SA* • *CSIR* • *Hudson Technologies*
Insert any additional indicators here	None	

B. Core impact indicators

<table>
<tr><th>Core indicator 1</th><th colspan="2">Anticipated metric tons of CO_2 equivalent (CO_2e) emissions reduced or avoided as a result of CTCN TA</th></tr>
<tr><td></td><td>Anticipated metric tons of CO_2, equivalent emissions reduced or avoided as a result of the TA on annual basis</td><td>Anticipated metric tons of CO_2, equivalent emissions reduced or avoided as a result of the TA in total</td></tr>
<tr><td>Quantitative value</td><td>One of the aims of the TA was to identify potential opportunities for improving power plant performance and ultimately reducing GHG emissions.

The Terragen power plant was able to provide accurate data and information. The information and data was used in identifying opportunities. If the following opportunities were identified at Terragen that could potentially be implemented at the other 4 facilities included in the study as well:
• Blowdown Management
• Blowdown Heat Recovery
• Enhancing Turbine Efficiency
In the following table the opportunities are listed and potential emissions savings calculated for Terragen and followed by simply extrapolating potential savings to the other power plants included in the study.

Total emissions that could be saved was 68 168 tCO_2/annum.
<table>
<tr><th>Opportunity</th><th>Fuel savings</th><th>Units</th></tr>
<tr><td>Blowdown Management</td><td>68 000</td><td>GJ/annum</td></tr>
<tr><td>Blowdown Heat Recovery</td><td>91 500</td><td>GJ/annum</td></tr>
<tr><td>Enhance Turbine Efficiency</td><td>98 400</td><td>GJ/annum</td></tr>
<tr><td>Total</td><td>257 900</td><td>GJ/annum</td></tr>
<tr><th>Emissions savings at Terragen</th><th>Value</th><th>Units</th></tr>
<tr><td>Weighted Mauritius efficiency of converting coal and bagasse to electricity*</td><td>24.5%</td><td></td></tr>
<tr><td>Terragen electrical savings</td><td>63 161</td><td>GJ_e/annum</td></tr>
<tr><td>Terragen electrical savings</td><td>17 544 687</td><td>kWh/annum</td></tr>
<tr><td>Grid emissions factor**</td><td>954.8</td><td>gCO_2/kWh</td></tr>
<tr><td>Emissions savings at Terragen</td><td>16 752</td><td>tCO_2/annum</td></tr>
<tr><th>Emissions savings for all 5 plants included in study</th><th>Value</th><th>Units</th></tr>
<tr><td>Terragen contribution to installed Generation Capacity</td><td>24.57%</td><td></td></tr>
<tr><td>Emissions savings for all 5 plants included in study</td><td>68 168</td><td>tCO_2/annum</td></tr>
<tr><td>Total nett CO_2 emmissions of Mauritius in 2017</td><td>3 861.5</td><td>$ktCO_2$</td></tr>
<tr><td>Percentatge of potential savings</td><td>1.8%</td><td></td></tr>
</table>
*This is a weighted average conversion calculated using values in Summary Table 2017 on page 41 of the "Energy Observations Report" as published by the Energy Efficiency Management Office of Mauritius. Also available online.

**Grid Emissions factor published in "Energy Observations Report" as published by the Energy Efficiency Management Office of Mauritius, page 38. Also available online.</td><td>NA</td></tr>
</table>

<table>
<tr><td></td><td>The following table shows the 5 plants/facilities that were included in the TA and their respective Installed capacities.

<table><tr><th>Power Plant</th><th>Generation (MW)</th></tr><tr><td>Terragen</td><td>62</td></tr><tr><td></td><td></td></tr><tr><td>Beau Champ</td><td>28.4</td></tr><tr><td></td><td></td></tr><tr><td>Alteo</td><td>40.5</td></tr><tr><td></td><td></td></tr><tr><td>Omnicane La Baraque</td><td>88.9</td></tr><tr><td></td><td></td></tr><tr><td>Omnicane St Aubin</td><td>32.5</td></tr><tr><td>Totals</td><td>252.3</td></tr></table></td><td></td></tr>
<tr><td>Unit</td><td>tCO_2/annum</td><td>NA</td></tr>
<tr><td>Methodology</td><td colspan="2">One of the aims of the TA was to identify potential opportunities for improving power plant performance and ultimately reducing GHG emissions. These opportunities have been identified and potential cost and energy savings calculated. Two power plants that would be representative of the broader Independent Power Producer (IPP) group were chosen (Project-specific approach), one that utilised coal only to produce power and one that consumed a fuel mix of coal, bagasse and cane field residue to produce power. No reliable data was however available to develop baselines for the “coal only” plant. The baseline provided here therefore is only applicable to (dual) coal and bagasse fired power plants.
Calculation of actual emissions savings can only be performed once opportunities have been implemented and savings have been verified.</td></tr>
<tr><td>GHG assessment boundary</td><td colspan="2">Post TA activities would include that the Mauritian Dept. of Environment would review the two plant specific reports and consolidated Independent Power Producer (IPP) report and together with the IPPs decide on actions that that they are willing to take and that are in accordance with their budget to implement.
The expected boundary of the study was the two assessed facilities (Omnicane St Aubin and Terragen).
Only the power plants were assessed and not the adjoining sugar cane factory as in the case of the Terragen plant.
GHG sources would include the coal and bagasse fired boilers at each facility.
Primary effects of activities that could eventually be implemented would be the reduction of coal utilised to produce power and the resultant reduction in carbon emissions. Secondary effects would include a reduction in costs related to the transporting of coal from South Africa and Indonesia to Mauritius to be utilised.
Another secondary effect would be a reduction of coal ash being used to level sugar cane fields on the island.</td></tr>
<tr><td>Baseline candidates</td><td colspan="2">Baseline candidates: The energy sources used to generate electricity includes coal, fuel oil and diesel, bagasse and other smaller sources such as solar PV, landfill gas, wind and hydroelectricity.
The main fuel sources for IPPs includes coal and bagasse. In addition to this the different designs (technology) were considered, the age of the plants as well as the generation capacity of the plants where one larger and one smaller plant were chosen.</td></tr>
</table>

	In terms of the **temporal range,** the current state of power generation in the country was targeted. It was applied to the Terragen baseline in that only data from 2016 to 2018 was used to develop the baseline as data issues were prevalent in the years preceding that.
Baseline emissions	Barriers to implementing projects as identified by this TA would include: • Financial and Budgetary barriers (Closely related to market and structure barriers. Contracts with the Mauritian Central Energy Board (CEB) to produce power are only valid for 5 years therefore discouraging big investment in new technology) • Market and structure (Lack of political will to spend funds on coal fired power plants, lack of action and certainty on what government plans to do about its fuel source composition is also a disincentive to invest) Energy Performance Baselines were developed for the Terragen Plant and are attached in Appendix 3. These Energy performance baselines can be used to determine energy performance of the coal and bagasse facility going forward and can easily with an emissions factor for Mauritian power generation be converted to emissions baselines.
Assumptions	Please refer to Appendix 3.

Core indicator 2	**Anticipated increased economic, health, well-being, infrastructure and built environment, and ecosystems resilience to climate change impacts as a result of technical assistance** *Please provide a **qualitative** description of the anticipated impacts on the categories below*
Infrastructure and built environment Anticipated increased infrastructure resilience (avoided/mitigated climate induced damages and strengthened physical assets)	None. Too early to determine whether corrective action and / or implementation arising from our recommendations were adopted and / or whether results arising from implementation. We welcome an opportunity to revisit Mauritius in 2020 to evaluate resultant effects of our intervention.
Ecosystems and biodiversity Anticipated increased ecosystem resilience (areas with increased resistance to climate-induced disturbances and with improved recovery rates)	None. Too early to determine whether corrective action and / or implementation arising from our recommendations were adopted and / or whether results arising from implementation. We welcome an opportunity to revisit Mauritius in 2020 to evaluate resultant effects of our intervention.
Economic Anticipated increased economic resilience (e.g. less reliance on vulnerable economic sectors or diversification of livelihood)	None. Too early to determine whether corrective action and / or implementation arising from our recommendations were adopted and / or whether results arising from implementation. We welcome an opportunity to revisit Mauritius in 2020 to evaluate resultant effects of our intervention.
Health and wellbeing Anticipated increased health and wellbeing of target group (e.g. improved basic health, water and food security)	None. Too early to determine whether corrective action and / or implementation arising from our recommendations were adopted and / or whether results arising from implementation. We welcome an opportunity to revisit Mauritius in 2020 to evaluate resultant effects of our intervention.

Core indicator 3	Anticipated number of direct and indirect beneficiaries as a result of the TA		
	Direct beneficiaries	**Indirect beneficiaries**	**Means of verification**
Adaptation related	NA	NA	NA
Mitigation related	All opportunities identified during our study would be Mitigation opportunities if implemented		No opportunities have been verified to be implemented and calculation of benefits is therefore not possible at present.
Both adaptation-and mitigation related	NA	NA	NA

Core indicator 4	Amount of funding/investment leveraged (USD) as a result of TA (disaggregated by public, private, national, and international sources, as well as between anticipated/confirmed funding)		
	Quantitative value Value and currency	**Qualitative description** List the various elements corresponding to the quantitative value as well as expected timelines and responsible institutions	**Methods** Describe method use for quantification of funds leveraged including assumptions made and attention paid to causality, attribution and avoidance of double-counting
Total anticipated amount of funding/investment mobilised or leveraged (USD) as a result of the TA	0		
Anticipated amount of **public funding** mobilised from **national sources** (USD)	0		
Anticipated amount of **public funding** mobilised from **international and regional sources** as a result of the TA	0		
Anticipated amount of **private investment** mobilised (in USD) from **national sources** as a result of the TA	0		
Anticipated amount of **private investment** mobilised (in USD) from **international and regional sources** as a result of the TA	0		

Annex 2 (for internal use – to be filled in by the CTCN)

CTCN evaluation
This section will be completed by the relevant CTCN Technology Manager.

- Evaluation of the timeliness of the TA implementation as measured against the timeline included in the response plan;
- Evaluation of TA quality as defined in the response plan;
- Overall performance of the Implementers;
- Overall engagement of the NDE and Proponent;
- Lessons learned on the CTCN process and steps taken by the CTCN to improve.

Appendix 1: Omnicane Pictures

Boiler stack

Ash collection

Coal handling conveyors

Ash re-introduction into boiler (system not working at the time of site visit)

Cooling tower

Effluent dam

Appendix 2: Terragen Pictures

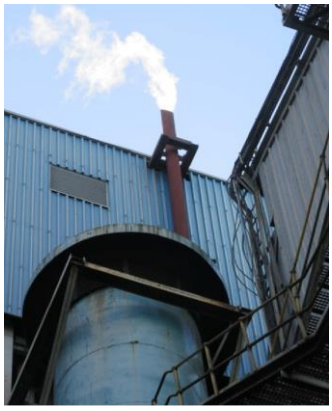
Steam Boiler and Turbine Building

Water Treatment Plant

Electrostatic Precipitator, Ash Collection System

Boiler Steam and Mud Drums & Steam headers

Boiler Stacks



Blowdown Flash Steam

Cane Field Residue Shredder

Candidates and facilitators at training

Appendix 3: Baselines

1.1 Baseline of Energy Performance

Parameters generally used to determine the efficiency of power plants include:

- Overall Power Station efficiency = Load available at generator terminal/(coal flow x Gross Caloriffic Value))
- Heat rate= Heat added to the steam boiler (kJ)/electrical energy exported (kWh)
- Specific Fuel Consumption = Fuel consumed in (kg/h)/Power generated (kW)

In addition the efficiency of components of the power plant can also contribute to the efficiency picture of a specific plant:

- Boiler efficiency: Calculated either by the direct or indirect method
- Turbine efficiency

The average global (Power Station) efficiency of Coal fired power plants is about 33% (in 2017) according to Mike Rycroft in his article "Efficiency improvement of coal-fired power stations" published in "ee Publishers" on 15 March 2017.

1.1.1 Boiler Efficiencies

The boiler efficiencies of the two power plants assessed in this study were:

- Omnicane: 89.7% (efficiency calculated from spot measurements taken during site visit in November 2018.)
- Terragen: **87.6%** (efficiency calculated from spot measurements taken during site visits in July 2019.) Notably this was for a period during which both coal and bagasse was being fed to the boiler. Based on data that was measured during **coal only operation (in 2018)** this number was **87.6%** and during times that **only Bagasse** was being fed to the boiler (in 2018) the efficiency dropped to **68.9%.** On average during dual firing periods efficiency was around 74.8% as calculated from 2018 data.

It is however very difficult to directly compare efficiency parameters since they are usually heavily influenced by many factors that include the type of technology, grade of coal or other fuel fed to the boiler etc.

1.1.1 Energy Performance Baselines

Performance baselines were developed for the Terragen plant that enables the comparison of current performance to historical performance of the plant. Omnicane was unable to provide data that was of the integrity to enable the development of such baselines.

All season's baseline

For Terragen the baseline that was developed to include **"all seasons"**, meaning January to December periods that include coal only, bagasse only as well as duel firing of fuel was:

Total energy supplied (coal + bagasse in GJ/day) = 609.77 + 12.62*(MWh produced/day) - 6.51*(Tons per day LP steam extracted)

At a 95% confidence interval, the Standard Error $(SE)_{savings}$ was as follows:

$$(SE)_{savings} = \pm t^* \sqrt{(n*(SE_{model})^2)} = 73\ 033 \text{ GJ/day}$$

Where:

- *SE_{model} was given in the regression results for the model (1388.97)*
- *n = number of observations = 1020*
- *Degrees of freedom = n-1 = 1020-1 = 1019*
- *t (95%, degrees of freedom) = 1.64635*

Coal only baseline

The model for energy consumption **(applicable January to June – Coal only)** is:

Total energy supplied (coal + bagasse in GJ/day) = 1661.17 + 12.63*(MWh produced/day) - 5.53*(Tons per day LP steam extracted) - 139.94*(HDD)

At a 95% confidence interval, the Standard Error $(SE)_{savings}$ is as follows:

$$(SE)_{savings} = \pm t^* \sqrt{(n*(SE_{model})^2)} = 22\ 187 \text{ GJ/day}$$

Where:

- *SE_{model} is given in the regression results for the model (622.29)*
- *n = number of observations = 468*
- *Degrees of freedom = n-1 = 468-1 = 467*

t (95%, degrees of freedom) = 1.648123

Bagasse only baseline

The model for energy consumption (applicable **June to December – Bagasse only**) is:

Total energy supplied (coal + bagasse in GJ/day) = - 4528.29 + 12.10*(MWh produced/day) - 6.41*(Tons per day LP steam extracted) + 103.54*(HDD)

At a 95% confidence interval, the Standard Error $(SE)_{savings}$ is as follows:

$$(SE)_{savings} = \pm t^* \sqrt{(n*(SE_{model})^2)} = 68\ 017 \text{ GJ/day}$$

Where:

- *SE_{model} is given in the regression results for the model (1757.08)*
- *n = number of observations = 552*
- *Degrees of freedom = n-1 = 552-1 = 551*
- *t (95%, degrees of freedom) = 1.647624*

Baselines as discussed in this section can be used to determine the performance of the facility going forward (from 2019 onwards) and can be used to monitor and evaluate savings from implemented energy projects.