# Facility for Low Carbon Technology Deployment

Promoting Innovation and Deployment of Low Carbon Technologies

## *Encon Thermal Engineers Private Limited*

**(Regenerative Burner System)**

## FLCTD 2019 Grant Winner- WHR

## Measurement and Verification Report of Technology

## Demonstration and Validation

**Prepared By**


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**Disclaimer**



This measurement and verification report is part of the United Nations Industrial Development Organization (UNIDO), Bureau of Energy Efficiency (BEE), Government of India and CII-Sohrabji Godrej Green Business Center's (CII-SGGBC) effort with the support of Global Environment Facility (GEF); to establish the efficacy of innovation that will lend credibility of the innovation to seek financing for scale-up.

The benefits estimated by CII-SGGBC were based on data gathered from field trials at different locations. Since this solution/product is not yet commercially available, the return on investment (ROI) has not been estimated.

# PREFACE

The main objective of the "Facility for Low Carbon Technology Deployment" (FLCTD) is to facilitate deployment and scaling up of low-carbon technologies in India that can address technology gaps in mitigating climate change and promote the use of clean energy applications in selected sectors. The main function of the 'Facility*' is to identify high-impact challenges that if solved have potential for large-scale carbon emission reductions. The project aims to locate and link the critical connections between the stakeholders – those who are aware of the high-impact challenge and those with the technical expertise to provide solutions – to solve problems identified by experts.

FLCTD project conducts annual innovation challenges to solicit applications from innovative technologies under three technology verticals, namely: Waste Heat Recovery, Space Conditioning and, Pump and Motor Systems. Winners of the innovation challenge are selected through a rigorous screening process by an expert panel. Each winner receives:

- Grant award up to USD 50,000 for winning technology demonstration at multiple locations.
- Performance verification to establish the efficacy of innovative technology in field working conditions.
- Recognition from Bureau of Energy Efficiency and UNIDO.

The grant award enables the deployment and validation of the innovations at field locations; typically, industries/firms willing for pilot demonstration where the technology is periodically monitored, and performance validated. The technology verification process is expected to validate the efficacy of innovation and will lend credibility to the innovation for replication.

To achieve these objectives, the project has built a Technology Verification process for all FLCTD grant winning innovations, in consultation with the implementation partner, the Confederation of Indian Industry - Sohrabji Godrej Green Business Centre, Hyderabad (hereinafter CII-SGGBC). The CII-SGGBC provides implementation support to the project, especially in outreach efforts, providing connects with industries for technology demonstration, and validation of winning technologies in actual field conditions.

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**The BEE, the PMU-UNIDO and the Expert Panel is referred to as "The Facility" henceforth.*

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| BEE | Bureau of Energy Efficiency |
| CII | Confederation of Indian Industry |
| $CO_2$ | Carbon dioxide |
| GHG | Greenhouse Gas |
| INR | Indian Rupees |
| IR | Infra-Red |
| M&V | Measurement and Verification |
| TOE | Tonne of Oil Equivalent |
| UNIDO | United Nations Industrial Development Organization |
| WHR | Waste Heat Recovery |

## UNIT OF MEASUREMENTS

| | |
|---|---|
| $^oC$ | Degree Celsius |
| kCal | kilo Calorie |
| kVA | Apparent Power |
| kW | Kilo Watt (Active Power) |
| MT | Million Tonne |
| SCM | Standard Cubic Meter |

# TECHNOLOGY VERIFICATION REPORT

## SELECTION UNDER FLCTD INNOVATION CHALLENGE

In 2019 the 2nd Annual Innovation Challenge under the FLCTD project was announced in 3rd week of May 2019. The Terms of Reference of the Waste Heat Recovery innovation challenge is attached in Annexure A. The application submission was closed on 18th August 2019, and 34 applications were received in the Waste Heat Recovery technology vertical. The review of applications by the expert panel members was held on 4th September, 2019 in which nine applications were shortlisted for final presentation. The final presentations by the shortlisted applicants under the was held at the UNIDO project office on 25th September 2019. Based on merit of innovations and replication potential, seven firms were selected by an expert panel for receiving financial assistance from FLCTD project. These are:

1. M/s Aspiration Energy Pvt Ltd
2. M/s Centre for Energy Environment and Productivity
3. M/s ENCON Thermal Engineers Pvt Ltd
4. M/s Forbes Marshall Pvt Ltd
5. M/s Promethean Energy Pvt Ltd
6. M/s Opel Energy Systems Pvt Ltd
7. M/s Oorja Energy Engineering Services Hyderabad Pvt Ltd

## ABOUT THE COMPANY

ENCON Thermal Engineers was established during the energy crisis of 1978 in INDIA. The name was coined from the phrase "Energy Conservation & Conversion". After establishing the credentials in heat recovery systems and energy management system, ENCON started manufacturing furnaces and its allied equipment. It is managed by qualified Engineers & technocrats who are well- versed in designing, manufacturing, installation and commissioning of fuel-efficient systems. ENCON Thermal Engineers has been involved in a lot of research and development programs and has developed a lot of heating technologies, Over the last 30 years, they have been pioneers in introducing new and better energy efficient and conservation technologies in the country. The technologies developed and introduced by them, have been successfully running in the public sector and the private sector of the country and outside the country.

## DETAILS OF THE INNOVATION

- **Name of the innovation:** Regenerative Burner System.
- **Areas of application:** Aluminium Melting Furnaces, Forging Furnaces, Glass Furnaces, Heat Treatment Furnaces, Kilns for Ceramic, Ladle Preheaters, Soaking Pits, Steel Reheating furnaces.

## DESIGN OBJECTIVES OF THE INNOVATION

Regenerative and Recuperative burners optimise the energy-efficiency of the process by to using the heat released by furnace exhaust which if not utilised would go waste. Typically, In Regenerative burners heat from the flue gases are stored in the Regenerator Box. Regenerative Burners work in pairs, where in one burner uses the energy stored in the Regenerator Box to preheat the combustion air and the Regenerator Box of the Second burner act as a reservoir where the heat from the flue gas is stored. This process is reversed after a set interval of time. The objective of the innovation is to successfully demonstrate the working of Regenerative Burner in the test furnace and to determine the percentage heat gain by the combustion air and effectiveness of the Waste Heat Recovery system. Once the results are satisfactory, this technology can be replicated in various industries across the country.

# 1. SCOPE OF DEMONSTRATION UNDER FLCTD

The objective of the innovation is to maximise the Energy recovery from the high temperature flue gases and use this energy to increase the temperature of combustion air. This will lead to reduction in fuel Consumption and increase in overall efficiency of the process. Each Regenerative Burner System consists of the following main parts

- Burner with Nozzles and Burner Block
- Regenerator Box with Media Balls
- LPG/NG Pilot burner with UV sensor and Ignition Transformer
- Gas & Combustion air Pressure and Flow Regulation System
- Blower for Combustion Air and Flue Gases

Key aspects taken into consideration for measuring the efficacy of the innovation:

- Type of furnace.
- Rated Capacity of Furnace (for each burner).
- Rated Combustion Blower Flow.
- Type of Fuel used/Fuel Calorific Value.
- Type of Media inside WHR (Regenerative units).
- Quantity and Weight of Media inside WHR (Regenerative units).
- Furnace Temperature.
- Combustion air; Inlet & Outlet temperature (across Ceramic media box).
- Flue gas: Inlet & Outlet Temperature (across Ceramic media box).
- Fuel Consumption (based on totalizer).
- Combustion Air Flow.

The details of the demonstration site are given below:

**Table 1: Pilot Site Details**

| **Demonstration Details** | |
|---|---|
| Name of the pilot/project site | M/s ENCON Thermal Engineers Private Limited |
| Address of the pilot/project site | 53 KM Stone, Delhi - Mathura Road,<br>Vill. Baghola, Distt. Palwal - 121 102<br>Haryana (India) |
| Name of the contact person at Site | Mr Puneet Mahendra (Director) |
| Contact details (Tel./Email) | +91 9971499079, pm@encon.co.in |
| Type of industry for site demonstration | Industry – Aluminium & Steel furnaces |

## 2. DETAILS OF THE REGENERATIVE BURNERS

Regenerative burner technology is developed to maximise energy recovery from the flue gas generated during direct heating process, this recovered energy is used for preheating the incoming combustion air. Preheating of combustion air increased the efficiency of the process and reduced the fuel required for heating. Regenerative burners operate in pairs and work on the principle of short-term heat storage using ceramic balls in the Regenerator Box of the burner. Thus, eliminating the need of conventional recuperator. The regenerative burner has two type of lances:

1. Flame less (above 750Deg C for low Nox)- The NOx emissions can reduce between 20 to 80% depending on the process temperature and parameters between the normal and Low NOx flameless mode
2. Normal flame

The typical operating principle is explained below:

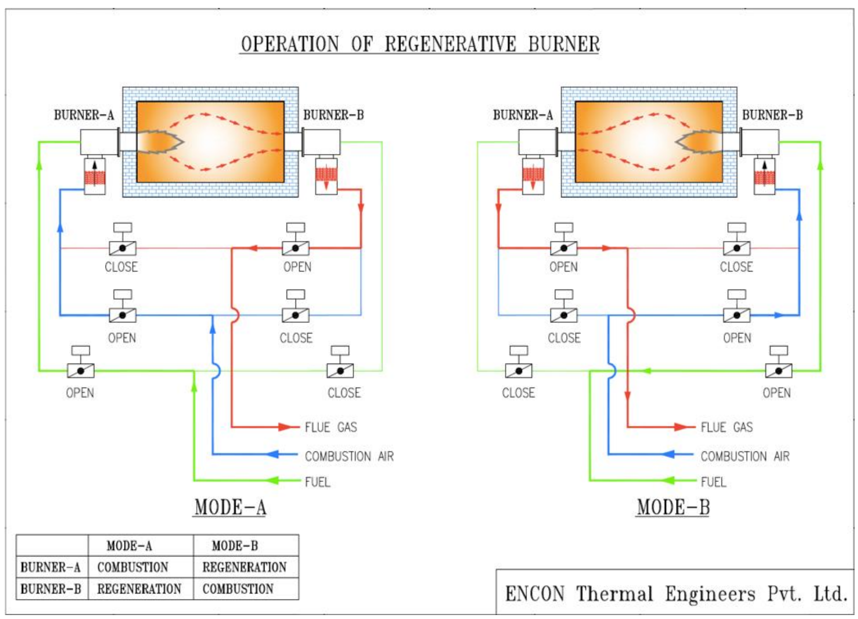



Figure 1: Block Diagram of Working Principle

In Mode A, Burner A fires and Burner B act as a Regenerator or Heat Sink, the flue gas is sucked by Burner B and the flue gas travels through the Regenerator Box of Burner B to the chimney, The Media box is filled with Ceramic balls which absorbs up to 85% of the heat of the flue gasses.

In Mode B, the process is reversed and Burner A act as the regenerator and Burner B fires. In this case combustion air passes through the hot media and can achieve a combustion air temperature in the range of 416 to 497°C, when the process temperature is in the range of 898 to 904°C. The compact and cost-effective system design can make it ideal for retrofit/upgrade projects for energy efficiency, productivity and/or $CO_2$ emission control in a variety of industrial heating applications.

The pilot demonstration of the system was done in a "closed box test furnace" at the factory of Encon Thermal Engineers Pvt Ltd in Vill- Baghola, Tehsil-Palwal, Haryana. And the initial site visits were made on February 2020, for understanding the progress of installation and commissioning of the furnace. The detailed parameters monitored and observed during site visit at the pilot site are given below:

**Table 2: Pilot Project details**

| Parameters | Units | Value | Reference/ Remarks |
|---|---|---|---|
| Type of Furnace | | Box test Furnace | Shared by plant team during site visit |
| Rated Capacity of Furnace (for each burner) | kCal/hr | 50,000 | |
| Rated Capacity of Combustion Blower | HP | 10 | Name Plate |
| Rated Combustion Blower Flow | $m^3$/Hr | 1360 | Shared by plant team |
| Rated Combustion Blower Head | inch wc | 40 | |
| Rated Capacity of Exhaust Blower | HP | 5 | Name Plate |
| Rated Exhaust Blower Flow (ENCON 40/5) | $m^3$/hr | 600 | |
| Rated Exhaust Blower Head | inch water column | 40 | Shared by plant team during site visit |
| Unit Price of fuel | INR/Kg | 46.58 | |
| Unit Price of Electricity | INR/kWh | 8.5 | |
| Fuel details (CNG / NG / LPG) | | LPG | |
| Fuel Density | Kg / $Nm^3$ | 1.96 | |
| Fuel Calorific Value | kCal /Kg | 11,000 | |
| Furnace Dimension | Dia | 1.490 metre | |
| | Length | 6 metre | |
| | Thickness | 150 mm | |
| Fuel to Air Ratio | Ratio | 1:35 | Ratio fixed by the plant team in the PLC |
| Average Furnace surface temperature | Deg C | 75-100 | Monitored during site visit |
| Ambient air temperature | $^0C$ | 30 | |
| Average Inlet combustion air temperature | $^0C$ | 30 | |
| Average Flue gas temperature, Inlet to ceramic media box | $^0C$ | 564 | |

## 3. TECHNOLOGY MEASUREMENT AND VERIFICATION

The overall system was commissioned in the month of March and the final measurement & verification (M&V) studies were conducted by UNIDO (Mr K V Kiran Kumar) and CII-Godrej Green Business Centre (Mr Dinesh Ghai and Mr Nitish Kumar) team on 22$^{nd}$ June and 01$^{st}$ Sep, 2020. With reference to the first collected data, there was an online discussion with one of the expert panel members, Mr A K Asthana along with Mr Sandeep Tandon, NPM, on 29$^{th}$ August 2020, for seeking their guidance to complete the trials.

**Figure 2 – Regenerative Burner System**

A technology verification template has been designed to capture all the parameters during the M&V process and same has been shared to the ENCON. As per the template, during the M&V period gas totalizer along with PLC controller data values were used to monitor and analyse the parameters. The test furnace started at 7:00AM on 1$^{st}$ September 2020 and the furnace temperature was set at 910 $^{0}$C. The furnace temperature got stabilised at around 10:30AM. After attaining the stable temperature key parameters captured with the help of PLC for every 10 sec and steady state values were used for the calculations. The data was recorded by varying the reversal cycle duration i.e. for 60 sec, 90 sec, 120 sec, 150 sec and 180 sec.

The data was recorded by connecting pen drive to the PLC system. To arrive at the optimum reversal cycle time, initially data for at least 2-4 batches/cycles was captured for each reversal cycle of the burner. After every reversal cycle, the data was transferred into excel sheet from the pen-drive by using the software. Later for at least 45 minutes data was collected by operating the furnace for each 90 sec & 120 sec reversal cycle to understand for further analysis. After collection of all readings, the furnace was switched of around 3:30 PM.

Some of the key parameters observed, monitored and analysed during the overall study were:

- Furnace Temperature, Combustion air, Inlet & Outlet temperature (across Ceramic media box)
- Flue gas, Inlet & Outlet temperature (across Ceramic media box)
- Fuel consumption (based on totalizer)
- Combustion Air flow. (based on Multiplication Factor 35)

**Figure 3: Furnace with Regenerative Burners on either ends**

Temperature probes in the air & flue gas path, instantaneous LPG gas flow meter in the LPG flow pipeline and Instantaneous air flow meter in the air flow duct were installed for the pilot study in the furnace. The data was continuously transferred from these instruments to the PLC for the monitoring & recording purpose.

# 4. FINDINGS

The system was tested at different duration of reversal cycles of burners and after achieving the steady, multiple batches of parameters were collected for analysis. The testing was conducted for 60, 90, 120, 150, and 180 seconds duration cycle to arrive at the optimum reversal cycle time, and initially data for at least 2-4 batches/cycles was captured for each reversal cycle of the burner. The major parameters monitored during each cycle are discussed below:

## 1. 60 second reversal cycle

Two sample batches for the duration of 60 seconds of burner reversal cycles were taken. In batch-1 burner A & B were in regenerative & firing mode respectively, and in batch-2 it was vice -versa. The detailed parameters captured during the study are given below:

**Table 3: Sample Data Batch -1 & 2**

| **Cycle time** | | | | **60 Seconds** | | | **Batch-1** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S No. | Time | Burner mode | | Temperatures (Deg C) | | | | | | |
| | | Regenerative | Firing | Furnace | combustion air | | | Flue gas | | |
| | secs | | | | inlet | outlet | ΔT | inlet | outlet | ΔT |
| 1 | 10 | A | B | 913 | 30 | 424 | 394 | 532 | 82 | 450 |
| 2 | 20 | A | B | 895 | 30 | 413 | 383 | 548 | 83 | 465 |
| 3 | 30 | A | B | 894 | 30 | 389 | 359 | 560 | 84 | 476 |
| 4 | 40 | A | B | 873 | 30 | 391 | 361 | 560 | 83 | 477 |
| 5 | 50 | A | B | 889 | 30 | 435 | 405 | 537 | 82 | 455 |
| 6 | 60 | A | B | 913 | 30 | 484 | 454 | 520 | 80 | 440 |
| **Cycle time** | | | | **60 Seconds** | | | **Batch-2** | | | |
| S No. | Time | Burner mode | | Temperatures (Deg C) | | | | | | |
| | | Regenerative | Firing | Furnace | combustion air | | | Flue gas | | |
| | secs | | | | inlet | outlet | ΔT | inlet | outlet | ΔT |
| 1 | 10 | B | A | 920 | 30 | 536 | 506 | 478 | 65 | 413 |
| 2 | 20 | B | A | 896 | 30 | 531 | 501 | 494 | 66 | 428 |
| 3 | 30 | B | A | 910 | 30 | 514 | 484 | 518 | 68 | 450 |
| 4 | 40 | B | A | 907 | 30 | 505 | 475 | 526 | 70 | 456 |
| 5 | 50 | B | A | 887 | 30 | 507 | 477 | 526 | 69 | 457 |
| 6 | 60 | B | A | 883 | 30 | 526 | 496 | 477 | 67 | 410 |

The average of all the steady state parameters for batch 1 & 2 were taken, and for calculation purpose the average of batch 1 & 2 parameters were considered.

**Table 4: Steady State Parameters at 60 Sec Cycle**

| **Batch - 60 Sec Cycle** | **Average Steady state Temperatures (Deg C)** | | | | | | | Fuel consumption (based on totalizer), $Nm^3/hr$ | Estimated Combustion Air flow, $Nm^3/hr$ |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace | Combustion air | | | Flue gas | | | | |
| | | Inlet | Outlet | ΔT | Inlet | Outlet | ΔT | | |
| Batch -1(A-Regen. and B -Firing) | 896 | 30 | 423 | 393 | 543 | 82 | 461 | 7.33 | 256.55 |
| Batch -2(A- Firing and B -Regen.) | 901 | 30 | 520 | 490 | 503 | 68 | 436 | 6.39 | 223.77 |
| Average of Batch 1 &2 | 898 | 30 | 471 | 441 | 523 | 75 | 448 | 6.86 | 240.16 |

**Table 5: Heat Gain in 60 Sec Cycle**

| **Calculations** | | | | Average | Reference / Annexure |
|---|---|---|---|---|---|
| Batch Number | | 1 | 2 | | |
| Heat Input from the fuel | kCal /hr | 1,58,035 | 1,37,841 | 1,47,938 | Page No 20 |
| Heat Gained by Combustion air | kCal /hr | 29,959 | 32,597 | 31,278 | |
| Total Heat input to maintain constant furnace temperature | kCal /hr | 1,87,994 | 1,70,437 | 1,79,216 | |
| % Heat gained by Combustion air or potential Fuel savings | % | 16% | 19% | 17% | |
| heat recovered from flue gas | kCal / hr | 40,052 | 33,050 | 36,551 | |
| WHR Effectiveness | % | 75 | 99 | 87 | |

During the steady state condition, heat gain by the combustion air for batch 1 & 2 was found to be 16% and 19 % respectively and the WHR effectiveness was found to be 75% & 99%. Whereas average heat gain & WHR effectiveness of the overall system in this reversal cycle were 17% and 87% respectively.

*Similarly, in the case of the 90, 120, 150- and 180-seconds reversal cycles multiple batches of data were taken to get the average steady values.*

## 2. 90 second reversal cycle

Four batches for the duration of 90 seconds of burner reversal cycles, were taken and the major average steady state parameters monitored and observed during the studies were as follows:

Table 6: Steady State Parameters at 90 Sec Cycle

| Batch - 90 Sec Cycle | Average Steady state Temperatures (Deg C) | | | | | | | Fuel consumption (based on totalizer), $Nm^3/hr$ | Estimated Combustion Air flow, $Nm^3/hr$ |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace | Combustion air | | | Flue gas | | | | |
| | | Inlet | Outlet | ΔT | Inlet | Outlet | ΔT | | |
| Batch -1(A-Regen. and B -Firing) | 904 | 30 | 460 | 430 | 587 | 97 | 490 | 6.32 | 221.13 |
| Batch -2(A- Firing and B -Regen.) | 904 | 30 | 543 | 513 | 542 | 80 | 461 | 6.50 | 227.58 |
| Batch -3(A-Regen. and B -Firing) | 901 | 30 | 432 | 402 | 570 | 100 | 470 | 9.55 | 334.29 |
| Batch -4(A- Firing and B -Regen.) | 906 | 30 | 552 | 522 | 532 | 79 | 453 | 7.31 | 255.74 |
| Average of all | 904 | 30 | 497 | 467 | 558 | 89 | 469 | 7.42 | 259.69 |

The steady state heat gain by batch 1, 2, 3 & 4 was found to be 17%, 20%, 16% and 20 % respectively, whereas average heat gain & WHR effectiveness of the overall system in the cycle were 18% and 86%

Table 7: Heat Gain in 90 Sec Cycle

| Calculations | | | | | | Average |
|---|---|---|---|---|---|---|
| Batch Number | | 1 | 2 | 3 | 4 | |
| Heat Input | kCal / hr | 1,36,216 | 1,40,192 | 2,05,924 | 1,57,535 | 1,59,967 |
| Heat Gained by Combustion air | kCal / hr | 28,248 | 34,751 | 39,976 | 39,700 | 35,669 |
| Total Heat | kCal / hr | 1,64,464 | 1,74,942 | 2,45,900 | 1,97,235 | 1,95,635 |
| % Heat gained by Combustion air or potential Fuel savings | % | 17% | 20% | 16% | 20% | 18% |
| heat recovered from flue gas | kCal / hr | 36,751 | 35,594 | 53,304 | 40,510 | 41,540 |
| WHR Effectiveness | % | 77 | 98 | 75 | 98 | 86 |

## 3. <u>120 second reversal cycle</u>

Four batches for the duration of 120 seconds of burner reversal cycles were taken, and the major average steady state parameters monitored and observed during the studies were as follows:

**Table 8: Steady State Parameters at 120 Sec Cycle**

| Batch - 120 Sec Cycle | Average Steady state Temperatures (Deg C) | | | | | | | Fuel consumption (based on totaliser), $Nm^3/hr$ | Estimated Combustion Air flow, $Nm^3/hr$ |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace | Combustion air | | | Flue gas | | | | |
| | | Inlet | Outlet | ΔT | Inlet | Outlet | ΔT | | |
| Batch -1(A-Regen. and B -Firing) | 904 | 30 | 422 | 392 | 593 | 88 | 505 | 8.69 | 304.09 |
| Batch -2(A- Firing and B -Regen.) | 903 | 30 | 522 | 492 | 544 | 82 | 462 | 7.61 | 266.42 |
| Batch -3(A-Regen. and B -Firing) | 903 | 30 | 421 | 391 | 593 | 89 | 504 | 8.47 | 296.30 |
| Batch -4(A- Firing and B -Regen.) | 904 | 30 | 528 | 498 | 549 | 82 | 467 | 7.89 | 276.04 |
| Average of all | 904 | 30 | 473 | 443 | 570 | 85 | 484 | 8.16 | 285.71 |

The steady state heat gain by batch 1, 2,3 & 4 was found to be 16%, 19%, 16% & 19% respectively, whereas average heat gain & WHR effectiveness of the overall system in the cycle were 18% and 80%

**Table 9: Heat Gain in 120 Sec Cycle**

| Calculations | | | | | | Average |
|---|---|---|---|---|---|---|
| Batch Number | | 1 | 2 | 3 | 4 | |
| Heat Input | kCal / hr | 1,87,320 | 1,64,113 | 1,82,520 | 1,70,044 | 1,75,999 |
| Heat Gained by Combustion air | kCal / hr | 35,450 | 38,974 | 34,424 | 40,882 | 37,433 |
| Total Heat | kCal / hr | 2,22,770 | 2,03,087 | 2,16,945 | 2,10,926 | 2,13,432 |
| % Heat gained by Combustion air or potential Fuel savings | % | 16% | 19% | 16% | 19% | 18% |
| heat recovered from flue gas | kCal / hr | 52,053 | 41,743 | 50,594 | 43,696 | 47,022 |
| WHR Effectiveness | % | 68 | 93 | 68 | 94 | 80 |

### 3. 150 second reversal cycle

Two batches for duration of 150 seconds of burner reversal cycles were taken, and the major average steady state parameters monitored and observed during the studies were as follows:

**Table 10: Steady State Parameters at 150 Sec Cycle**

| Batch - 150 Sec Cycle | Average Steady state Temperatures (Deg C) | | | | | | | Fuel consumption (based on totalizer), $Nm^3/hr$ | Estimated Combustion Air flow, $Nm^3/hr$ |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace | Combustion air | | | Flue gas | | | | |
| | | Inlet | Outlet | ΔT | Inlet | Outlet | ΔT | | |
| Batch -1(A-Regen. and B -Firing) | 905 | 30 | 538 | 508 | 556 | 83 | 473 | 6.93 | 242.64 |
| Batch -2(A-Regen. and B -Firing) | 904 | 30 | 404 | 374 | 611 | 108 | 503 | 8.82 | 308.80 |
| Average of Batch 1 & 2 | 904 | 30 | 471 | 441 | 583 | 95 | 488 | 7.88 | 275.72 |

The steady state heat gain by batch 1 & 2 was found to be 20% and 15 % respectively, whereas the average heat gain & WHR effectiveness of the overall system in the cycle were 17% and 78%.

**Table 11: Heat Gain in 150 Sec Cycle**

| Calculations | | | | Average |
|---|---|---|---|---|
| Batch Number | | 1 | 2 | |
| Heat Input | kCal / hr | 1,49,468 | 1,90,221 | 1,69,845 |
| Heat Gained by Combustion air | kCal / hr | 36,633 | 34,383 | 35,508 |
| Total Heat | kCal / hr | 1,86,101 | 2,24,604 | 2,05,352 |
| % Heat gained by Combustion air or potential Fuel savings | % | 20% | 15% | 17% |
| heat recovered from flue gas | kCal / hr | 38,904 | 52,708 | 45,806 |
| WHR Effectiveness | % | 94 | 65 | 78 |

## 5. 180 second reversal cycle

Two batches for the duration of 180 second of burner reversal cycles were taken, and the major average steady state parameters monitored and observed during the studies were as follows:

| Batch - 180 Sec Cycle | Average Steady state Temperatures (Deg C) | | | | | | | Fuel consumption (based on totaliser), $Nm^3/hr$ | Estimated Combustion Air flow, $Nm^3/hr$ |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace | Combustion air | | | Flue gas | | | | |
| | | Inlet | Outlet | ΔT | Inlet | Outlet | ΔT | | |
| Batch -1(A-Regen. and B - Firing) | 904 | 30 | 427 | 397 | 582 | 91 | 491 | 7.22 | 252.82 |
| Batch -2(A-Regen. and B - Firing) | 900 | 30 | 406 | 376 | 589 | 85 | 504 | 10.13 | 354.62 |
| Average of Batch 1 & 2 | 902 | 30 | 416 | 386 | 585 | 88 | 497 | 8.68 | 303.72 |

The steady state heat gain by batch 1 & 2 was found to be 16% and 15 % respectively, whereas average heat gain & WHR effectiveness of the overall system in the cycle were 16% and 68%.

| Calculations | | | | Average |
|---|---|---|---|---|
| Batch Number | | 1 | 2 | |
| Heat Input | kCal / hr | 1,55,737 | 2,18,446 | 1,87,091 |
| Heat Gained by Combustion air | kCal / hr | 29,861 | 39,624 | 34,743 |
| Total Heat | kCal / hr | 1,85,598 | 2,58,070 | 2,21,834 |
| % Heat gained by Combustion air or potential Fuel savings | % | 16% | 15% | 16% |
| heat recovered from flue gas | kCal / hr | 42,070 | 60,572 | 51,321 |
| WHR Effectiveness | % | 71 | 65 | 68 |

The average furnace temp. was 904$^{O}$C and flue gas inlet.558$^{O}$C and 89$^{O}$ C outlet. The gap between furnace and flue gas temp. was 346$^{O}$C. In absence of any heat transfer media this much temp. drop is not possible in a furnace fitted with regenerative burner. Normally the difference should not be more than 150$^{O}$C if the furnace temp is less than 1000$^{o}$C. This could be due to improper positioning of thermocouple due to limited combustion volume. But this will not affect the performance of the burner.

# 5. CONCLUSION AND REPLICATION POTENTIAL

The summary of results for all the 60, 90, 120, 150, and 180 seconds cycles are given below:

**Table 12: Summary of Results**

| Cycle Time, Seconds | | 60 Sec | 90 Sec | 120 Sec | 150 Sec | 180 Sec | Average |
|---|---|---|---|---|---|---|---|
| Combustion air Temperature, ºC | Inlet | 30 | 30 | 30 | 30 | 30 | **30** |
| | Outlet | 471 | 497 | 473 | 471 | 416 | **466** |
| | ΔT | 441 | 467 | 443 | 441 | 386 | **436** |
| Flue gas Temperature, ºC | Inlet | 523 | 558 | 570 | 583 | 585 | **564** |
| | Outlet | 75 | 89 | 85 | 95 | 88 | **87** |
| | ΔT | 448 | 469 | 484 | 488 | 497 | **477** |
| **Fuel consumption** | $m^3$/hr | 6.86 | 7.42 | 8.16 | 7.88 | 8.68 | **7.8** |
| **Combustion air flow** | $m^3$/hr | 240.16 | 259.69 | 285.71 | 275.72 | 303.72 | **273** |
| **Heat Input** | kCal / hr | 1,47,938 | 1,59,967 | 1,75,999 | 1,69,845 | 1,87,091 | **1,68,168** |
| **Heat Gained by Combustion air** | kCal / hr | 31,278 | 35,669 | 37,433 | 35,508 | 34,743 | **34,926** |
| **% Heat Gained by Combustion air/Fuel Savings** | % | 17.45% | 18.23% | 17.54% | 17.29% | 15.66% | **17.24%** |
| **Heat recovered from flue gas** | kcal /hr | 36,551 | 41,229 | 47,022 | 45,806 | 51,321 | **44,386** |
| **WHR Effectiveness** | % | 87 | 86 | 80 | 78 | 68 | **79** |

**Table 13: Savings for 50,000 kcal / hr furnace**

| Parameters | Units | Value |
|---|---|---|
| **Rated Capacity of Furnace** | kCal/Hr | 50,000 |
| **Percentage Fuel Saving** | % | 18.23% |
| **Fuel consumption per hour** | kg/hr | 15.29 |
| **Fuel Saving per hour** | kg/hr | 2.79 |
| **Fuel GCV** | kcal / kg | 11,000 |
| **Energy saving** | TOE / hr | 0.0031 |
| **Emission factor** | kg $CO_2$ / kg fuel | 2.9800 |
| **GHG Reduction per Hour** | kg $CO_2$ /hr | 8.31 |

The monitoring and verification study conducted by CII- GBC and UNIDO team members at Encon Thermal Engineers for newly installed Regenerative Burners in the furnace to assess the performance of waste heat recovery device. Different reversal cycle trails (60, 90, 120, 150, 180 seconds) were conducted to ascertain the best heat recovery performance of the system, it was observed, the waste heat recovery effectiveness is 86 % when the reversal time is 90 seconds. (Reversal cycle means that the weight of silica balls in each burner attains heat saturation in 90 seconds).

**Figure 4 Plaque on Furnace with Regenerative Burners**

The measured average operating parameters during the course of study **for optimum reversal time of 90 secs** are as follows:

- Furnace temperature at steady state 902°C
- Flue gas temperature inlet to regenerator 558°C
- Flue gas temperature outlet of chimney 89°C
- Drop in flue gas temperature 469°C
- Inlet combustion air temperature 30°C
- Combustion air preheated temperature 497°C
- Increase combustion air temperature 467°C
- Waste heat recovery effectiveness 86%
- Fuel savings 18.23%

Fuel and GHG savings for a furnace with 50,000 kcal capacity were 2.79 kg of LPG /hr and 8.31 kg $CO_2$ /hr.

On the basis of above operating parameters of Regenerative Burner performance, following are our key observations for computation of fuel savings:

a. Regenerative Burners are mostly installed in high temperature furnaces for reheating and melting application. For high flue gas temperature metallic recuperator is not used.

b. The flame temperature is around 1,400-1,500$^{o}$C, when combustion air temperature is 30$^{O}$C, the flame temperature increases to around 2,000$^{O}$C if combustion air preheated to 500$^{O}$C.

c. In high temperature furnaces the mode of heat transfer is through radiation (95%) which is function of the fourth power of Temperature or $(T)^4$. An increase in radiation heat transfer results higher fuel savings which would be accrued due to less excess air for combustion, reduce cold start up time, increase in production capacity of furnace and uniform temperature distribution across furnace.

All the above factors could not be established in the absence of base line assessment, it is expected that fuel savings would be much more than 18.23% as reported in M&V report.

**Replication Potential**

The replication potential of the technology is very high, there are more than 10,000 different types of furnaces running across different industries (Aluminium melting, Steel Reheating, Forging Furnaces, Heat treatment furnaces) in India of different sizes and fuel. Regenerative burner system can potentially retrofit all these furnaces and each furnace will require at least 1 set of these burner.

***

The anticipated replication potential across various sectors in given below in the table:

**Table 134: Anticipated replication potential across different sectors**

| Sector | Number of units in the country | Type of Furnace / Kiln | Kiln / furnace capacity (Reference) | Furnace temperature, Deg C | Exhaust gas temperature available for (recovery) Deg C | Fuel saving possible | Annual fuel saving for reference plant* | Replication potential | | Annual Cost savings (INR Million) | Annual GHG emission reduction possible (MT $CO_2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Values for a typical Reference unit | | | % | GWh - Thermal | % | Number of units | Total Replication potential | Total Replication potential |
| Steel - ISP, SIP | 163 | Reheating furnace/Blast furnace hot stove/ LADLE Preheaters/Soaking Pits | 100 - 300 TPH | 1150 -1300 | 500- 1000 | 20-30 | 4.32 | 20 | 32 | 446.08 | 25,611 |
| Steel Re Rolling | 1800 | Reheating Furnace | 8 - 320 TPH (Billets - Input) | 1200 | 800 - 900 | 25-30 | 0.75 | 10 | 180 | 435.60 | 25,011 |
| Aluminium (Recycled /secondary) | 3500 | Melting / Holding furnace | 3000 kW -25000 kW | 1300 -1400; 700 - 800 | 800 - 900; 600 -700 | 20-30 | 1.8 | 10 | 350 | 2033.5 | 1,16,717 |
| Forging | 400 | Forging Furnace | 1 - 150 TPH | 900-1350 | 500-650 | 5-40 | 0.15 | 20 | 80 | 38.40 | 2,223 |
| Glass | 200 | Glass furnace | | 1400-1700 | 450-600 | 10-30 | 2.88 | 10 | 20 | 186.00 | 10,671 |
| **Total** | **6,063** | | | | | | **9.90** | | **662** | **3,140** | **1,80,233** |

* Assuming Natural Gas will be used as a fuel in the furnaces with Gross Calorific Value of 12,500 kcal/kg of fuel and the $CO_2$ emission factor at 2.69 kg of $CO_2$/kg of fuel

Considering the adoption of the technology in 662 units (10.9%) out of 6,063 units in above mentioned sectors; the annual monetary saving of INR 3,140 Million can be anticipated, with an overall GHG reduction potential of 1,80,233 MT $CO_2$.

***Disclaimer:*** *Benefits estimated by CII-GBC based on data gathered from field trials. Since this solution/product is not yet commercially available, the ROI has not been estimated.*

# 6. ANNEXURE

## ANNEXURE A : ASSUMPTIONS MADE IN THE REPORT

The following assumptions were made whiling preparing the report:

- Calorific value of fuel (LPG)- 11,000 kCal/kg;
- Grid electricity- 860 kCal/kW.
- Gas to Air ratio was Set as 1:35, for every 1Nm$^3$ of LPG, 35Nm$^3$ of Air was supplied
- Specific heat of flue gas; $c_p$ = 0.23 kcal/kg/°C and
- density of flue gas =1.293kg/m$^3$ @900 Deg. Celsius
- $CO_2$ emission factor of LPG fuel : 2.98 kg $CO_2$ /kg of LPG
- Combustion air temperature at inlet : 30 Deg. Celsius

## ANNEXURE B : MAJOR FORMULAE USED IN THE REPORT

The following formulae were used while preparing the report:

1. Combustion Air flow, Nm$^3$/hr

   = Fuel consumption (Nm$^3$/hr) x 35 (Theoretical air requirement)

2. Heat Input to the furnace, kCal/hr

   = Fuel consumption (kg/hr) x Calorific value of fuel (kCal/kg)

3. Heat Gained by Combustion air, kCal/hr

   = Flowrate of flue gas (Nm$^3$/hr) x Density of flue gas (kg/m$^3$) x Specific heat of flue gas($c_p$) x difference in inlet-outlet temperature ($\Delta T$)

4. Total Heat, kCal/hr

   = Heat Input to the furnace + Heat Gained by Combustion air

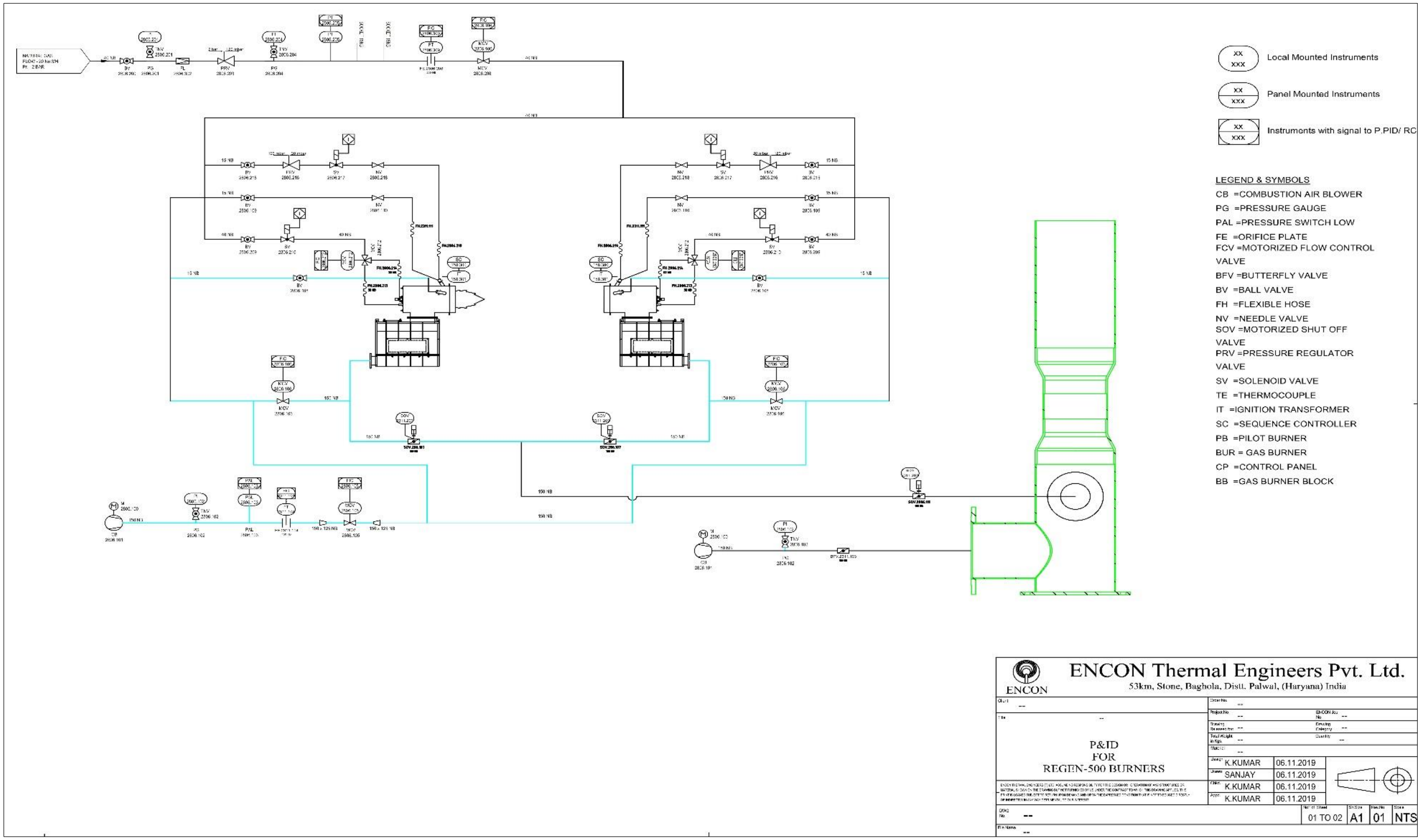
5. % Heat Gained by Combustion air or potential Fuel savings, %

   = (Heat Gained by Combustion air/ Total Heat) x 100

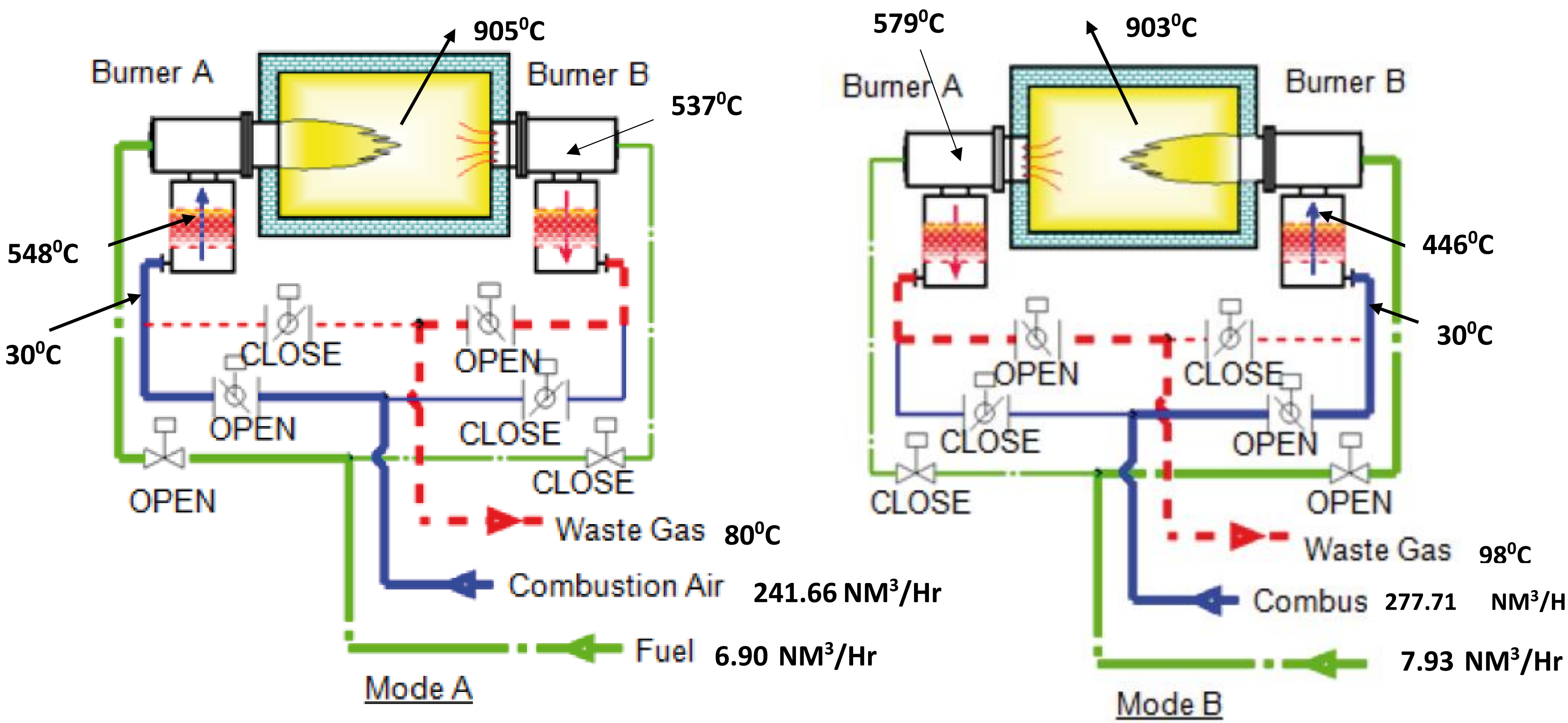
## ANNEXURE C : REFERNCES & REPORTS REFERRED FOR ESTIMATING REPLICATION POTENTIAL


1. PAT document /notifications from PAT cycle 2 – 6
2. http://srma.co.in/home.html
3. https://www.alcircle.com/news/asma-files-a-petition-in-the-commerce-ministry-against-hiking-import-duty-on-aluminium-and-scrap-40860,https://www.metalbulletin.com/events/download.ashx/document/speaker/6563/a0ID000000X0jaoMAB/Presentation , page 56, ESEL, JICA SIDBI 9.1
4. https://www.jamnagarfactoryassociation.com/about.php, BOP - BEE best practices
5. https://www.jamnagarfactoryassociation.com/about.php, BOP - BEE best practice

# ANNEXURE D : P&I DIAGRAM OF THE EXISTING SETUP

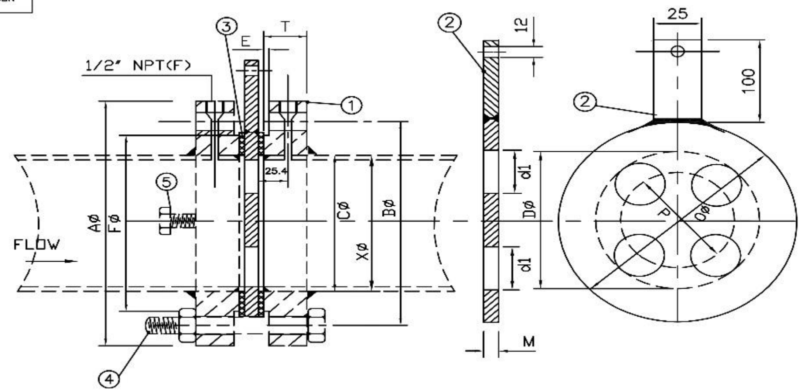


ANNEXURE E : BLOCK DIAGRAM CONSIDERING 90 SEC REVERSAL CYCLE FOR MODE A & MODE B




**Note:** Four batches of 90 seconds reversal cycle data were taken; Batch 1 & 3 were in mode B, whereas batch 2 & 4 were in mode A. Average values are shown in the block diagram for mode B and A.

FILE NAME:-48017 ENCON




NOTES:–

1. ORIFICE PLATE DESIGNED AS PER ISO–5167
2. BORE TOLERANCES AS PER ISA–RP–3.2
3. TAPPING : FLANGE TAPS 1 Pair
4. FLANGE FACING AS PER ANSI B16.5 150#(SORF)
5. ALL DIMENSIONS IN M.M. UNLESS OTHERWISE STATED.
6. ALL UNSPECIFIED TOLERANCE ± 2 M.M.
7. TAG NO., BORE DIA, AND FLOW DIR., WILL BE PUNCHED ON THE ORIFICE PLATE. NB SIZE, TAG NO, RATING & MOC SHALL BE PUNCHED ON THE FLANGE.

FLANGE. DIM.

| TAG NO | SERVICE | PIPE O.D. | PIPE I.D. D | N.B. SIZE | QTY. | O.D. A | P.C.D. B | R.F.Ø F | I.D. C | THK. T | R.F.(ht.) E | DRILLING | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | HOLE SIZE | NOS |
| FE-1 | LPG | 48.3 | 40.9 | 40 | 1 | 127 | 98 | 73 | 50 | 38 | 1.6 | 15.9 | 4 |
| FE-2 | AIR | 168.3 | 154.08 | 150 | 1 | 279 | 241 | 216 | 171 | 38 | 1.6 | 22.2 | 8 |

ORIFICE PLATE DIM.

| O.D. O | THK. M±0.5 | Calc. Bore | NO. OF HOLES | BORE d1 | PCD P |
|---|---|---|---|---|---|
| 82 | 3.2 | 16.88 | 4 | 8.44 ± 0.04 | 26 |
| 219 | 3.2 | 103.54 | 4 | 51.77 ± 0.04 | 96 |

| NO. | DESCRIPTION | QUANTITY (PER ASSY.) | MATERIAL |
|---|---|---|---|
| 1. | FLANGES (SORF.) | 2 | ASTM A105 (Not in Espl's scope) |
| 2. | ORIFICE PLATE | 1 | S.S.–316 |
| 3. | GASKETS | 2 | NON ASBESTOS FIBRE (Not in Espl's scope) |
| 4. | FASTENERS | As Reqd. | CARBON STEEL (Not in Espl's scope) |
| 5. | JACK SCREW | 2 | CARBON STEEL (Not in Espl's scope) |

ENGINEERING SPECIALITIES (PVT.) LTD.
30 F, FREE SCHOOL STREET KOLKATA 700016
Tel :(033) 2252 2064,2252 5584 , e–mail: contact@espl.co.in

Client : ENCON THERMAL ENGINEERS PVT. LTD.
Project :

Subject : MULTI–BORE ORIFICE PLATE ASSEMBLY

| | | | | | |
|---|---|---|---|---|---|
| Drn. | P.B. | 24.09.2019 | DRG. NO. | scale | Rev. 1 04.03.20 |
| Cked. | D.P. | 24.09.2019 | ESC–48017 | N.T.S. | |
| Appvd. | | | | | Sheet 1 of 1 |

FLCTD
Promoting Innovation and Deployment of Low Carbon Technologies

## ANNEXURE G : ORIFICE PLATE BORE CALCULATION AS PER ISO-5167 FOR AIR

Date : 04-03-2020 PREP BY : DP

**ORIFICE PLATE BORE CALCULATION AS PER ISO-5167**

(Prog. By Engineering Specialities Pvt Ltd., Kolkata 700016, Ph : 33-2252-5584/2064, email : contact@espl.co.in)

| | | | | |
|---|---|---|---|---|
| CLIENT | : | ENCON THERMAL ENGINEERS PVT.LTD. | PO# 338 of 24/09/2020 | |
| PROJECT | : | | | |
| NB SIZE | : | 150 mm NB Sch. 40 | Rev. No. : | 1 - 04032020 |
| TAG NO. | : | FE-2 | Quantity : | 1 No. |
| SERVICE | : | AIR | FLANGE | TAPS |

| | | | |
|---|---|---|---|
| PIPING DATA | PIPE SIZE & SCH | : | 150 mm NB Sch. 40 |
| | PIPE MATERIAL | : | CARBON STEEL |
| | FLANGE STANDARD | : | ANSI-B16.5 150# SORF |
| | FLANGE MATERIAL | : | ASTM-A105 |

FLOW DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Std.Pipe ID(at 20°C) | = | 0.15408 | M | = | 154.08 | mm | |
| | Temp. Corr. For I.D. | = | 1.00017 | | | | | |
| D | Corrected I.D. | = | 0.154105 | M | | | | |
| T | Operating Temperature | = | 35 | deg. C | | | | |
| BP | Barometric Pressure | = | 100000 | Pa | = | 1 | Bar | |
| Pr | Line Pressure | = | 9715 | Pa | = | 97.145 | mBar (g) | = 39 "WC |
| Op | Operating Pressure | = | 109715 | Pa | = | 1.10 | Bar (a) | |
| v | Dynamic Viscosity | = | 0.000017 | Pa.s | = | 0.00017 | Poise | |
| G | Specific Gravity | = | 1 | | = | 1.293 | Kg/NcM | |
| p | Density Oper. Cond. | = | 1.24104 | Kg/cM | | | | |
| **Qn** | **Volumetric Flow** | **=** | **1250** | **NcM/Hr** | | | | |
| Qv | Actual Vol. Flow | = | 0.361760 | cM/sec | = | 1302.34 | cM/Hr | |
| Qm | Mass Flow | = | 0.448958 | Kg/sec | = | 1616.25 | Kg/hr | |
| **h** | **Differential Press.** | **=** | **2500** | **Pa** | **=** | **25** | **mBar** | |

SIZING CRITERIA

| | | |
|---|---|---|
| ReD | Reynold's Number at 70% flow | = 152738.1 |
| k | Isentropic Exponent | = 1.4 |
| e | Expansibility Factor | = 0.992172 |
| E | Velocity of Approach Factor | = 1.120862 |
| **B** | **d/D (Beta) Ratio** | **= 0.672086** |
| C | Discharge Coefficient | = 0.608296 |
| | Temp. corr. For Bore | = 1.00027 |

ELEMENT DATA

| | | | | | |
|---|---|---|---|---|---|
| ELEMENT TYPE | : | MULTI-BORE ORIFICE PLATE | | | |
| ELEMENT MOUNTING | : | FLANGED | | | |
| ELEMENT MATERIAL | : | SS-316 | | | |
| ORIFICE BORE | : | 0.103544 | M | | |
| **ORIFICE BORE (Corr.)** | : | **0.103544** | M | = | **103.54 mm** |
| TOLERANCE AS PER ISA | : | +/- 0.05 | mm | | |
| PLATE THICKNESS | : | 3.2 | mm | | |
| THROAT THICKNESS(t) | : | 3.2 | mm | | |

NOTES :

PERMANENT PRESSURE LOSS AT MAXIMUM FLOW : 13.2 mBar = 52.9 % of DP

ERROR IN CALCULATION : 0.00008 %

FLOW CHECK = 0.449 Kg/sec

**MULTI-BORE ORIFICE PLATE : NOS. OF HOLES - 4 NOS. HOLE SIZE : 51.77 mm ф**

MAXIMUM FLOW : 500 NcM/hr DP AT MAXIMUM FLOW : 4.0 mBar

d/Xcalc/misc/Encon-lpg air op 19092019

## ANNEXURE H : ORIFICE PLATE BORE CALCULATION AS PER ISO-5167 FOR LPG

Date : 19-09-2019 PREP BY : DP

**ORIFICE PLATE BORE CALCULATION AS PER ISO-5167**

(Prog. By Engineering Specialities Pvt Ltd., Kolkata 700016, Ph : 33-2252-5584/2064, email : contact@espl.co.in)

| | | | | |
|---|---|---|---|---|
| CLIENT | : | ENCON THERMAL ENGINEERS PVT.LTD. | | |
| PROJECT | : | | | |
| NB SIZE | : | 40 mm NB Sch. 40 | Rev. No. : | 0 |
| TAG NO. | : | FE-1 | Quantity : | 1 No. |
| SERVICE | : | LPG GAS | FLANGE | TAPS |

| | | | |
|---|---|---|---|
| PIPING DATA | PIPE SIZE & SCH | : | 40 mm NB Sch. 40 |
| | PIPE MATERIAL | : | CARBON STEEL |
| | FLANGE STANDARD | : | ANSI-B16.5 150# SORF |
| | FLANGE MATERIAL | : | ASTM-A105 |

FLOW DATA

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Std.Pipe ID(at 20°C) | = | 0.0409 | M | = | 40.9 | mm |
| | Temp. Corr. For I.D. | = | 1.00017 | | | | |
| D | Corrected I.D. | = | 0.040907 | M | | | |
| T | Operating Temperature | = | 35 | deg. C | | | |
| BP | Barometric Pressure | = | 100000 | Pa | = | 1 | Bar |
| Pr | Line Pressure | = | 15000 | Pa | = | 150 | mBar (g) |
| Op | Operating Pressure | = | 115000 | Pa | = | 1.15 | Bar (a) |
| v | Dynamic Viscosity | = | 0.000017 | Pa.s | = | 0.00017 | Poise |
| G | Specific Gravity | = | 1.516 | | = | 1.960 | Kg/NcM |
| p | Density Oper. Cond. | = | 1.97205 | Kg/cM | | | |
| **Qn** | **Volumetric Flow** | **=** | **25** | **NcM/Hr** | | | |
| Qv | Actual Vol. Flow | = | 0.006903 | cM/sec | = | 24.85 | cM/Hr |
| Qm | Mass Flow | = | 0.013612 | Kg/sec | = | 49.0047 | Kg/hr |
| **h** | **Differential Press.** | **=** | **2500** | **Pa** | **=** | **25** | **mBar** |

SIZING CRITERIA

| | | |
|---|---|---|
| ReD | Reynold's Number at 70% flow | = 17446.1 |
| k | Isentropic Exponent | = 1.4 |
| e | Expansibility Factor | = 0.993477 |
| E | Velocity of Approach Factor | = 1.014828 |
| **B** | **d/D (Beta) Ratio** | **= 0.412702** |
| C | Discharge Coefficient | = 0.607418 |
| | Temp. corr. For Bore | = 1.00027 |

ELEMENT DATA

| | | | | | |
|---|---|---|---|---|---|
| ELEMENT TYPE | : | MULTI-BORE ORIFICE PLATE | | | |
| ELEMENT MOUNTING | : | FLANGED | | | |
| ELEMENT MATERIAL | : | SS-316 | | | |
| ORIFICE BORE | : | 0.016878 | M | | |
| **ORIFICE BORE (Corr.)** | : | **0.016878** | M | = | **16.88 mm** |
| TOLERANCE AS PER ISA | : | +/- 0.01 | mm | | |
| PLATE THICKNESS | : | 3.2 | mm | | |
| THROAT THICKNESS(t) | : | 3.2 | mm | | |

NOTES :

PERMANENT PRESSURE LOSS AT MAXIMUM FLOW : 20.2 mBar = 81.0 % of DP

ERROR IN CALCULATION : 0.00010 %

FLOW CHECK = 0.014 Kg/sec

**MULTI-BORE ORIFICE PLATE : NOS. OF HOLES - 4 NOS. HOLE SIZE : 8.44 mm ф**

MAXIMUM FLOW : 500 NcM/hr DP AT MAXIMUM FLOW : 10000.0 mBar

d/Xcalc/misc/Encon-lpg air op 19092019

# Facility for Low Carbon Technology Deployment

## BEE UNIDO GEF Initiative

**Waste Heat Recovery Innovation Challenge 2019**

The **Facility for Low Carbon Technology Deployment (FLCTD)** project**,** implemented by the United Nations Industrial Development Organization (UNIDO) in collaboration with the Bureau of Energy Efficiency (BEE) is launching the 2019 Innovation challenge in Waste Heat Recovery (WHR) technology vertical.

In the annual challenge concluded in 2018, 3 winning innovations were selected for technology demonstration in the WHR vertical. The total award money committed for the winners is INR 85,97,000 (US$122,814). The list of winners of FLCTD Innovation Challenge 2018 is available here: https://low-carbon-innovation.org/2018-winners

Entries are invited to the 2019 FLCTD Innovation Challenge for Waste Heat Recovery to identify the promising innovations in the areas described below, which can be deployed to address technology gaps and improve energy efficiency. The total award money earmarked for this particular technology vertical for 2019 Annual Innovation Challenge is US $400,000.

The Challenge is open for Waste Heat Recovery technology innovations across all industrial sectors for the following:

- **High temperature range**– Innovations demonstrating heat recovery at temperature ranges above 600 degree Celsius for productive end-use applications such as, but not limited to, power generation, pre-heating of feedstock, pre-heating of primary / secondary air, space conditioning or any other use in the process or utility service that requires heating. The innovation should demonstrate reduction in the energy released in atmosphere from the production processes that are either continuous or intermittent (batch process) type, without effecting product quality.

- **Medium temperature range–** Innovations demonstrating heat recovery at temperature ranges between 600 degree and 150 degree Celsius for productive end-use applications such as, but not limited to, power generation, pre-heating of feedstock, pre-heating of primary / secondary air, moisture removal from feedstock or solid fuel, space conditioning or any other use in the process or utility service that requires heating. The innovation should demonstrate reduction in the energy released in atmosphere from the production processes that are either continuous or intermittent (batch process) type, without effecting product quality.

- **Low temperature range –** Innovations demonstrating heat recovery at temperature range below 150 degree Celsius for productive end applications such as, but not limited to, pre-heating of feedstock, moisture removal from solid fuel, cooling or any other use in the process or utility service that utilizes heat. The innovation should demonstrate reduction in the energy released in atmosphere from the production processes that are either continuous or intermittent (batch process) type.

All innovative solutions should be based on the proof-of-concept or early stage prototype and clearly indicate the replication potential and opportunities for scale-up, and also the following:

- ✓ Innovations that result in overall efficiency improvements
- ✓ Emerging and novel technology applications that reduces energy consumption, including through power generation, system heat requirement reduction, etc.
- ✓ Design improvements that reduce energy consumption, overcome application constraints and improve economic feasibility
- ✓ Heat recovery from untapped/un-utilized sources of heat
- ✓ Fossil fuel reduction in applications or integration of renewable energy.

## Eligibility

- The innovation challenge is open to Entrepreneurs, Startups, Indian Technical Institutes / Universities, Research Institutes, Micro, Small and Medium Enterprises, Industries, Public Sector Enterprises and Government Laboratories.
- Consortiums of entrepreneurs and academic institutions with industry partnerships are highly encouraged to participate in the innovation challenge.
- Innovation teams with **women entrepreneurs** will be given preference.

## Incentives for Participation

- **Grant** up to USD 50,000 for winning technology with provision for demonstration at multiple locations, wherever required;
- **Performance Verification** to establish the efficacy of innovative technology in-field working conditions;
- **Business Acceleration and Mentoring** support from industry experts;

- Opportunity to **Network** with investors and industry stakeholders to publicize the innovation;
- The winners of the Innovation Challenge will receive recognition from Bureau of Energy Efficiency and UNIDO;
- Grant disbursement will be linked to specific progress-based milestones
  - 30% of the award grant will be given to the innovator winning the innovation challenge
  - 50% after installation/commissioning of the innovation
  - 20% at the end of the deployment phase, upon completion of Technology Verification Reporting

## Parameters for Selection

*This is only an indicative list, and is not exhaustive, and is subject to change and modification.*

- Nature of innovation (Product design/Process Innovation)
- Addresses a key issue/technology gap in the industry
- Replication potential
- Scalability and sustainability
- Energy saving and greenhouse gas emission reduction potential
- Financials (pay-back period, Internal Rate of Return)
- Technology readiness stage (R&D/ Prototype/Pilot demonstration/Commercial)
- Intellectual Property Right / Patents (granted/applied)

## General Guidelines, Terms, and Conditions

- Participant shall submit solutions/product designs owned by them or to which they have right to claim and use as owned by them. Suitable documents to this effect must be submitted along with the entry.
- Participant shall ensure that any submission made in the Challenge does not violate any of theirs or any third party's intellectual property rights, confidentiality, trade secret and violate any statutory provisions.
- BEE, UNIDO, its employees, members of Expert Panel and organizers of this innovation challenge shall in no event be liable for any violation of IPR, or license or permits required from third party.
- Participant shall not assign any rights, obligations, or privileges hereunder without the prior written consent of Organizers of the Challenge.
- BEE, UNIDO, Organizers, members of Expert Panel, supporting organizations or any employee or agent shall not be liable for, any costs incurred or loss or liability or loss in expectation of profits or loss due to failure of understanding the terms and conditions of

the Challenge or of any expected benefit of the participant in relation to entry and submission in the Challenge.

- By way of selecting the entries for evaluation at any Stage or for Final Award, Participants shall not be entitled to claim or have got endorsement from BEE and UNIDO of any sought whatsoever, or have earned approval of any sought whatsoever of BEE and UNIDO, for use in any form whatsoever anywhere in the Industry.
- At any Stage while evaluating the entries, organizers shall be free to contact the Participants and carry out discussions on the matter submitted by the Participants and seek clarifications. Any solicitation by participants in whatever form in respect of their entries shall not be entertained and entries of such participant shall be disqualified from the Innovation Challenge.
- BEE/UNIDO/Organizers may change the Terms and Conditions of participation at any time without prior notice. It shall be sole responsibility of the Participants to update themselves of information posted in the website from time to time.
- BEE/UNIDO/Organizers may disqualify a Participants from the Challenge for breach of any of the conditions of this Challenge or discontinue this Challenge.

***