# Detailed Project Report
# On
# Waste heat recovery in kiln

## Jagdamba Ceramic Works
Thangadh (Gujarat)

*Prepared for*

Bureau of Energy Efficiency
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## Disclaimer

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The Energy and Resources Institute (TERI)
New Delhi

# Table of contents

# List of tables



# List of figures

# List of abbreviations

| | | |
|---|---|---|
| BEE | : | Bureau of Energy Efficiency |
| $CO_2$ | : | Carbon Dioxide |
| D/E | : | Debt /Equity |
| DPR | : | Detailed Project Report |
| DSCR | : | Debt Service Coverage Ratio |
| EE | : | Energy Efficient |
| GEF | : | Global Environmental Facility |
| GHG | : | Green House Gas |
| HSD | : | High Speed Diesel |
| IDC | : | Investment without interest defer credit |
| IGBT | : | Insulated-gate Bipolar Transistor |
| IGDPR | : | Investment Grade Detailed Project Report |
| IRR | : | Internal Rate of Return |
| kW | : | Kilo Watt |
| kWh | : | Kilo Watt Hour |
| LSPs | : | Local Service Providers |
| MSME | : | Micro, Small and Medium Enterprises |
| MT | : | Metric Tonne |
| NG | : | Natural Gas |
| NPV | : | Net Present Value |
| O&M | : | Operation and Maintenance |
| PCB | : | Pollution control board |
| RE | : | Renewable Energy |
| ROI | : | Return On Investment |
| SCM | | Standard Cubic Meter |
| SME | : | Small and Medium Enterprises |
| SPP | : | Simple Payback Period |
| TERI | : | The Energy and Resources Institute |
| Toe | : | Tonnes of oil equivalent |
| UNIDO | : | United Nations Industrial Development Organization |
| WACC | : | Weighted Average Cost of Capital |

# Executive summary

The overall aim of the GEF-UNIDO-BEE project 'Promoting Energy Efficiency (EE) and Renewable Energy (RE) in selected MSME clusters in India' is to develop and promote a market environment for introducing energy efficiency and enhancing the use of renewable energy technologies in process applications in selected energy-intensive MSME clusters in India. This would help in improving the productivity and competitiveness of the MSME units, as well as in reducing the overall carbon emissions and improving the local environment.

Under the GEF-UNIDO-BEE Project, TERI has been entrusted to undertake Capacity building of Local Service Providers (LSPs) to BEE. The Scope of Work under the project

- Organizing 4 one-day training/ capacity building workshops for LSPs in each cluster.
- Development of 10 bankable DPRs for each cluster, based on mapping technology needs with capacities of local technology suppliers/service providers, and also replication potential and applications to banks in each cluster.

## Brief introduction of the MSME unit

| | |
|---|---|
| Name of the unit | M/s Jagdamba Ceramic Works |
| Constitution | Partnership |
| MSME Classification | Small |
| No. of years in operation | 2 |
| Address: Registered Office: | Thangadh, Surendra Nagar, Thangadh - 363530, Gujarat, |
| Industry-sector | Sanitary ware (Ceramic) |
| Products manufactured | Ceramic Pedestal Wash Basins, Ceramic Wash Basins, Ceramic Water Closets, Ceramic Urinals, Ceramic Bidets, Ceramic Shower Trays, Squatting Pan etc. |
| Name(s) of the promoters/ directors | Mr. Darshan S Naraina<br>Mr. Sanjay V Naraina |
| Existing banking arrangements along with the details of facilities availed | Bank of India |

## Brief highlights of the past financial position of the MSME unit

(Rs lakh)

| S. No | Particulars | FY 2017-18 (Audited) |
|---|---|---|
| 1 | Total income | 322 |
| 2 | Net profit | Under depreciations |

A detailed assessment study was undertaken in the identified area with the use of the sophisticated handheld instruments. Energy consumption pattern and production data were collected to estimate the specific energy consumption of the unit. The plant is consuming about 3,73,848 kWh of electricity per year. The annual consumption of the HSD is 2,800 litres and natural gas is 4,72,500 SCM. The total energy consumption of the unit during last 12 months is estimated to be 456.9 toe which is equivalent to 159.21 lakh rupees. The total $CO_2$

emission during this period is estimated to be 1,141 tonnes. Electricity, HSD and NG were considered for $CO_2$ emission estimation.

The unit manufactures the ceramic pedestal wash basins, ceramic wash basins, ceramic water closets, ceramic urinals, ceramic bidets, ceramic shower trays, and squatting pan etc. The total annual production of the unit during 2017-18 is estimated to be about 3,85,000 pieces. The major source of energy is natural gas, consume in the kiln and electricity consume in utilities and lighting.

## Accepted/ recommended technology implementation

The recommended technology considered after discussion with the plant personnel for implementation in the unit is given below.

| S. No | Energy conservation measure | Annual energy saving NG (SCM) | Investment[1] (Rs. Lakh) | Monetary savings (Rs. Lakh per year) | Simple payback period (Yrs) | Emission reduction (tonnes of $CO_2$) |
|---|---|---|---|---|---|---|
| 1 | Heat pipe based waste heat recovery system in kiln | 33,075 | 20.47 | 9.26 | 2.2 | 57.9 |

## Other benefits

- The proposed project is not expected to bring in any change in process step or operating practices therefore no change expected in the product quality.
- Implementation of the selected technology in the unit may result in reduction in $CO_2$ emissions.

## Cost of project & means of finance

| S. No. | Particulars | Unit | 100% equity | D/E- 70:30 | D/E- 50:50 |
|---|---|---|---|---|---|
| 1 | Cost of Project | Rs. In Lakh | 20.47 | 20.47 | 20.47 |
| 2 | D/E Ratio | - | - | 7:3 | 1:1 |
| 3 | Project IRR | % | 22.0 | 17.5 | 18.8 |
| 4 | NPV | Rs. In Lakh | 6.3 | 3.6 | 4.4 |
| 5 | DSCR | - | - | 2.1 | 0.9 |

[1] Investment including the (i) heat pipe based heat exchanger – Rs. 17.8 lakh, and (ii) fabrication and other misc. cost – Rs. 2.67 lakh

# 1.0 Details of the unit

## 1.1 Particulars of unit

**Table 1.1:** Particulars of the unit

| | | | |
|---|---|---|---|
| 1 | Name of the unit | M/s Jagdamba Ceramic Works | |
| 2 | Constitution | Partnership | |
| 3 | Date of incorporation / commencement of business | 2016 | |
| 4 | Name of the Contact Person | Mr. Sanjay V Naraina | |
| 5 | Mobile / Ph. No | 91-9925070655 | |
| 6 | Address:<br>Registered Office | Thangadh, Surendra Nagar,<br>Thangadh - 363530, Gujarat, | Owned |
| 7 | Factory | Thangadh, Surendra Nagar,<br>Thangadh - 363530, Gujarat, | Owned |
| 8 | Industry / Sector | MSME/Manufacturing | |
| 9 | Products Manufactured | Manufacturer, exporter and supplier of designer wash basin, wash basin, ceramic wash basin, Indian toilet seats, urinal, antique wash basin, sanitary | |
| 10 | No of hours of operation/shift | 12 | |
| 11 | No of shifts/ day | 2 | |
| 12 | No of days/year | 350 | |
| 13 | Installed Capacity | 1,700 Pcs per day | |
| 14 | Whether the unit is exporting its products (Yes/ No) | Yes | |

# 2.0 Energy profile

## 2.1 Process flow diagram

Manufacturing of ceramic item uses wide range of raw material combination to produce different shape, size and colour. It requires both electrical and thermal energy at different stages of the process to operate the ball mill, casting/moulding, kilns, cutting & finishing machines and utilities such as motors, pumps air compressor etc. Ceramic manufacturing process primarily consists of mould preparation, body material preparation, shaping, drying and firing. Typical process flow chart is shown with figure 2.1.

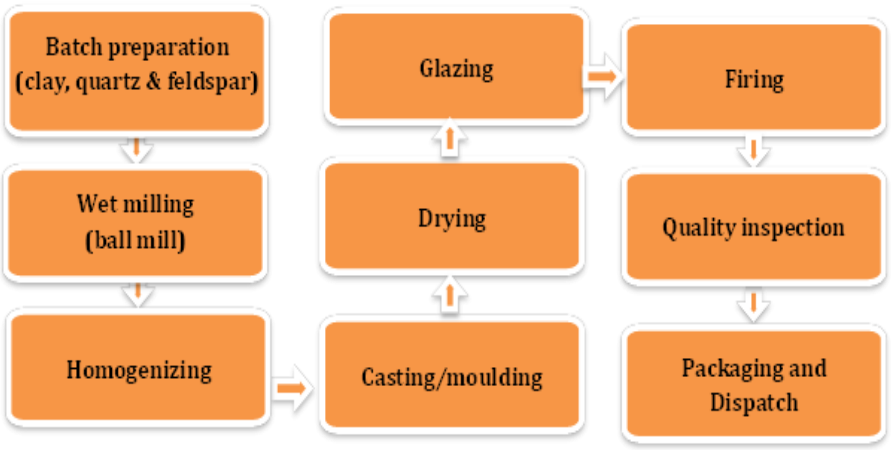


**Figure 2.1:** Process flow chart

## 2.2 Details of technology identified

The details of the exhaust system of the tunnel kiln installed in the unit are given in table 2.2.

**Table 2.2** Details of exhaust system

| Parameter | Value |
|---|---|
| Type of kiln | Tunnel kiln |
| Maximum temperature of combustion zone | 1,200 °C |
| Stack Details | • Natural Draft,<br>• 12 inch Diameter,<br>• FD 5 hp X 2<br>• Damper control |
| Type of fuel | • Natural Gas |
| Exhaust temperature | 215-230 °C |
| Minimum recommended exhaust temperature | 130 °C |
| Fuel Consumption rate | 50-60 SCM per hour |
| Burner details | 14 burners<br>(total gas consumption 1,350 SCM per day) |
| Operating Period | 24 hours per day |

## 2.3 Energy used and brief description of their usage pattern

The unit uses grid power supplied by Paschim Gujarat Vij Company Ltd. (PGVCL) under the tariff category HTP -1. Table 2.3 provides the details of energy uses.

**Table 2.3:** Energy used and description of use

| S No | Energy source | Description of use |
|---|---|---|
| 1 | Electricity | Motive power for different drives in different process sections and utilities |
| 2 | NG | Kiln |
| 3 | HSD | For diesel generator (backup power during power cuts) |

## 2.4 Energy sources, availability & tariff details

Different energy sources, availability of listed energy types and their respective tariffs are given in table 2.4.

**Table 2.4:** Energy sources, availability and tariffs

| Particular | HTP-1 |
|---|---|
| Supplied by PGVCL<br>Connection category: HTP – 1 | Demand charges:<br>▪ For first 500 kVA of billing demand: Rs. 150/- per kVA per month<br>▪ For next 500 kVA of billing demand: Rs. 260/- per kVA per month<br>Energy charges: 420 paise per unit<br>**Penalty:**<br>▪ 1% of energy charges for every point drop in PF between 0.85 to 0.90<br>▪ 2% of energy charges for every point drop in PF below 0.85<br>**Rebate**<br>0.5% of energy charges for every point increase in PF over 0.95<br>TOU Pricing: For energy consumption during the two peak periods, viz., 0700 Hrs to 1100 Hrs and 1800 Hrs to 2200 Hrs<br>▪ For Billing Demand up to 500kVA: 35 Paise per unit<br>▪ For Billing Demand above 500kVA: 75 Paise per unit. |

## 2.5 Analysis of electricity consumption

**Table 2.5:** Electricity consumption profile

| Month & Year | Total electricity consumption (kWh) | Sanctioned load/demand (kW) | Power factor | Recorded demand, kVA | Demand charges (Rs) | Energy charges (Rs) | Monthly bill (Rs) |
|---|---|---|---|---|---|---|---|
| Oct-17 | 31,154 | 100 | 0.91 | 103 | 14,795 | 1,43,308 | 2,10,284 |

The annual electricity consumption of the unit from the grid of Paschim Gujarat Vij Company Ltd under the tariff category HTP–1 is estimated to be 3,73,848 kWh per year (based on the information provided by plant). The average electricity price is Rs. 6.75 per kWh.

## 2.6 Analysis of other energy forms/ fuels

The analysis of the other fuels/forms of energy used in the unit is given in table 2.6.

**Table 2.6:** Analysis of other energy/ fuel consumption

| Parameters | NG (SCM) | HSD (Litre) |
|---|---|---|
| Consumption unit/year | 4,72,500 | 2,800 |
| Calorific value per unit | 8,935 | 9,202 |
| Equivalent toe per year | 422.2 | 2.6 |
| Price (Rs per unit) | 28.0 | 60.0 |
| Total price per year | 1,32,30,000 | 1,68,000 |

The share of various energy forms used in the unit is given in figure 2.6.

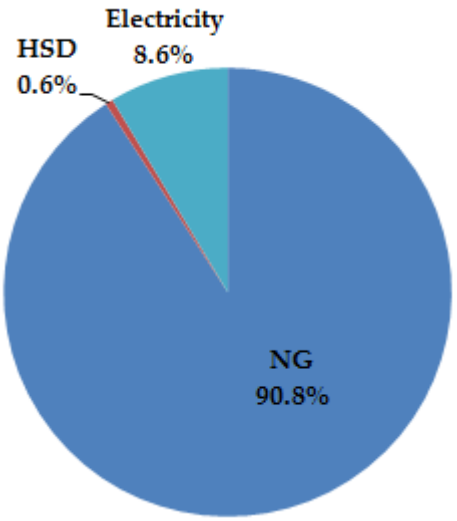


**Figure 2.6:** Percentage share of various fuel types in the unit

The plant is consuming about 3,73,848 kWh of electricity per year. The annual consumption of the HSD is 2,800 litres and natural gas is 4,72,500 SCM. The total energy consumption of the unit during last 12 months is estimated to be 456.9 toe which is equivalent to 159.21 lakh rupees. The total $CO_2$ emission during this period is estimated to be 1,141 tonnes. Electricity, HSD and NG were considered for $CO_2$ emission estimation.

# 3.0 Proposed technology for energy efficiency

Based on the measurements, observations/ findings during detailed assessment study conducted in the unit, the following technology has been identified for energy efficiency improvement. The detail is given below.

## 3.1 Heat pipe based waste heat recovery system in kiln

### 3.1.1 Background

Kilns are important segment in sanitary manufacturing process and accounting for more than 80% of energy consumption. Various operating parameters such as temperatures, draft, retention time and material arrangement, etc. may vary with the type of kilns used. More the air is used to burn the fuel, more is the heat wasted in heating air. The details of the exhaust system of the tunnel kiln installed in the unit are given in table 3.1.1.

**Table 3.1.1:** Details of exhaust system

| Parameter | Value |
|---|---|
| Type of kiln | Tunnel kiln |
| Maximum temperature of combustion zone | 1,200 $^{o}$C |
| Stack Details | • Natural Draft,<br>• 12 inch Diameter,<br>• FD 5 hp X 2<br>• Damper control |
| Type of fuel | • Natural Gas |
| Exhaust temperature | 215-230 $^{o}$C |
| Minimum recommended exhaust temperature | 130 $^{o}$C |
| Fuel Consumption rate | 50-60 SCM per hour |
| Burner details | 14 burners<br>(total gas consumption 1,350 SCM per day) |
| Operating Period | 24 hours per day |

The operational parameters including the electricity consumption and material loaded were measured during the detailed assessment study.

### 3.1.2 Observations and analysis

Firing is a major process of ceramic production in the kiln. There is continuous process of production in tunnel kiln in ceramic production, of which the thermal efficiency is relatively low. Besides combustion losses due to improper air to fuel ratio control mechanism, the most important heat loss is the exhaust losses. The exhaust temperature of the flue gases (waste gases) has been recorded to be 243.8 $^{o}$C. Firing tunnel kiln emissions of heat loss is estimated to be about 13% (at exhaust from precooling zone) of the total calories input. The heat loss from the waste gases for tunnel kiln is shown in table 3.1.2.

**Table 3.1.2:** Heat loss from the waste gases for tunnel kiln

| Operating Parameters | Unit | Value |
|---|---|---|
| Fuel | - | PNG |
| Fuel CV | kCal/kg | 8,935 |
| Average gas consumption | SCM/Hour | 56.3 |
| **Operating parameters** | | |
| $O_2$% in flue gas | % | 8.1 |
| Flue Gas Temperature | °C | 243.8 |
| CO2% in flue gas | % | 7.3 |
| **Ambient air Conditions** | - | |
| DBT | °C | 34.7 |
| RH | % | 56.5 |
| WBT | °C | 27.2 |
| Specific Humidity | kg/kg of air | 0.02 |
| **Fuel Analysis** | | |
| Carbon | % | 74.7 |
| Hydrogen | % | 25.0 |
| Sulphur | % | - |
| Oxygen | % | - |
| Nitrogen | % | 0.8 |
| Moisture | % | - |
| Ash | % | - |
| Total | % | 100.5 |
| **Combustion air analysis** | | |
| Theo. Air required | kg/kg of fuel | 17.37 |
| % Excess air | % | 62.79 |
| Total air supplied | kg/kg of fuel | 28.27 |
| Excess air quantity | kg/kg of fuel | 10.90 |
| **Flue Gas Constituents** | | |
| H2O formation due to $H_2$ in fuel | kg | 2.25 |
| H2O from moisture in fuel | Kg | - |
| H2O from moisture in air | kg | 0.56 |
| N2 in air supplied | kg | 21.71 |
| O2 in excess air | kg | 2.53 |
| Total flue gas generated | kg | 27.05 |
| Total DFG generated | kg | 24.24 |
| **Energy saving analysis** | | |
| Dry flue gas losses | kCal/SCM | 1,165.8 |
| Percentage heat loss in waste gases | % | 13.0 |

The total heat loss in waste gases of the tunnel kiln is estimated to be approximate 13% of the total heat input to the kiln. Therefore recovery of the kiln back-end emission of heat is the key to improve the efficiency of the kiln. Using heat pipe heat exchanger to recycle waste heat in the smoke and gas to heat air as heat source for drying blank pieces or use as combustion air can get good energy-saving efficiency. According to the needs of unit, waste heat recovery

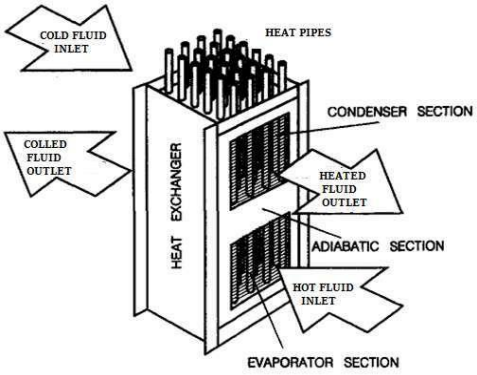


**Figure 3.1.2:** Heat exchanger

can be used to heat the combustion air which not only reduces the kiln exhaust temperature, but also saves fuel for drying application within the kiln.

### 3.1.3 Recommendation

It is recommended to retrofit the heat pipe based waste heat recovery system to generate hot air from the cooling zones of tunnel kilns is usually used in the drying stage, and added to the hot air from gas burners. A large amount of energy is saved using this innovative technique of heat recovery. Waste heat recovery using heat pipe based heat exchangers has been conducted in many industrial sectors but not the ceramic tile sector.

The use of heat pipe in waste heat recovery delivers many advantages. The design of the heat pipe ensures no cross contamination between the exhaust air and the air supply. The effectiveness of a heat pipe based heat exchanger is higher than for a conventional heat exchanger. The heat pipe system tends to be more compact, with fewer mechanical parts and minimal pressure drops. Such a system ensures a complete separation between the hot and cold flows and a high reliability, with minimal need for maintenance.

## 3.2 Cost benefit analysis

The estimated saving in annual operation cost by retrofit the heat pipe based waste heat recovery system is Rs. 1.4 lakhs for three operating ball mills. The investment requirement is Rs 2.3 lakh with a simple payback period of 1.7 years. The detailed calculations of the recommended energy conservation measures for DPR are provided in table 3.2.

**Table 3.2:** Cost benefit analysis for recommended energy savings measures

| Operating Parameters | | Existing | Proposed |
|---|---|---|---|
| Fuel | | PNG | PNG |
| Fuel CV | kCal/kg | 8,935 | 8,935 |
| Average gas consumption | SCM/Hour | 56.3 | 52.3 |
| **Operating parameters** | | | |
| $O_2$% in flue gas | % | 8.1 | 8.1 |
| Flue Gas Temperature | °C | 243.8 | 135.0 |
| CO2% in flue gas | % | 7.3 | 7.3 |
| **Ambient air Conditions** | | | |
| DBT | °C | 34.7 | 34.7 |
| RH | % | 56.5 | 56.5 |
| WBT | °C | 27.2 | 27.2 |
| Specific Humidity | kg/kg of air | 0.02 | 0.02 |
| **Fuel Analysis** | | | |
| Carbon | % | 74.7 | 74.7 |
| Hydrogen | % | 25.0 | 25.0 |
| Sulphur | % | - | - |
| Oxygen | % | - | - |
| Nitrogen | % | 0.8 | 0.8 |
| Moisture | % | - | - |
| Ash | % | - | - |
| Total | % | 100.5 | 100.5 |
| **Combustion air analysis** | | | |
| Theo. Air required | kg/kg of fuel | 17.37 | 17.37 |

| Operating Parameters | | Existing | Proposed |
|---|---|---|---|
| % Excess air | % | 62.79 | 62.79 |
| Total air supplied | kg/kg of fuel | 28.27 | 28.27 |
| Excess air quantity | kg/kg of fuel | 10.90 | 10.90 |
| **Flue Gas Constituents** | | | |
| H2O formation due to $H_2$ in fuel | kg | 2.25 | 2.25 |
| H2O from moisture in fuel | Kg | - | - |
| H2O from moisture in air | kg | 0.56 | 0.56 |
| N2 in air supplied | kg | 21.71 | 21.71 |
| O2 in excess air | kg | 2.53 | 2.53 |
| Total flue gas generated | kg | 27.05 | 27.05 |
| Total DFG generated | kg | 24.24 | 24.24 |
| **Energy saving analysis** | | | |
| Dry flue gas losses | kCal/SCM | 1,165.8 | 559.2 |
| Percentage heat loss in waste gases | % | 13.0 | 6.0 |
| Reduction in heat loss in waste gases | % | - | 7.0 |
| Reduction in fuel consumption | SCM/hour | - | 3.94 |
| Annual reduction in gas consumption | SCM/Year | - | 33,075 |
| Annual monetary benefits (@ Rs 28 per SCM) | Rs/year | - | 9,26,100 |
| Investment towards heat pipe based heat exchanger (UK Pound 20,000 @ Rs 89 per pound)) | Rs | - | 17,80,000 |
| Other fabrication & Misc. charges @ 15 % | Rs | - | 2,67,000 |
| Total investment[2] | Rs | - | 20,47,000 |
| Simple payback period | Years | - | 2.2 |

## 3.3 Pre-training requirements

The training would be required on best operating and maintenance practices for new WHR system.

## 3.4 Process down time for implementation

The estimated process down time required for implementation of recommended measure is estimated to be 7 days.

[2] Quotation – 1 has been considered for financial calculation

## 3.5 Environmental benefits

### 3.5.1 $CO_2$ reduction[3]

Implementation of the selected energy conservation measures in the unit may result in reduction in $CO_2$ emissions due to reduction in overall energy consumption. The estimated reduction in GHG emission by implementation of the recommended energy conservation measures is 57.9 tonne of $CO_2$ per year.

### 3.5.2 Reduction in other pollution parameters (gas, liquid and solid)

There is not significant impact on the reduction in other pollution parameters including gas, liquid and solid.

[3] Source for emission factor: 2006 IPCC Guidelines for National Greenhouse Gas Inventories & electricity: CO2 Baseline Database for the Indian Power Sector, user guide version 12.0, May 2017 (CEA)

# 4.0 Project financials

## 4.1 Cost of project and means of finance

### 4.1.1 Particulars of machinery proposed for the project

The particulars of machinery proposed for the project is given in table 4.1.1.

**Table 4.1.1:** Particulars of machinery proposed for the project

| S, No | Name of machinery (Model/ specification) | Name of manufacturer, contact person | Advantage | Disadvantage |
|---|---|---|---|---|
| 1 | Heat pipe based waste heat recovery system for tunnel kiln | Econotherm (UK) Ltd<br>Neel Shrushti, A102, Sector -4<br>New Panvel<br>Navi Mumbai | design and manufacture heat pipes and heat pipe heat exchangers | - |

### 4.1.2 Means of finance

The means of finance for the project is shown in table 4.1.2.

**Table 4.1.2:** Means of finance

| S. No. | Details | 100% equity | D/E- 70:30 | D/E- 50:50 |
|---|---|---|---|---|
| 1 | Additional (Share) Capital | 20.47 | 6.14 | 10.24 |
| 2 | Internal Accruals | - | - | - |
| 3 | Interest free unsecured loans | - | - | - |
| 4 | Term loan proposed (Banks/FIs) | - | 14.3 | 10.2 |
| 5 | Others | - | - | - |
| | **Total** | **20.5** | **20.5** | **20.5** |

## 4.2 Financial statement (project)

### 4.2.1 Assumptions

The assumptions made are provided in table 4.2.1.

**Table 4.2.1:** Assumptions made

| Details | Unit | 100% equity | D/E- 70:30 | D/E- 50:50 |
|---|---|---|---|---|
| **General about unit** | | | | |
| No of working days | Days | | 350 | |
| No of shifts per day | Shifts | | 2 | |
| Annual operating hours | Hrs/year | | 8,400 | |
| Installed production capacity | Pcs/year | | 5,95,000 | |
| Production in last financial years | Pcs/year | | 3,85,000 | |
| Capacity utilization factor | % | | 65 | |
| **Proposed investment (Project)** | | | | |
| Total cost of the project | Rs. (in Lakh) | 20.5 | 20.5 | 20.5 |
| Investment without interest defer credit (IDC) | Rs. (in Lakh) | 20.5 | 20.5 | 20.5 |
| Implementation time | Months | 3.0 | 3.0 | 3.0 |

| Details | Unit | 100% equity | D/E-70:30 | D/E-50:50 |
|---|---|---|---|---|
| Interest during the implementation phase | Rs. in lakhs | - | 0.1 | 0.1 |
| Total investment | Rs. in lakhs | 20.5 | 20.6 | 20.5 |
| **Financing pattern** | | | | |
| Own funds | Rs. in lakhs | 20.5 | 6.2 | 10.3 |
| Loan funds (term loan) | Rs. in lakhs | - | 14.3 | 10.2 |
| Loan tenure | Years | - | 5.0 | 5.0 |
| Moratorium period (No EMI (interest and principal amount)) | Months | - | 3.0 | 3.0 |
| Total repayment period | Months | - | 60.0 | 60.0 |
| Interest rate | % | - | 10.5 | 10.5 |
| **Estimation of costs** | | | | |
| Operation & maintenance costs | % | | 5.0 | |
| Annual escalation rate of O&M | % | | 5.0 | |
| **Estimation of revenue** | | | | |
| Reduction in energy cost | Rs Lakh/year | | 9.3 | |
| Total saving | Rs Lakh/year | | 9.3 | |
| Straight line depreciation | % | | 16.21 | |
| IT depreciation | % | | 80.0 | |
| Income tax | % | | 33.99 | |
| Period of cash flow analysis | Years | | 5.0 | |

## 4.2.2 Payback

The simple payback period on the investments made are shown in table 4.2.2.

**Table 4.2.2:** Payback

| Details | 100% equity | D/E- 70:30 | D/E- 50:50 |
|---|---|---|---|
| Total project cost (Rs. In lakh) | 20.5 | 20.6 | 20.5 |
| Cash flow as annual saving (Rs. In lakh/year) | 9.3 | 9.3 | 9.3 |
| O&M Expenses for first year (Rs. In lakh/year) | 1.0 | 1.0 | 1.0 |
| Net Cash flow (Rs. In lakh/year) | 8.2 | 8.2 | 8.2 |
| SPP (months) | 29.8 | 30.0 | 29.9 |
| Considered (month) | 29.8 | 30.0 | 29.9 |

## 4.2.3 NPV and IRR

**Table 4.2.3a:** NPV and IRR (100% equity)

| Particulars / years | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | | | (Rs. in lakhs) | | | |
| Profit after tax | - | 4.92 | 5.96 | 2.27 | 2.06 | 1.98 |
| Depreciation | - | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 |
| Cash outflow | 20.47 | - | - | - | - | - |
| Net cash flow | -20.47 | 8.24 | 9.28 | 5.59 | 5.37 | 5.30 |
| Discount rate % @ WACC | 9.30 | 9.30 | 9.30 | 9.30 | 9.30 | 9.30 |
| Discount factor | 1.00 | 0.92 | 0.84 | 0.77 | 0.70 | 0.64 |
| Present value | -20.47 | 7.54 | 7.78 | 4.29 | 3.77 | 3.41 |
| **Net present value** | **6.31** | | | | | |
| **Simple IRR considering regular cash flow** | **21.96%** | | | | | |

**Table 4.2.3b:** NPV and IRR (D/E- 70:30)

| Particulars / years | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | | | (Rs. in lakhs) | | | |
| Profit after tax | - | 4.17 | 5.38 | 1.59 | 1.57 | 1.71 |
| Depreciation | - | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 |
| Cash outflow | 20.56 | - | - | - | - | - |
| Net cash flow | -20.56 | 7.50 | 8.72 | 4.92 | 4.90 | 5.05 |
| Discount rate % @ WACC | 10.10 | 10.10 | 10.10 | 10.10 | 10.10 | 10.10 |
| Discount factor | 1.00 | 0.91 | 0.83 | 0.75 | 0.68 | 0.62 |
| Present value | -20.56 | 6.81 | 7.19 | 3.69 | 3.33 | 3.12 |
| **Net present value** | **3.58** | | | | | |
| **Simple IRR considering regular cash flow** | **17.51%** | | | | | |

**Table 4.2.3c:** NPV and IRR (D/E- 50:50)

| Particulars / years | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | | | (Rs. in lakhs) | | | |
| Profit after tax | - | 4.39 | 5.55 | 1.79 | 1.71 | 1.79 |
| Depreciation | - | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 |
| Cash outflow | 20.53 | - | - | - | - | - |
| Net cash flow | -20.53 | 7.71 | 8.88 | 5.11 | 5.04 | 5.12 |
| Discount rate % @ WACC | 9.90 | 9.90 | 9.90 | 9.90 | 9.90 | 9.90 |
| Discount factor | 1.00 | 0.91 | 0.83 | 0.75 | 0.69 | 0.63 |
| Present value | -20.53 | 7.02 | 7.35 | 3.86 | 3.46 | 3.20 |
| **Net present value** | **4.35** | | | | | |
| **Simple IRR considering regular cash flow** | **18.79%** | | | | | |

## 4.3 Marketing & selling arrangement

The marketing and selling arrangements of the unit are given in table 4.3.

**Table 4.3:** Marketing & selling arrangements

| Items | Remarks |
|---|---|
| Main Markets (locations) | Pan India/UAE |
| Locational advantages | - |
| Any USP or specific market strength | - |
| Whether product has multiple applications | NA |
| Distribution channels (e.g. direct sales, retail network, distribution network) | Direct sales/ Through market |
| Marketing team details, if any. | NA |

## 4.4 Risk analysis and mitigation

The risk analysis and mitigation for the proposed options are given in table 4.4.

**Table 4.4:** Risk analysis and mitigation

| Type of risk | Description | Mitigation |
|---|---|---|
| Technology | The equipment/technology provided by the supplier may not be of high quality which may result in underperformance. | The equipment/technology should be procured from standard/reputed vendors only. |
| Market /Product | Demand of the product manufactured by the unit may change resulting in lower capacity utilization. | Regular vigilance/tab on the market scenario by the SME will help in better understanding of new substitute product. The unit may modify the product line based on the emerging market trend. |
| Policy/ Regulatory | Changes in government regulation/policy related to pollution and taxes & duties can affect the viability of the unit. | Local industrial association may play a role in discussing these issues with the relevant governmental bodies on a regular basis, so that any concerns of the unit are brought to their notice. |

## 4.5 Sensitivity analysis

A sensitivity analysis for various scenarios which may affect the return on investment is given in table 4.5.

**Table 4.5:** Sensitivity analysis

| S. No. | Scenario | D/E ratio | Payback period (months) | NPV (Rs lakh) | IRR (%) | DSCR | ROI (%) |
|---|---|---|---|---|---|---|---|
| 1 | 10% increase in estimated savings | 100% equity | 2.2 | 11.6 | 48.9 | - | 44.2 |
| | | 70:30 | 2.2 | 11.2 | 48.3 | 2.1 | 47.0 |
| | | 50:50 | 2.2 | 11.3 | 48.5 | 0.9 | 46.2 |
| 2 | 10% reduction in estimated savings | 100% equity | 2.7 | 9.3 | 39.3 | - | 43.3 |
| | | 70:30 | 2.7 | 9.0 | 38.7 | 2.1 | 46.6 |
| | | 50:50 | 2.7 | 9.1 | 38.9 | 0.9 | 45.6 |
| 3 | 10% rise in interest rates | 70:30 | 2.4 | 9.9 | 43.4 | 2.1 | 46.8 |
| | | 50:50 | 2.4 | 10.1 | 43.6 | 0.9 | 45.9 |
| 4 | 10% reduction in interest rates | 70:30 | 2.4 | 10.3 | 43.6 | 2.1 | 46.8 |
| | | 50:50 | 2.4 | 10.4 | 43.7 | 0.9 | 45.9 |

# 5.0 Conclusions & recommendations

The DPR prepared for the retrofit the heat pipe based waste heat recovery system in tunnel kiln based on the performance assessment study conducted at unit and the acceptance of the unit management. The brief of selected energy conservation measures is given below.

## 5.1 List of energy conservation measures

The brief summary of the energy conservation measures are given in table 5.1.

**Table 5.1:** summary of the energy conservation measures

| S. No | Energy conservation measure | Annual energy saving NG (SCM) | Investment (Rs. Lakh) | Monetary savings (Rs. Lakh per year) | Simple payback period (Yrs) | Emission reduction (tonnes of $CO_2$) |
|---|---|---|---|---|---|---|
| 1 | Heat pipe based waste heat recovery system in kiln | 33,075 | 20.47 | 9.26 | 2.2 | 57.9 |

These measures have an estimated investment of 20.47 lakh rupees and can yield a savings of 9.26 lakh rupees per year. The total annual reduction in emission by implementation of recommended measures is estimated to be 57.9 tonnes of $CO_2$. The financial indicators provided above in the table shows the project is financially viable and technically feasible.

## 5.2 Summary of the project

The summary of the project is given in table 5.2.

**Table 5.2:** Summary of the project

| S. No. | Particulars | Unit | 100% equity | D/E- 70:30 | D/E- 50:50 |
|---|---|---|---|---|---|
| 1 | Cost of Project | Rs. In Lakh | 20.47 | 20.47 | 20.47 |
| 2 | D/E Ratio | - | - | 7:3 | 1:1 |
| 3 | Project IRR | % | 22.0 | 17.50 | 18.80 |
| 4 | NPV | Rs. In Lakh | 6.30 | 3.60 | 4.40 |
| 5 | DSCR | - | - | 2.10 | 0.90 |

## 5.3 Recommendations

The financial indicators provided above show the project is financially viable and technically feasible. It is recommended that the implementation of the identified the energy conservation measures may be undertaken by the unit.

# 6.0 Financing schemes for EE investments for MSME sector

Government of India has many schemes to provide concessional finance for EE technologies among MSMEs. Some major government schemes are summarised in table 6.1.

**Table 6.1:** Major government schemes

| Name of the scheme | Brief Description and key benefits |
|---|---|
| ZED assessment and certification | Assessment process, fee and subsidy are as follows:<br>Online (e-Platform) self-assessment: Nil fee<br>Desk Top assessment : Rs 10,000 per SME<br>Complete assessment : Rs 80,000 ZED rating per SME; Rs 40,000 for additional ZED defence rating; Rs 40,000 for re-rating<br>The rating costs will include cost of Rs 10,000/- as certification cost by QCI.<br>Subsidy for Micro, Small and Medium Enterprises are 80%, 60% and 50% respectively. |
| Credit Linked Capital Subsidy Scheme (CLCSS) (2000-ongoing) | 15% capital subsidy of cost of eligible plant and machinery / equipment for adoption of proven technologies for approved products / sub-sectors for MSE units subject to ceiling of INR 15 lakhs |
| Credit Guarantee Fund Scheme for Micro and small Enterprises (in partnership with SIDBI) (2000-ongoing) | This scheme was launched by MoMSME and SIDBI to alleviate the problem of collateral security and enable micro and small scale units to easily adopt new technologies. Under the scheme, collateral free loans up to Rs 1 crore can be provided to micro and small scale units. Additionally, in the event of a failure of the SME unit which availed collateral free credit facilities to discharge its liabilities to the lender, the Guarantee Trust would guarantee the loss incurred by the lender up to 75 / 80/ 85 per cent of the credit facility. |
| Technology and Quality Up gradation Support to MSMEs (TEQUP) (2010-ongoing) | The benefits available to SMEs under TEQUP include—technical assistance for energy audits, preparation of DPRs and significant capital subsidy on technologies yielding an energy savings of over 15%. The scheme offers a subsidy of 25% of the project cost, subject to a maximum of Rs. 10 lakhs. TEQUP, a scheme under NMCP, focuses on the two important issues in enhancing competitiveness of the SME sector, through EE and Product Quality Certification. |
| Technology Upgradation Fund Scheme (TUFS) (1999-ongoing) | Interest subsidy and /or capital subsidy for Textile and Jute Industry only.<br>1. To facilitate Technology Up gradation of Small Scale (SSE) units in the textile and jute industries. Key features being:<br>• Promoter's margin -15%;<br>• Subsidy – 15% available on investment in TUF compatible machinery subject to ceiling of Rs 45 lakh;<br>• Loan amount – 70% of the cost of the machinery by way of Term Loan |

| Name of the scheme | Brief Description and key benefits |
|---|---|
| | • Interest rate: Reimbursement of 5% on the interest charged by the lending agency on a project of technology upgradation in conformity with the Scheme<br>• Cover under Credit Guarantee Fund Scheme for Micro and Small Enterprises (CGMSE) available<br><br>2. To enable technology upgradation in micro and small power looms to improve their productivity, quality of products and/ or environmental conditions<br>• 20% margin subsidy on investment in TUF compatible specified machinery subject to a ceiling of Rs 60 lakhs or Rs 1crore (whichever is applicable) on subsidy amount to each unit – released directly to the machinery manufacturer. |
| Tax incentives | • Accelerated depreciation is provided to the customers / users of the energy saving or renewable energy devises under the direct tax laws.<br>• Under indirect taxes, specific concessional rates of duty are only available to CFLs and not to all energy efficient products<br>• A further waiver of import tariffs and taxes for EE technology imports are dealt on a case to case basis, meaning higher costs for those imported technologies that are not available in the domestic markets at present. |

Two financing schemes have been created by Bureau of Energy Efficiency (BEE) under The National Mission for Enhanced Energy Efficiency (NMEEE) for financing of energy efficiency projects - Venture Capital for Energy Efficiency (VCFEE) and Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE). These funds seek to provide appropriate fiscal instruments to supplement the efforts of the government for creation of energy efficiency market. Highlights of these two schemes are provided in the table 6.2.

**Table 6.2:** BEE's VCFEE and PRGFEE scheme

| | |
|---|---|
| Venture Capital for Energy Efficiency (VCFEE) | • This fund is to provide equity capital for energy efficiency projects in Government buildings and Municipalities in the first phase.<br>• A single investment by the fund shall not exceed Rs 2 crore<br>• Fund shall provide last mile equity support to specific energy efficiency projects, limited to a maximum of 15% of total equity required, through Special Purpose Vehicle (SPV) or Rs 2 crore, whichever is less |
| Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) | • A PRGF is a risk sharing mechanism lowering the risk to the lender by substituting part of the risk of the borrower by granting guarantees ensuring repayment of part of the loan upon a default event.<br>• Guarantees a maximum 50% of the loan (only principal). In case of default, the fund will:<br>o Cover the first loss subject to maximum of 10% of the total guaranteed amount<br>o Cover the remaining default (outstanding principal) amount on |

| | |
|---|---|
| Venture Capital for Energy Efficiency (VCFEE) | • This fund is to provide equity capital for energy efficiency projects in Government buildings and Municipalities in the first phase.<br>• A single investment by the fund shall not exceed Rs 2 crore<br>• Fund shall provide last mile equity support to specific energy efficiency projects, limited to a maximum of 15% of total equity required, through Special Purpose Vehicle (SPV) or Rs 2 crore, whichever is less |
| | partial basis upto the maximum guaranteed amount<br>• PFI shall take guarantee from the PRGFEE before disbursement of loan to the borrower.<br>• The Guarantee will not exceed Rs 300 lakh per project or 50% of loan amount, whichever is less.<br>• Maximum tenure of the guarantee will be 5 years from the date of issue of the guarantee |

Indian Renewable Energy Development Agency (IREDA), a non-banking financial institution established by the government also extends financial assistance for setting up projects relating to new and renewable sources of energy and energy efficiency/conservation. The detailed financing guidelines for energy efficiency projects are provided in table 6.3.

**Table 6.3:** IREDA's financing guidelines

| | |
|---|---|
| Eligible companies who can apply | Private Sector Companies/ firms, Central Public Sector Undertaking (CPSU), State Utilities/ Discoms/ Transcos/ Gencos/ Corporations, Joint Sector Companies which are not loss making. |
| Minimum loan amount | • Rs. 50 lakh |
| Type of projects considered for term loans | • Replacement / retrofit of selected equipment with energy efficient equipment<br>• Modification of entire manufacturing processing<br>• Recovery of waste heat for power generation |
| Incentive available | • Rebate in central excise duty<br>• Rebate in interest rate on term loan<br>• Rebate in prompt payment of loan instalment |
| Interest rate | • 10.60% to 11.90% depending upon the grading of the applicant with prompt payment rebate of 15 bps if payment is made on / before due dates<br>• Interest rates are floating and would be reset on commissioning of the project or two years from the date of first disbursement. Thereafter, the rates will be reset after every two years.<br>• Rebate of 0.5% in interest rates are available for projects set up in North Eastern States, Sikkim, J&K, Islands, Estuaries. Rebates of 0.5% in interest rates are also available for projects being set up by SC/ST, Women, Ex Servicemen and Handicapped categories involving project cost of upto Rs. 75.00 lakh. |
| Loan | Upto 70% of the total project cost. Promoter's contribution should be Minimum 30% of the total project cost |
| Maximum debt | 3:1 |

| | |
|---|---|
| equity ratio | The project cash flow should have a minimum average Debt Service Coverage Ratio of 1.3 |
| Maximum repayment period | 12 years with moratorium of maximum 12 months |
| Procurement procedures | The borrower is required to follow the established market practices for procurement and shall demonstrate that the quality goods and services are being purchased at reasonable and competitive prices. Wherever the loan is sanctioned against international lines of credit such as the World Bank, Asian Development Bank, kfW, etc., the relevant procedures will have to be followed and requisite documents will have to be submitted by the borrower |

Small Industries Development Bank of India (SIDBI) has several schemes and focused lines of credit for providing financial assistance for energy efficiency and cleaner production projects for SMEs. Highlights of some of the major financial assistance schemes/projects managed by SIDBI are given in table 6.4.

**Table 6.4:** Major EE financing schemes/initiatives of SIDBI

| | |
|---|---|
| End to End Energy Efficiency (4E) Program | Support for technical /advisory services such as:<br>• Detailed Energy Audit<br>• Support for implementation<br>• Measurement & Verification<br><br>Financing terms:<br>• Terms loans upto 90%<br>• Interest rate upto 3% below normal lending rate. |
| TIFAC-SIDBI Revolving Fund for Technology Innovation (Srijan Scheme) | To support SMEs for up-scaling and commercialization of innovative technology based project at flexible terms and interest rate.<br><br>Preference accorded to sustainable technologies / products. Soft term loan with an interest of not more than 5%. |
| Partial Risk Sharing Facility for Energy Efficiency (PRSF) Project (supported by World Bank) | Sectors covered:<br>• Large industries (excluding thermal power plants)<br>• SMEs<br>• Municipalities (including street lighting)<br>• Buildings<br><br>Coverage:<br>• The minimum loan amount Rs 10 lakh and maximum loan amount of Rs 15 crore per project.<br>• The extent of guarantee is 75% of the loan amount |
| JICA-SIDBI Financing Scheme | • The loan is used to provide SMEs with funds necessary to invest in energy-saving equipment (and some medical equipment) in the form of two-step loans through SIDBI or three-step loans through intermediary financial institutions. |

| | |
|---|---|
| | • Project uses an Energy Saving Equipment List approach<br>• Equipment/machinery with energy saving potential less than 10% is not eligible.<br>• Interest rate: As per credit rating and 1% below the normal lending rate<br>• Separate technical assistance component which is used for wetting of loan applications, holding seminars to raise awareness of energy saving among SMEs and to improve the ability of financial institutions to screen loan applications for energy-saving efforts |
| KfW-SIDBI Financing Scheme | Coverage<br>a) SMEs for energy efficiency projects<br>b) SMEs and clusters for cleaner production and emission reduction measures, waste management and Common Effluent Treatment Plant (CETP) facilities<br>Interest rate<br>As per credit rating and 1% below the normal lending rate<br><br>Eligible criteria<br>3 t $CO_2$ emission reduction per year per lakh invested<br>List of eligible equipment/technology and potential suppliers developed for guidance |

State Bank of India (SBI) has been provided a green line of credit by Japan Bank for International Cooperation (JBIC) for financing of energy efficiency investments. Highlights of the line of credit are given in table 6.5.

**Table 6.5:** JBIC-SBI Green Line

**Key Features**

- Amount : USD 90 million
- Repayment Schedule: First repayment on May 30, 2017 and final repayment date May 30, 2025 (equal instalment)

**Eligibility Criteria**

- Projects contributing to preservation of global environment, i.e. significant reduction of GHG emissions
- Acceptance of JBIC-MRV ('J-MRV") by the project proponent in terms of the numerical effect of the environment preservation. To ensure effective GHG reduction emissions in Green financed projects, JBIC reviews such effects through simple and practical Measurement Reporting Verification (MRV) process both in (a) prior estimation and (b) ex-post monitoring.
- Procurement in line with the "Guidelines for Procurement under Untied Loans by Japan Bank for International Cooperation"

Canara bank has a dedicated scheme for financing EE investment among SME sector as mentioned in table 6.6.

**Table 6.6:** Canara bank scheme of EE SME loans

| | |
|---|---|
| **Purpose** | **For acquiring/adopting energy conservation/savings equipment/ measures by SMEs** |
| **Eligibility** | Units under Small and Medium Enterprises<br>Cost of energy for the unit should constitute not less than 20% of the total cost of production<br>Unit should possess energy audit report issued by an approved energy Consultant/Auditor.<br>Borrowal a/cs-ASCC code S1 or S2 during previous review.<br>Current account holders having dealings exclusively with us satisfactorily for a period of last one year |
| **Maximum loan** | Maximum Rs 100 lakhs in the form of term loan |
| **Security** | Prime: Assets created out of loan<br>Collateral: Upto Rs.5 lakhs – NIL<br>Above Rs.5 lakhs, as determined by the bank |
| **Repayment** | Maximum 5-7 years including moratorium of 6 months |
| **Guarantee cover** | Cover available under CGMSE of CGTMSE available for eligible loans |
| **Margin** | 10% of the project cost |
| **Rate of interest** | 1% less than the applicable rate |
| **Upfront fee** | 1% of the loan |
| **Insurance cover** | Assets acquired and charged as security to Bank to be insured |
| **Special offer, if any** | **Grants :** Bank provides 25% of the cost of Energy Audit / Consultancy charges with a maximum of Rs 25000/- to the first 100 units on a first come first served basis which is in addition to the grant of Rs 25000/- being provided by IREDA(First 100 units) |

Among the private sector banks in India, Yes Bank is also active in financing of renewable energy and energy efficiency projects. The bank has an MOU with SIDBI for providing funding for EE through PRSF.

Most commercial banks charge interest rate between from 11% to 13% from MSMEs depending upon general criteria such as credit ratings, references, past lending record, balance sheet for last 3 years and so on. Interest rebate is offered for a few customers whose collateral value is around 125% of the loan amount. Further 0.5% concession in interest rate was offered to women entrepreneurs.

# Annexures

# Annexure 1: Budgetary offers / quotations

## Quotation – 1: Econotherm

Heat pipe technical details / performance

Recovering the Irrecoverable

| | |
|---|---|
| Possible lengths | 2m [up to 10m] |
| Outer diameter | 28mm [15, 22, 38mm] |
| Wall thickness | 2.5mm [3.5mm] |
| Construction materials | Carbon steel and stainless steel, aluminium, copper … |
| Fins | According to application: 5-11mm height, 3-6mm pitch |
| Working fluids | Water [Acetone, Ammonia, Dowtherm, Naphthalene] |
| Maximum allowable pressure | 400 bar (burst pressure is ~800 bar) |
| Normal working pressure | 15-30 bar (steam tables, according to WPT) |
| Weight - smooth<br>- finned | 1.8 kg/m pipe only. 2.5kg/m carcass weight<br>3.1 kg/m " 4.3kg/m " |
| Joint types | Gravity, Push fit, Compression |
| DUTY RANGES (1 metre, 28mm diameter, carbon steel pipe, with H2O working fluid) | 500W-3000W per meter length of pipe, depending on application, ΔT and finning profile [= 5kW-30kW/m2]<br>[Flat panel duty = 70-80kw @ 350C surface] |

An associate company of Spirax-Sarco Engineering plc

econotherm WASTE HEAT RECYCLING TECHNOLOGY

Formal interaction at TERI office to explore heat pipe oppurtunities - IBM Notes

File Edit View Create Actions Tools Window Help

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Discover | Replication and Sync | Pawan Tiwari - Mail | Archive a_ptiwar - Mail | Replication and Sync | Formal interaction at TERI office to...

New Reply Reply to All Forward Display More

**Formal interaction at TERI office to explore heat pipe oppurtunities**

Chander Kamra to: pawan.tiwari@teri.res.in 04-05-2018 11:10

Cc: "chhn.rupesh@gmail.com", "swmradhe@yahoo.com" , "cso@radhegroup.com", Mark Boocock , Andrew Holgate Show Details

Dear Mr Pawan Tiwari,

Following my discussion had with you over the phone today, I would like to introduce myself and Econotherm UK to you.

A brief introduction Econotherm (more information can be found at our website www.econotherm.eu)
Econotherm UK Ltd is a well-established UK company specialising in industrial waste heat recovery and recycling technology based on thermal superconductor heat pipes.

Thanks a lot for your remarkable initiative for energy saving through TERI. Under your profound guidance and mentorship, I am sure that Industrial India will save billions of rupees in energy saving which will contribute to our Nation's growth. Your recent address at the RAJKOT - TERI event( Ceramics Cluster) has further given us many insights in the field of energy saving.

I would request you to recall your Discussion with Mr Javia and Mr Rupesh from Radhe Renewable Energy Pvt LTD at the event and I appreciate your interest in case studies and projects done by Econotherm. We manufacture heat pipes and heat pipe heat exchangers for use in diverse areas of industrial waste heat recovery and focus mainly on difficult to recover waste heat.

It would be most appreciated if you would arrange a formal meeting with you at Lodhi Road Office on 17th May (At around 16:15 Hrs) to explore the possible opportunities for us to support you energy conservation ambitions.

I would request you to give us an opportunity for the detailed study and analysis and we can move a step further towards your initiative of energy saving.

Regards,

Chander Kamra
Business Development Manager Asia
Econotherm (UK) Ltd

Sametime Conta... Pawan Tiwari Work 1/1 Pawan Tiwari Day-At-A-Glance My Widgets Feeds Broadcast Com... Chat Rooms

14:37 02-08-2018

An ISO9001 Organisation

econotherm
WASTE HEAT RECYCLING TECHNOLOGY
Telephone: +44(0)1656 658640
E-mail: enquiries@econotherm.eu

Reference ID: ECT/2017-18/74 Date: 17/06/2018

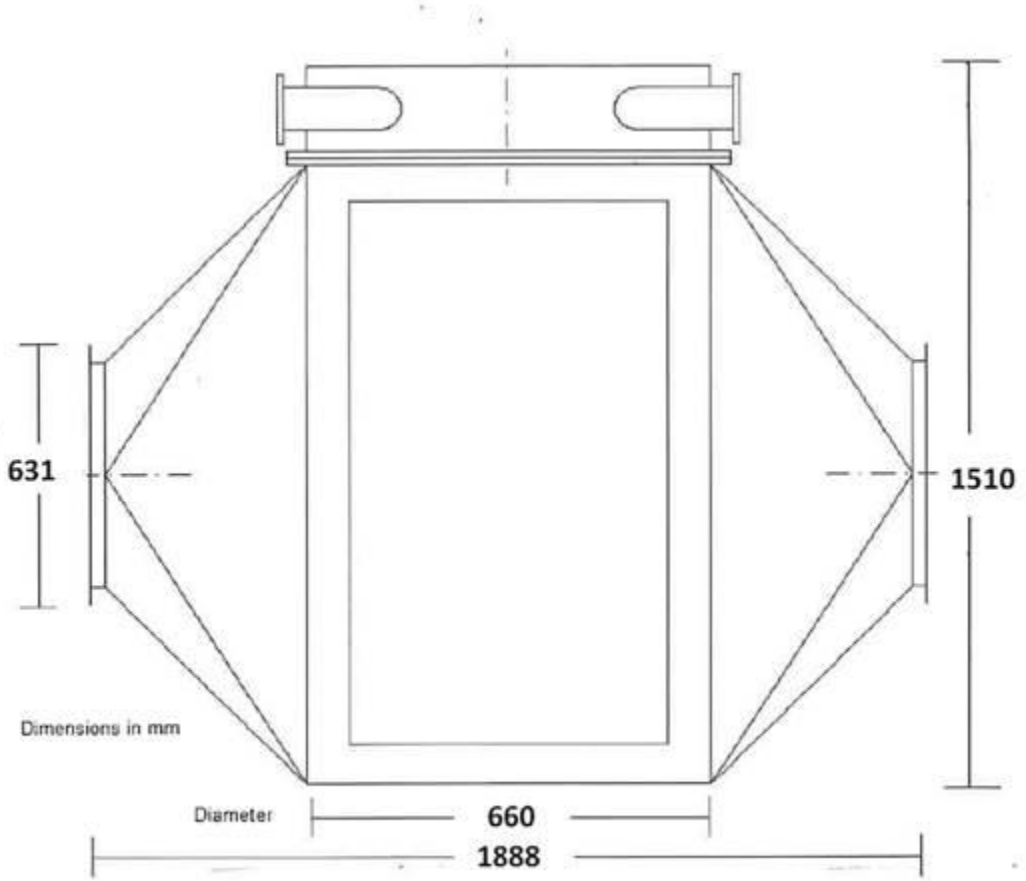
Subject: Techno-Commercial Offer for WHR system

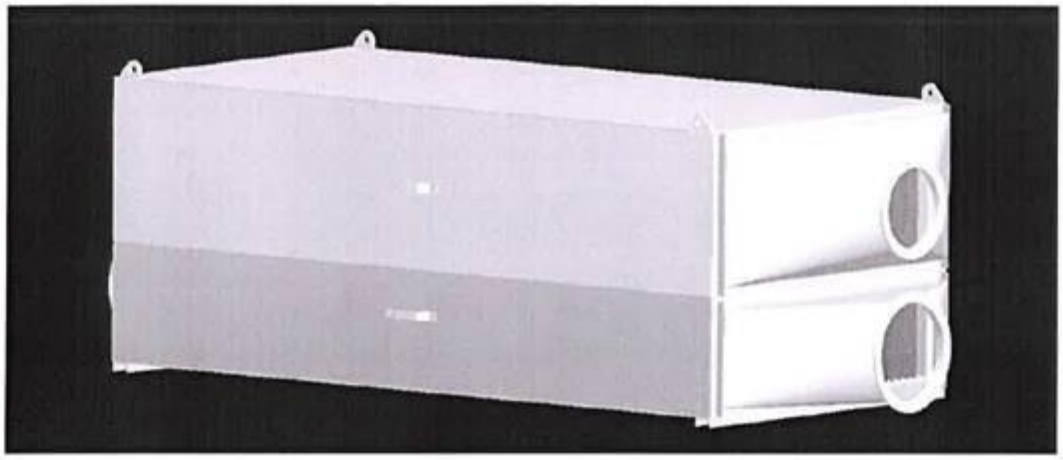
Dear Sir,

With reference to you enquiry, please find offer below

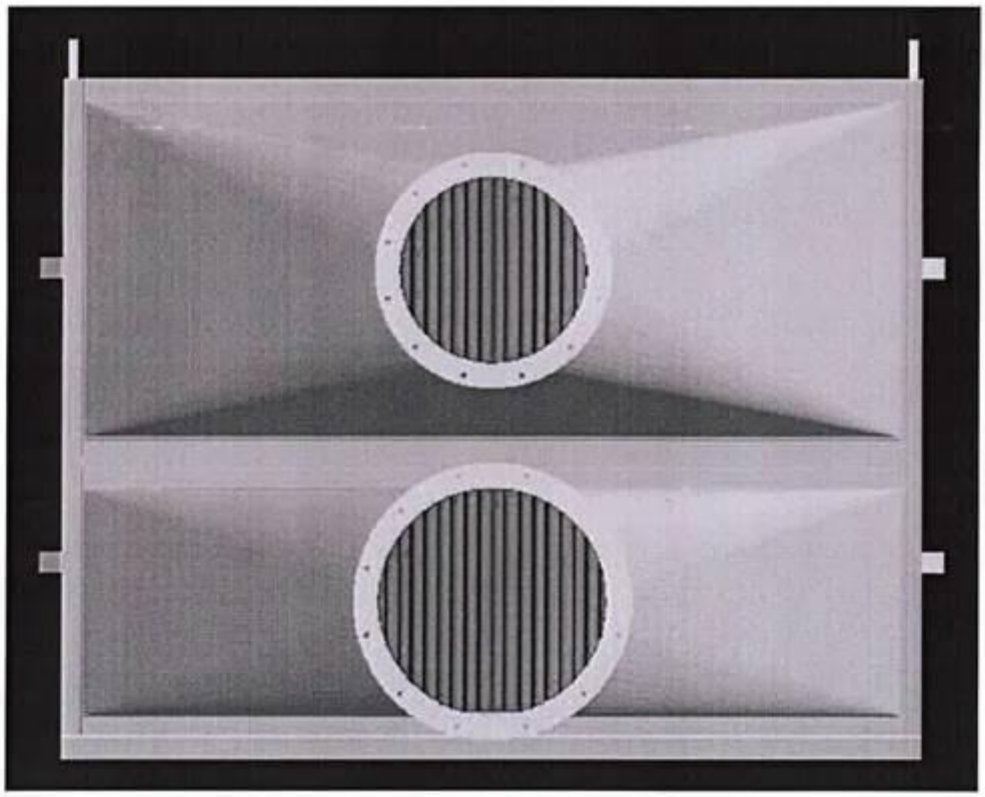
| **Client Supplied Design Parameters** | | | |
|---|---|---|---|
| Exhaust inlet temperature [°C] | | 250 | |
| Air inlet temperature [°C] | | 25 | |
| Fuel Type | | Natural Gas | |
| **Assumed Design Parameters** | | | |
| Exhaust (Source) specific heat [Kcal/kg °C ] | | 0.257320317 | |
| Air (Sink) specific heat [Kcal/kg. °C ] | | 0.24028 | |
| | | | |
| **Exchanger Specification** (Subject To Final Design) | | | |
| Heat Pipe Outline Specification - | | Heat source - Exhaust | |
| | | Heat sink - Air | |
| Length [mm] | 1,480 | **Estimated Unit Dimensions** | |
| Outside diameter [mm] | 28 | Height [mm] | 1,510 |
| Pipe wall thickness [mm] | 2 | Width [mm] | 660 |
| Exhaust outlet temperature [°C] | 135 | Length [mm] | 1,219 |
| Air outlet temperature [oC] | 150 | Weight [Kg] | 1,203 |
| | | | |
| **Price (Offer)** | | | |
| Description | | Unit Price | Total |
| 1) Unit cost gas to gas | | - | £ 20,000 |
| 2) Miscellaneous cost | | - | £ 3,000 |
| **Total Cost** | | | £ 23,000 |

| Casing Specifications | | | | Heat Pipe Detailed Specification | | | |
|---|---|---|---|---|---|---|---|
| Materials | | | | Materials | | | |
| Primary Side (Exhaust) | Carbon steel | | | Tube | Carbon steel | | |
| Secondary Side (Water) | Carbon steel | | | Evaporation Section Fin | N/A | | |
| Separation Plate | Carbon steel | | | Condensation Section Fin | Carbon steel | | |
| Heat Pipe Working Fluid | | | | Dimensions | | | |
| Dowtherm | | | | Evaporation Length [m] | tba | | |
| Heat Pipe Sealing Specification | | | | Condensation Length [m] | tba | | |
| Type | Grafoil Compression | | | Evaporation Fin Height [m] | N/A | | |
| Gasket Material | Round 28mm | | | Evaporation Fin Pitch [m] | N/A | | |
| Design Pressure | N/A | | | Condensation Fin Height [m] | tba | | |
| Design Temperature | N/A | | | Condensation Fin Pitch [m] | tba | | |
| Design Condition | | | | | | | |
| Primary Side | | | | Secondary Side | | | |
| Pressure [Bar] | 0.1 | Temp [°C] | 250 | Pressure [Bar] | 0.1 | Temp [°C] | 150 |

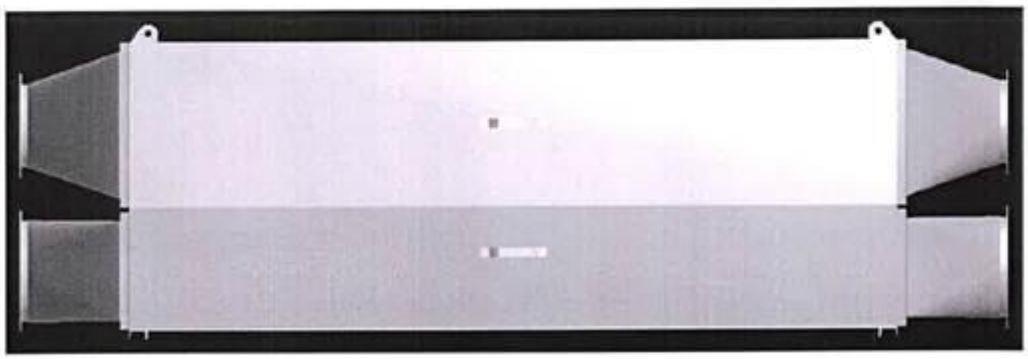




*General arrangement drawing of heat exchanger*



*General arrangement drawing of heat exchanger*



Approximate Heat Pipe Weight: 3.6kg

Approximate Casing Weight: 3000kg

Approximate Surface Area: 30.75 Sqm

# Annexure 2: Instruments used

| Instruments | Model/ Make | Application | Accuracy |
|---|---|---|---|
| Power analysers | Fluke: 435, Fluke: 43B, | Electrical Parameters Harmonics analysis, power logging | ± 0.5% |
| Flue gas analyser | Testo: 330-2LL | Flue gas $O_2$, CO, $CO_2$ & Temperature | ± 0.1vol%, 1ppm, 1ppm, 0.1°C |
| Thermal imager | 875-2/Testo | Surface Temperature & Image | ± 2% |
| Digital Temperature indicator | Comark: N1001, Testo: 925 | Temperature | ± 1% |
| Anemometer | Testo: 425, Airflow: TA45 | Air Velocity | ± (0.03 m/s +5% of mv) |
| Differential pressure meter | Testo: 512 | Air pressure | 0.5% full-scale value / ± 1 digit |
| Temperature data logger | 175-T3/Testo | Temperature | ± 0.5% |