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Confederation of Indian Industry





ECO Metal Foundry

Energy Efficiency

Automation & Digitalization

Compendium of Clean Technologies and Use Cases for Resource Efficiency & Cleaner Production

Disclaimer

The compendium has been prepared for the Raising and Accelerating MSME Performance, RAMP: Greening of MSMEs initiative being implemented by Research and Innovation Circle of Hyderabad (RICH) with technical assistance and field support from the Confederation of Indian Industry (CII). The RAMP program is a program for results under the Ministry of MSME, Government of India, with support from the World Bank. In Telangana the program is being overseen by the Industries & Commerce Department, Government of Telangana, and implemented by Research and Innovation Circle of Hyderabad (RICH), to guide MSMEs in Telangana clusters towards improved resource utilisation, energy efficiency, and cleaner production practices. The information presented in this document is intended as a reference guide for MSME owners, energy managers, plant operators, and policymakers.

The technologies, performance parameters, and financial estimates provided are indicative in nature and may vary based on site specific conditions. MSMEs are advised to undertake detailed technical, financial, and operational feasibility assessments prior to implementation of any recommended measures. The vendor or technology provider details included in this compendium are for informational purposes only and do not constitute an endorsement or recommendation by CII, RICH, the Industries Department of Telangana, or any other stakeholders under the RAMP Programme.

The energy savings potential, benchmarks, and case references presented are derived from secondary sources and cluster-level studies, including but not limited to studies conducted by the Bureau of Energy Efficiency (BEE), National Productivity Council (NPC), 2022 and with the expertise of CII – GBC on conducting detailed energy audits. While every effort has been made to ensure accuracy and relevance, CII, RICH, the Industries Department of Telangana, and associated stakeholders do not assume any responsibility or liability for decisions made based on the information contained in this document or for any consequences arising thereof.

About the Project - RAMP Program

The Micro, Small and Medium Enterprises (MSME) sector plays a vital role in India's economic and social progress. As of July 4, 2025, MSMEs account for 30.1% of India's GDP, 35.4% of manufacturing and 45.73% of exports in the country. The Udyam Registration Portal, launched on July 1, 2020, and designed to provide a free, paperless and self-declared registration process, has recorded more than 3.80 crore MSME units. Additionally, the Udyam Assist Portal, introduced on January 11, 2023, to support informal micro enterprises and extend access to formal benefits such as Priority Sector Lending, has registered over 2.72 crore units. Together, these platforms cover around 6.5 crore MSME units across India, representing all eligible MSME category businesses, and collectively generating employment for nearly 28 crore people.

Despite its potential to drive entrepreneurship, economic growth and employment generation, the sector faces persistent challenges such as limited access to credit, technology and markets, infrastructure constraints, and delayed payments. The COVID-19 pandemic further exacerbated these issues, impacting liquidity, increasing non-performing assets, leading to unsold inventories, and disrupting supply chains.

To address these concerns, the Ministry of MSME, Government of India, introduced a new Central Sector Scheme called 'RAMP (Raising and Accelerating MSME Performance)', which is financially supported by the World Bank. The scheme is planned for implementation over a five-year period, starting from FY 23 till FY 27. The Cabinet approved the scheme on 30th March 2022 and the same was launched by the Hon'ble Prime Minister on 30th June 2022.

The RAMP programme is designed to have a nationwide impact, aiming to benefit all 63 million enterprises that fall under the MSME category, either directly or indirectly. However, the scheme specifically targets 5,55,000 MSMEs for measurable performance improvements. Additionally, it envisions expanding its reach to include service sector enterprises and aims to increase the participation of women-led MSMEs by approximately 70,500.

To operationalize RAMP, the central government directed all states and union territories to prepare and submit a Strategic Investment Plan (SIP) outlining their priorities and interventions under the programme. Telangana submitted its SIP identifying key objectives to strengthen the MSME ecosystem. One of the major priorities under Telangana's RAMP plan is Greening of MSMEs, which aims to:

- Promote energy efficiency, resource optimization, and cleaner production practices
- Reduce environmental impact and improve compliance
- Support MSMEs in adopting sustainable technologies and processes

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List of Abbreviations

Abbreviation	Full Form
AI	Artificial Intelligence
BEE	Bureau of Energy Efficiency
CAGR	Compound Annual Growth Rate
CCTS	Carbon Credit Trading Scheme
CPCB	Central Pollution Control Board
DRI	Direct Reduced Iron
EC	Energy Conservation
EMS	Energy Management System
GHG	Greenhouse Gas
GOI	Government of India
IFA	Indian Foundry Association
IIF	Institute of Indian Foundrymen
IGBT	Insulated Gate Bipolar Transistor
IoT	Internet of Things
kWh	Kilowatt Hour
LED	Light Emitting Diode
MoEFCC	Ministry of Environment, Forest and Climate Change
MoMSME	Ministry of Micro, Small and Medium Enterprises
MSME	Micro, Small and Medium Enterprise
$MtCO_2e$	Million Tonnes of CO_2 Equivalent
NDC	Nationally Determined Contributions
NIC	National Industrial Classification
PAT	Perform, Achieve and Trade
PNG	Piped Natural Gas
RAMP	Raising and Accelerating MSME Performance
RECP	ResourceEfficiency and Cleaner Production
RoI	Return on Investment

SCADA	Supervisory Control and Data Acquisition
SCR	Silicon Controlled Rectifier
SEC	Specific Energy Consumption
SIDBI	Small Industries Development Bank of India
SME	Small and Medium Enterprise
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
TERI	The Energy and Resources Institute
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drive
WHR	Waste Heat Recovery
ZLD	Zero Liquid Discharge

Unit of Measurement

Units	Description
°C	Degree Celsius
kW	Kilowatt
kWh	Kilowatt-hour
kWp	Kilowatt peak
LMT	Lakh Metric Tonnes
MMT	Million Metric Tonnes
kg	Kilogram
MT	Metric Tonne
%	Percentage
Rs.	Indian Rupees
m^3	Cubic meter
m^2	Square meter
hr	Hour
TOE	Tonne of Oil Equivalent
MT	Metric Tonne
GJ	Gigajoule
CO_2	Carbon Dioxide
kCal	Kilo Calorie

Executive Summary

The Indian Basic Metal Foundry sector stands at a pivotal juncture as it continues to balance decades of manufacturing tradition with increasing challenges related to energy costs, environmental compliance, raw material volatility, and global competitiveness. This Compendium Report, prepared under the aegis of the RAMP Program, presents an assessment of energy consumption patterns, resource efficiency opportunities, technology interventions, and implementation case studies for approximately 5,000 MSME foundry units located across major industrial clusters in India. The Indian foundry industry is the second largest in the world by volume of castings produced, contributing over USD 20 billion to the national economy and employing approximately 5 lakh persons directly and another 15 lakh indirectly. The sector produces around 15–17 million metric tonnes of castings annually for end-user industries such as automobiles, agriculture, railways, pipes and fittings, valves, and heavy engineering. MSMEs constitute nearly 75–80% of all foundry units and contribute more than 50% of the total casting output.

Foundry operations are highly energy intensive, with the melting process accounting for 55–65% of total energy consumption, followed by heat treatment furnaces at 10–15%, compressed air systems at 8–12%, fettling and finishing operations at 5–8%, pumping systems at 3–5%, lighting and utilities at 3–5%, and other miscellaneous uses at 2–4%. The average Specific Energy Consumption (SEC) of Indian MSME foundries ranges between 600 and 900 kWh per metric tonne of good casting, which is significantly higher than global benchmarks of 400–600 kWh per metric tonne, indicating substantial potential for efficiency improvement.

Table 1: Energy Consumption Profile

Energy Consumer	Energy Type	% Share of Total Energy	Key Improvement Area
Melting Furnace	Electrical / Thermal	55-65%	Induction furnace upgrade, refractory optimization
Compressed Air System	Electrical	8-12%	VFD on compressors, leak audit, pressure optimization
Heat Treatment Furnace	Thermal (Gas / Oil)	10-15%	Waste heat recovery, PID control, insulation
Fettling & Finishing	Electrical	5-8%	Efficient motors, VFD on grinding machines
Pumping Systems	Electrical	3-5%	Right-sizing, VFD, efficient impellers
Lighting & Utilities	Electrical	3-5%	LED lighting, occupancy sensors
Other Miscellaneous	Mixed	2-4%	Housekeeping, SOP improvements

Note: *The energy consumption shares presented above are indicative ranges based on typical induction/cupola-based foundry operations reported in BEE energy mapping studies, UNIDO technology compendiums, and published foundry energy-efficiency literature*

Field assessments and energy audits conducted across representative foundry units indicate that energy savings of 15-25% of total energy costs can be achieved through a combination of low, medium, and high investment measures. Major opportunities include induction furnace modernization, installation of VFDs on motors and compressors, pneumatic leak reduction, refractory lining upgrades, waste heat recovery from furnace exhaust gases, LED lighting retrofits, and implementation of IoT-based energy monitoring systems.

Key Savings Potential Summary

Energy Savings: 15-25% | CO_2 Emission Reduction: 0.5-1.2 kg CO_2 per kg of casting | Water Savings: 20-30% | Waste Reduction (foundry sand): 40-60% through sand reclamation | Typical Simple Payback Period: 1-4 years for low-medium investment measures

These measures contribute to broader resource efficiency outcomes, including CO_2 emission reductions of 0.5-1.2 kg CO_2 per kilogram of casting, water savings of 20-30%, and waste reduction of 40-60% through foundry sand reclamation. Typical simple payback periods for low- and medium-investment measures range from one to four years. Implementation of RECP measures in the foundry sector delivers significant environmental benefits by reducing specific energy consumption and associated greenhouse gas emissions. Adoption of sand reclamation technologies can divert 40–60% of spent foundry sand from landfill disposal, supporting circular economy objectives, while improved water management practices can reduce freshwater withdrawal by 20-30%. Enhanced dust collection and emission control systems further contribute to improved ambient air quality within foundry clusters.

The sector also presents opportunities for modernization through digital technologies such as IoT-based energy management systems, SCADA platforms, and predictive maintenance solutions, which can unlock an additional 5-10% productivity gain beyond direct energy savings. Financial support mechanisms, including MSME subsidy schemes, interest subventions, Green Credit programs, risk-sharing facilities, and green lending instruments, are available to support these investments and accelerate the transition towards a more resource-efficient and competitive foundry sector.

1. Introduction - About the Sector

1.1 National Level Profile

Overview of the Indian Foundry Industry

The foundry industry in India occupies a position of strategic importance in the national manufacturing ecosystem. Castings - the primary product of foundry operations - are critical intermediate inputs for virtually every major industry, including automobiles, railways, defence, agriculture, construction, water infrastructure, and power generation. The Indian foundry sector is recognized as the second largest global producer of castings after China, and the fourth largest exporter of castings worldwide.

The sector comprises an estimated 5,000-6,000 manufacturing units, of which approximately 75-80% are micro and small enterprises operating with annual turnovers below INR 250 crore. The industry is geographically concentrated in specific clusters, each with its own specialization in terms of alloy type, casting methodology, and end-use markets. This cluster-based structure, while creating economies of agglomeration, also gives rise to common environmental and energy challenges that can be most effectively addressed through cluster-level RECP interventions.

Major Production Clusters

India's foundry industry is organized around geographically defined clusters, each with distinct product specializations and market orientations. The following table presents the major foundry clusters, their geographic spread, principal products, and approximate number of units:

Table 2: Major Foundry Cluster in India

Cluster	State	Principal Products	No. of Units (Approx.)
Kolhapur	Maharashtra	Grey CI, SG Iron - Auto Components	700-800
Rajkot	Gujarat	Grey CI, SG Iron - Pump & Valve Components	600-700
Coimbatore	Tamil Nadu	Grey CI, Alloy Steel - Pumps, Auto	800-900
Howrah	West Bengal	Grey CI - Railways, Heavy Engineering	400-500
Agra / Aligarh	Uttar Pradesh	Grey CI, Malleable CI - Sanitary, Locks	300-350
Batala / Jalandhar	Punjab	SG Iron - Agricultural Equipment	250-300
Belgaum / Hubli	Karnataka	Grey CI, SG Iron - Pumps, Auto	200-250
Bhavnagar / Ahmedabad	Gujarat	Non-Ferrous - Brass, Aluminium Die Casting	150-200
Ludhiana	Punjab	Grey CI - Cycles, Auto Parts	200-250

Economic Contribution and Export Performance

The Indian foundry industry contributes approximately 1.5–2% of national GDP when downstream value addition is considered. Export earnings from castings have grown at a CAGR of approximately 8–10% over the past decade, with principal export destinations including the United States, Germany, United Kingdom, France, Italy, and Australia. Cast iron pipes and fittings, automotive castings, railway castings, and valve bodies constitute the major export product categories.

Energy and Environmental Challenges

Despite its impressive production credentials, the Indian foundry sector faces significant energy and environmental headwinds. Energy costs typically constitute 20-35% of total manufacturing costs for MSME foundries – far exceeding global benchmarks. The widespread prevalence of ageing cupola furnaces (particularly in smaller foundries), lack of energy monitoring infrastructure, absence of formal energy management systems, and low awareness of available RECP technologies collectively contribute to this energy cost burden.

On the environmental front, foundry operations generate significant quantities of particulate matter, sulphur dioxide (So_2), and nitrogen oxides (NOx) from combustion processes. Spent foundry sand - generated at an average rate of 0.5-1.0 MT per MT of casting produced - constitutes a major solid waste challenge for cluster-based MSME units. Water consumption in sand cooling, shot blasting, and emission control systems adds to the environmental footprint.

1.2 State Level Profile

While the foundry sector has a pan-India presence, its distribution across states reflects historical industrial development patterns, resource availability, and proximity to end-use markets. The following analysis presents a state-level profile of key foundry states.

Table 3: State-wise Distribution of Foundry Units in India

State	Est. No. of Units	Key Clusters	Principal Products
Maharashtra	1,000-1,200	Kolhapur, Pune, Nasik	SG Iron, Grey CI Auto Components
Gujarat	900-1,100	Rajkot, Ahmedabad, Bhavnagar	Pumps, Valves, Non-Ferrous
Tamil Nadu	800-1,000	Coimbatore, Chennai	Grey CI, Auto Components
West Bengal	500-600	Howrah, Durgapur	Railways, Heavy Engineering
Uttar Pradesh CI Casting	400-500	Agra, Aligarh,	Sanitary, Lock Fittings,
Punjab	400-500	Ludhiana, Batala, Jalandhar	Agriculture Equip., Cycles, Auto

Karnataka	300-400	Belgaum, Hubli, Bangalore	Auto, Pumps, Valves
Rajasthan	200-300	Jaipur, Jodhpur Bangalore	Non-Ferrous, Handicraft Castings
Telangana	80-100	Hyderabad, Patancheru, Sangareddy, Jeedimetla	Engineering Castings, Auto Components, Pumps, Valves

State-level MSME policies, including subsidy schemes for technology upgradation, cluster development programs, and pollution control incentives, play a significant role in shaping the pace of RECP adoption across clusters. States such as Maharashtra, Gujarat, and Tamil Nadu have relatively more mature MSME support ecosystems compared to states in the eastern and northern regions. Data for specific states should be updated with primary survey findings as the RAMP Program progresses.

Note for Report Users

State-specific data in this section will be progressively updated as cluster-level energy audits, stakeholder consultations, and primary surveys are completed under the RAMP Program. Please refer to the RAMP Program Progress Reports for the latest state and cluster-level statistics.

2. Energy Consumption Profile

Understanding the energy consumption profile of foundry units is the foundation for identifying and prioritizing RECP opportunities. Foundry operations involve a sequence of energy-intensive processes - each with distinct fuel requirements, efficiency characteristics, and improvement potential. This section presents a comprehensive assessment of energy use across the major consumption areas in typical MSME foundry operations.

2.1 Major Energy Consuming Processes

2.1.1 Melting Operations

Melting is the most energy-intensive operation in a foundry, accounting for 55–65% of total energy consumption. The energy requirement depends on the type of metal being melted, the furnace technology employed, and the efficiency of operation. The following furnace types are commonly used in Indian MSME foundries:

Table 4:Overview of Furnace Technologies for Metal Melting in Foundries

Furnace Type	Fuel / Energy Source	Typical Capacity (MT/Hr)	SEC (kWh/MT)	Efficiency (%)
Induction Furnace (Medium Freq.)	Electricity	1 - 10	550 - 700	60 - 75
Cupola Furnace (Coke)	Metallurgical Coke	2 - 15	750 - 950 (equiv.)	35 - 50%
Reverberatory Furnace	Furnace Oil / Gas	0.5 - 5	600 - 850 (equiv.)	30 - 45%
Electric Arc Furnace (EAF)	Electricity	5 - 50	500 - 650	65 - 80%
Oil-Fired Tilting Crucible	Furnace Oil / HSD	0.1 - 1	800 - 1200 (equiv.)	25 - 35%
Gas-Fired Crucible Furnace	LPG / PNG	0.1 - 2	650 - 900 (equiv.)	30 - 45%

Among these technologies, the medium-frequency coreless induction furnace has emerged as the most preferred melting technology for MSME foundries owing to its superior controllability, lower emissions, flexibility in charge mix, and relatively better energy efficiency compared to coke-fired cupolas. However, the capital cost of induction furnaces remains a barrier for smaller micro-enterprises.

2.1.2 Compressed Air Systems

Compressed air is extensively used across foundry operations for sand moulding, core blowing, pneumatic conveying, cleaning, and fettling. Compressed air systems typically account for 8–12% of total electrical energy consumption in a foundry. Key inefficiency drivers include air leakages (typically 20–30% of generated air in poorly maintained systems), pressure mismatches, inefficient compressor loading, and absence of VFD.

2.1.3 Heat Treatment Furnaces

Heat treatment operations – including annealing, normalizing, and quenching – are employed in the production of engineering castings, malleable iron, and steel castings. Heat treatment furnaces typically run on furnace oil, LPG, PNG, or electricity, and account for 10–15% of total energy consumption. Thermal energy losses occur through inadequate insulation, excess air in combustion, and flue gas heat that is not recovered.

2.1.4 Fettling and Finishing

Fettling operations – including gate and riser removal, shot blasting, grinding, and surface finishing – are electrical energy consumers accounting for approximately 5–8% of total foundry energy use. The installation of VFDs on high-power fettling equipment and the use of high-efficiency motors can yield significant savings.

2.2 Energy Balance and Benchmarking

The following energy balance table presents a simplified overview of energy inputs and their utilization across the foundry process chain:

Table 5:Energy Balance Across the Foundry Process Chain

Energy Consumer Energy (GJ/MT)	Thermal Energy (kWh/MT)	Electrical Energy	Total Share (%)	Improvement Potential (%)
Melting Furnace	0.5 - 2.5	400 - 600	55 - 65%	15 - 25%
Heat Treatment Furnace	0.3 - 1.2	–	10 - 15%	20 - 30%
Compressed Air System	–	60 - 90	8 - 12%	20 - 35%
Fettling & Finishing	–	40 - 70	5 - 8%	10 - 20%
Pumping Systems	–	25 - 45	3 - 5%	15 - 25%
Lighting & HVAC	–	20 - 35	3 - 5%	30 - 50%
Auxiliary / Miscellaneous	–	15 - 25	2 - 4%	10 - 15%
TOTAL	~0.8 - 3.7	~600 - 900	100%	15 - 25% (overall)

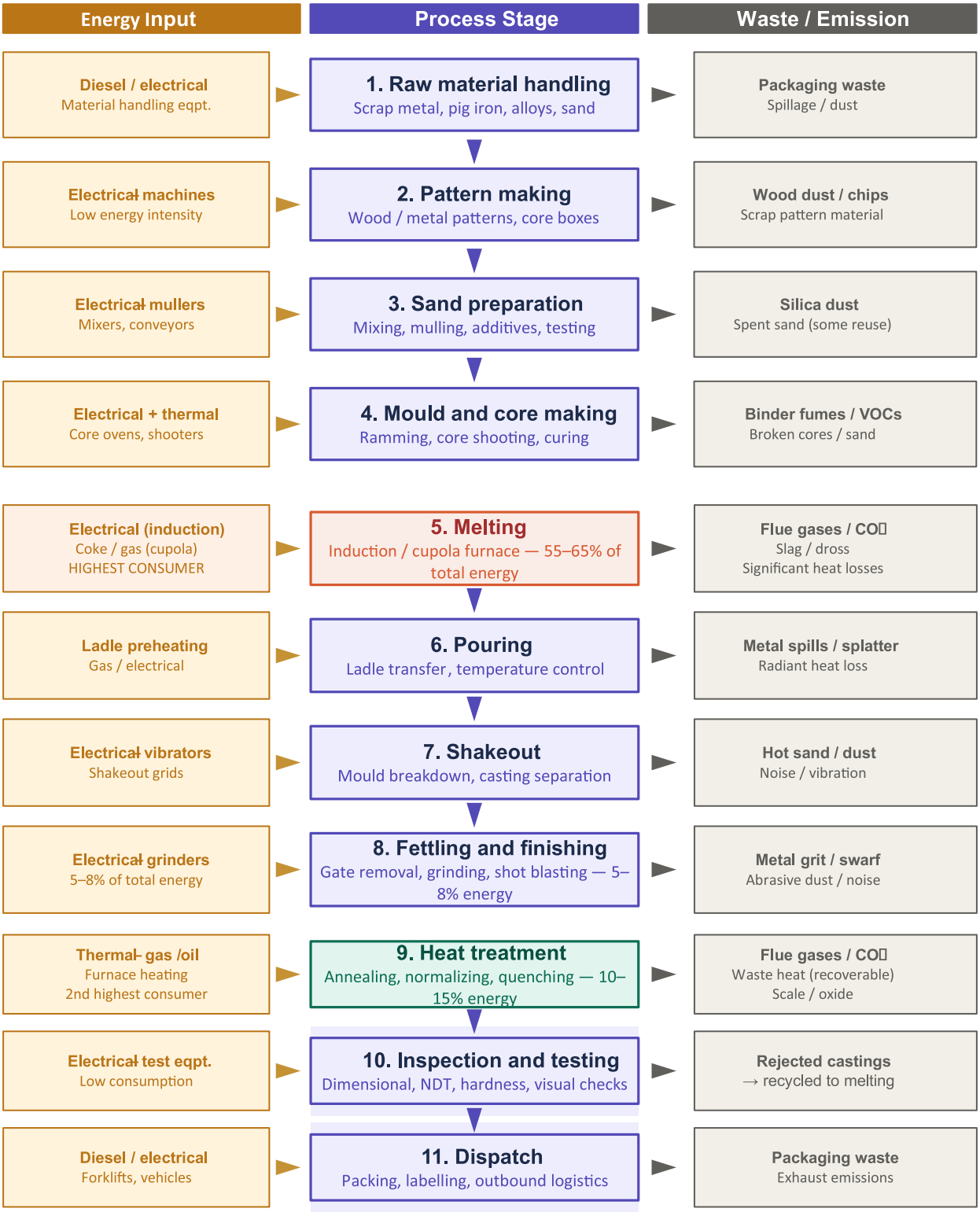
Benchmarking Reference

Indian MSME Foundry SEC: 600–900 kWh/MT of good casting | Global Best Practice (Induction Furnace): 400–550 kWh/MT | European Average: 450–600 kWh/MT | Improvement Gap: 150–350 kWh/MT, indicating significant RECP potential in the Indian MSME context.

3. Process Description

The foundry manufacturing process involves a series of interdependent stages, each contributing to the transformation of raw metallic inputs into finished castings of precise geometry and metallurgical specification. Understanding these process steps in detail is essential for identifying energy consumption hotspots, waste generation points, and RECP intervention opportunities. This section provides a step-by-step description of the major foundry operations.

Figure 1: Foundry Manufacturing Process Overview



3.1 Raw Material Handling and Charge Preparation

The foundry process commences with the procurement, storage, and preparation of metallic charge materials. The charge typically comprises pig iron, scrap (both in-house scrap and purchased), ferroalloys, and in some cases, direct reduced iron (DRI). The quality and composition of the charge directly influence melt quality, energy consumption, and casting yield.

- Energy Consumption: Relatively low in this stage; material handling by EOT cranes and conveyors.
- Waste Generation: Metal fines, oil and grease contamination from scrap, packaging waste.
- RECP Opportunity: Improved scrap sorting and charge optimization to minimize melting energy per MT of good casting.

3.2 Pattern Making

Patterns are replicas of the desired casting, used to create the mould cavity in sand. Patterns may be made from wood, aluminium, cast iron, or plastic, depending on the production volume and casting complexity. Computer-aided design (CAD) and rapid prototyping technologies are increasingly being adopted for pattern manufacturing.

3.3 Sand Preparation and Moulding

Green sand moulding is the predominant moulding process in Indian MSME foundries. The moulding sand (silica sand, bentonite clay, coal dust, and water) is prepared in muller mixers and tested for properties such as compressive strength, permeability, and moisture content. Sand preparation and conditioning is an energy consumer (via muller drives and conveyors) and generates spent sand as the primary solid waste stream.

Table 6: Sand Preparation and Moulding Operation

Process Step	Energy Input	Outputs / Products	Waste / Emissions
Sand Preparation	Electrical (muller, conveyor)	Conditioned moulding sand	Rejected sand, dust
Moulding (Manual / DISA)	Electrical (moulding machines)	Green sand moulds	Spillage, sand fines
Core Making	Electrical + Gas / LPG (hot box)	Sand cores	Binder fumes, waste cores
Mould Assembly	Manual / Mechanical	Assembled mould	Sand spillage

3.4 Core Making

Cores are preformed sand shapes placed inside moulds to create internal cavities in castings. Core making processes include cold box (furan/phenolic urethane binders), hot box (heated cores), and shell process. Core binders and gases involved in core baking are sources of volatile organic compound (VOC) emissions and odour, requiring effective local exhaust ventilation.

3.5 Melting and Metal Treatment

The melting stage is the heart of foundry operations and the largest energy consumer. Metal is charged into the furnace (induction, cupola, EAF, or crucible), melted to the required temperature, and treated with inoculants, magnesium (for SG iron), and deoxidizers to achieve the specified metallurgical properties. Precise temperature control minimizes energy waste and reduces remelting. Following are the key areas of energy loss in this process:

- Excessive tapping temperature (overheating) – increases energy consumption by 0.5–1% per 10°C excess.
- Refractory heat storage losses – inadequate lining condition increases heat loss per heat.
- Idle running of furnace between heats – energy lost in maintaining temperature.
- Power factor losses in induction furnace operations.

3.6 Pouring and Cooling

Molten metal is poured into prepared moulds using ladles or automatic pouring systems. Pouring temperature, pouring rate, and gating system design are critical to casting quality and yield. After pouring, castings are allowed to cool in the mould before shakeout. Controlled cooling in inoculated irons and steel castings may require temperature-controlled cooling tunnels.

3.7 Shakeout and Sand Reclamation

After solidification, castings are separated from the mould sand through vibrating shakeout grids. The spent sand – now containing clay, organic matter, and metal oxides – is the single largest solid waste stream from foundry operations. A portion of this sand may be mechanically and thermally reclaimed for reuse, significantly reducing virgin sand consumption and disposal costs.

3.8 Fettling and Finishing

Fettling involves the removal of gates, risers, fins, and surface imperfections from the rough casting. Operations include abrasive disc cutting, pneumatic chiselling, shot blasting, and grinding. Fettling is labour-intensive and generates significant quantities of metal fines, grinding dust, and used abrasives. Dust collection systems and personal protective equipment (PPE) are essential in fettling areas.

3.9 Heat Treatment

Many casting products require post-solidification heat treatment to achieve specified mechanical properties. Common heat treatments include annealing normalizing, quenching, tempering, and malleablizing. Heat treatment furnaces – continuous roller hearth or batch box-type – operate on gas, oil, or electricity and are significant thermal energy consumers.

3.10 Inspection and Dispatch

Finished castings undergo dimensional inspection, non-destructive testing (radiography, ultrasonic testing, dye penetrant), and mechanical testing as per customer specifications. Accepted castings are painted, packed, and dispatched. Rejection rates – a key indicator of process quality and efficiency – directly impact overall energy intensity per unit of saleable casting.

4. RECP Measures for the Foundry Sector

Resource Efficiency and Cleaner Production (RECP) encompass a systematic approach to improving the environmental and economic performance of industrial operations through the adoption of preventive strategies. For MSME foundries, RECP measures span a wide spectrum of technical interventions – from simple operational improvements requiring minimal investment to capital-intensive technology upgrades. This section categorizes RECP opportunities by investment level and presents detailed descriptions, savings potential, and implementation guidance for each measure.

4.1 Low Investment RECP Measures

Low investment measures are those requiring minimal capital expenditure (typically below INR 5 lakh) with implementation through operational changes, housekeeping improvements, standard operating procedure (SOP) revisions, and minor maintenance activities. These measures typically offer short payback periods from 6 months to 1 year and can be implemented immediately.

Table 7:Low-Investment RECP Opportunities

RECP Measure	Application Area	Typical Investment	Energy Savings	Payback Period
Compressed air leak detection and repair	Compressed air system	INR 20,000-1,00,000	10-20% reduction in compressor load	< 3 months
Refractory lining inspection & repair	Melting furnace	INR 50,000-2,00,000	3-8% reduction in melting energy	3-6 months
Optimum tapping temperature control	Melting furnace	NIL (SOP change)	2–5% reduction in melt energy	Immediate
LED lighting replacement	All areas	INR 50,000-3,00,000	50-60% reduction in lighting load	6-12 months
Power factor correction – capacitor banks	Electrical distribution	INR 50,000-2,00,000	Reduced PF penalties (5-10% bill reduction)	3-8 months
Preventive maintenance of motors and drives	All rotating equipment	INR 10,000-50,000 (tools/labour)	2-5% reduction in motor energy	< 3 months
Insulation of hot surfaces and piping	Heat treatment / pipelines	INR 30,000-1,50,000	5-10% reduction in thermal losses	3-6 months
Load scheduling - off-peak operation	Melting furnace / compressors	NIL (scheduling change)	8-15% reduction in energy billing	Immediate
Installation of lid mechanism	Melting and holding furnace	INR 3,00,000 - 5,00,000	5-6%	< 6 months

4.2 Medium Investment RECP Measures

Medium investment measures require capital expenditure in the range of INR 5 lakh to INR 50 lakh and typically offer payback periods of 1-3 years. These measures involve the installation of energy-efficient equipment or the adoption of improved process technologies.

Table 8: Medium-Investment RECP Opportunities

RECP Measure	Application Area	Typical Investment	Energy Savings	Payback Period
VFD installation on compressors	Compressed air system	INR 3-15 Lakh (per compressor)	20-35% reduction in compressor energy	1-2 years
VFD on fettling and sand plant motors	Fettling / sand preparation	INR 1-5 Lakh (per drive)	15-25% reduction in motor energy	1-2 years
Energy-efficient burners / recuperative burners	Heat treatment furnace	INR 5-20 Lakh reduction in fuel consumption	10-20%	1.5-3 years
Waste heat recovery from furnace exhaust	Heat treatment / cupola	INR 10-40 Lakh	15-25% thermal energy savings	2-3 years
Automatic power factor improvement panels	Electrical distribution	INR 3-10 Lakh	8-12% reduction in energy billing	1-2 years
Thermal sand reclamation system	Sand plant	INR 15-50 Lakh	30-50% reduction in virgin sand purchase	2-4 years
High-efficiency motors (IE3/IE4)	All large motor applications	INR 1-10 Lakh per motor	5-10% reduction per motor	1.5-3 years
Automated temperature control in heat treatment	Heat treatment furnace	INR 3-15 Lakh	8-15% fuel savings	1.5-2.5 years

4.3 High Investment RECP Measures

High investment measures require capital expenditure exceeding INR 50 lakh and involve significant technology upgradation. While payback periods may extend to 3-7 years, these measures offer the highest absolute savings and position foundry MSMEs for long-term competitiveness and compliance with tightening environmental regulations.

Table 9:High -Investment RECP Opportunities

RECP Measure	Application Area	Typical Investment	Energy Savings	Payback Period
Cupola to induction furnace conversion	Melting	INR 1-5 Cr	25-35% energy reduction	4-7 years
Advanced baghouse dust collection system	Melting / fettling	INR 50 L-2 Cr	Compliance benefit;3-5% energy in fan savings	3-5 years
Automated DISA/ Hunter moulding lines	Moulding	INR 2-10 Cr	15-25% energy/ productivity improvement	5-8 years
Solar PV system for auxiliary loads	Electrical supply	INR 30 L-2 Cr	20-30% reduction in grid electricity purchase	4-6 years
IoT-based energy management system	Entire plant	INR 15-50 Lakh	8-15% overall energy reduction via monitoring	2-4 years
Smart melting with AI-assisted charge optimization	Melting	INR 20-80 Lakh	5-10% reduction in melting energy + lower reject	3-5 years

4.4 Water Efficiency and Wastewater Management

Although foundries are not as water intensive as some other industrial sectors, water is used in significant quantities for sand cooling, wet scrubbers (in cupola operations), shot blasting, cooling towers, and dust suppression. RECP measures in water management can reduce freshwater withdrawal by 20-30% and minimize wastewater generation.

- Cooling Tower Optimization: Regular descaling, drift eliminator maintenance, and conductivity-based blowdown control can reduce cooling water consumption by 10–20%.
- Closed-Loop Water Recycling: Establishing closed-loop systems for cooling water and scrubber water eliminates process wastewater discharge and reduces freshwater intake.
- Sand System Water Balance: Monitoring moisture content in moulding sand and optimizing water addition reduces excess water use and improves sand properties.

- Rainwater Harvesting: Collection and storage of rainwater for non-potable uses (dust suppression, green belt irrigation) reduces dependence on municipal or groundwater sources.
- Zero Liquid Discharge (ZLD): For larger foundry units, investment in ZLD systems ensures full compliance with CPCB/SPCB discharge norms and eliminates effluent treatment costs.

4.5 Waste Minimization and Resource Recovery

Foundry Sand Reclamation

Spent foundry sand is the single largest solid waste generated by foundry operations - typically 0.5 to 1.0 MT per MT of casting produced. Mechanical reclamation systems (vibratory attrition scrubbers) can recover 60-70% of spent sand for reuse. Thermal reclamation systems achieve 85-95% sand recovery and are particularly suited for chemically bonded core sands (furan/phenolic). Sand reclamation not only reduces solid waste disposal costs but also significantly reduces the cost of virgin silica sand procurement.

Slag and Dross Utilization

Slag generated during induction melting and dross from aluminium die casting operations have potential for beneficial use. Iron foundry slag can be used as partial aggregate replacement in road construction and low-strength concrete. Aluminium dross is rich in aluminium oxide and can be processed for value recovery. Formal agreements with registered recyclers and material recovery facilities can convert waste management costs into revenue.

Scrap Metal Optimization

Improving in-house scrap sorting, grading, and reprocessing practices reduces metallic losses and minimizes the proportion of charge requiring remelting at higher energy cost. AI-assisted charge calculations can optimize the scrap-to-virgin metal ratio for each heat, balancing metallurgical quality with material and energy cost minimization.

4.6 Digitalization and Industry 4.0 Solutions

The integration of digital technologies into foundry operations represents a transformative opportunity for MSME competitiveness. While full-scale Industry 4.0 implementation may be beyond the immediate reach of micro-enterprises, incremental digitalization – beginning with IoT-based monitoring and advancing to AI-assisted process optimization – offers a practical and scalable pathway.

Table 10:Digital Transformation in the Foundry Sector

Technology	Application in Foundry	Investment Range	Expected Benefit
IoT-based Energy Monitoring	Real-time energy use tracking at equipment level	INR 5-20 Lakh	8-15% energy reduction through behavioural change and anomaly detection
SCADA Systems	Process monitoring and control for melting, heat treatment	INR 15-60 Lakh	Improved process consistency, reduced energy variance

Predictive Maintenance	Vibration, temperature sensors on critical equipment	INR 5-25 Lakh	15-25% reduction in maintenance costs; prevents unplanned downtime
AI/ML Charge Optimization	Intelligent charge calculation for optimal metallurgy at minimum cost	INR 10-50 Lakh	3-8% reduction in raw material cost; lower rejects
Smart Metering	Sub-metering at department/ equipment level	INR 2-10 Lakh	Enables precise energy accounting and bill verification
Digital Twin	Virtual simulation of foundry process for optimization	INR 20-100 Lakh	Reduced trial and rejection rates; faster new product introduction
ERP Integration	Linking production, inventory, quality, and energy data	INR 10-50 Lakh	Holistic operational visibility; improved decision-making

5.RECP - Technology Case Studies and Opportunities

The following case studies have been compiled from documented RECP interventions in Indian MSME foundry units. These examples demonstrate practical implementation of energy efficiency and cleaner production measures, the investment involved, and the quantified savings achieved. They serve as replicable models for similar units in comparable clusters.

Case Study 1: Lid Mechanism for 750 kg Duraline Furnace - M/s K&K Foundry Pvt. Ltd, Kolhapur

Problem statement:

Radiation loss in melting furnace accounts for 5-6%.

Solution Implemented: During the audit period, it was found that the opening of 750 kg induction furnace is circular with 460 mm diameter. The opening heat losses for one batch (heat) were calculated & it is recommended to use lid mechanism for the opening with hydraulic operation. Post implementation study witnessed that the plant has installed lid mechanism to reduce the heat loss due to the opening. By successfully implementing this project, the plant has achieved energy savings of nearly 83,727 kWh.

Figure 2:Induction Furnace Lid Mechanism



Table 11:Comparison of Performance Indicators

S.No	Implementation Details	Before	After
1	Temperature of the opening (^{0}C)	1,500	465
2	Ambient temperature (^{0}C)	33.6	35.2
3	Total heat loss per heat (kWh)	24.45	11.16
4	Saving potential per heat (kWh)	13.29	
5	Total heats per day	21	
6	Operational days in a year	300	
7	Annual saving potential (kWh/year)	83,727	
8	Energy Savings, TOE/ year	7.2	
9	Annual reduction in CO_2 at 0.82 emission factor*	68.65 MT	

**Fy2019 Emission factor by CEA*

Annual Electricity Savings	Annual Energy Savings	Annual GHG Savings
83,727 kWh	7.2 TOE	68.65 T CO_2

Case Study 2: Reduction in furnace oil consumption by relining of melting furnace to reduce heat losses- Aum Prasad Casting (p) Ltd, Pune

Problem statement:High surface temperature of the melting furnace was causing excessive heat loss, leading to increased furnace oil consumption and reduced furnace efficiency

Solution Implemented: The unit is operating FO fired melting furnace of capacity 180 kg per batch. The average surface temperature was very high which was leading to higher heat loss & resulting in poor efficiency. The unit has implemented the measure of relining of the furnace to avoid the surface heat loss in terms of radiation & convection.

Figure 3: AI-generated representation of furnace relining for reduction of surface heat losses and furnace oil consumption

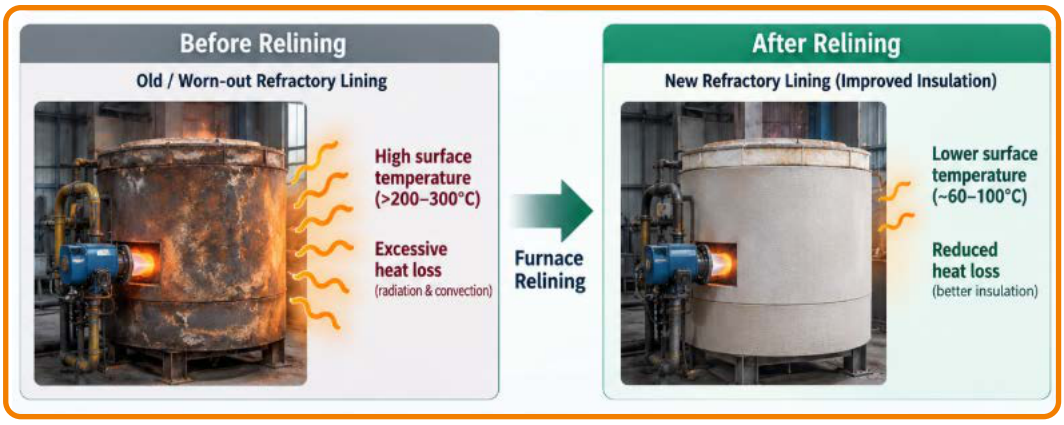


Table 12:Comparison of Performance Indicators

S.No	Implementation Details	Before	After
1	Capacity of the Furnace, kg	180	180
2	Furnace Type	FO-Fired	FO-Fired
3	GCV of the fuel, kcal/lit	9870	9870
4	Annual Production, MT/year	142	142
5	Operating Temperature (°C)	750	750
6	Skin Temperature	130	73.15
7	Fuel cost, INR/Lt	52	42.74
8	Reduction in Surface Losses, kcal/hr	2,654.32	
9	Energy Savings, TOE/year	1.97	
10	Annual reduction in CO_2 at 0.82 emission factor*	18.78 MT	

**FY2019 Emission factor by CEA*

Annual Thermal Savings	Annual Energy Savings	Annual GHG Savings
19,700,000 kCal	1.97 TOE	18.78 T CO_2

Case Study 3: Replacement of SCR based Induction furnace with IGBT Induction Furnace- M/S Marvelous Metals Pvt Ltd. (Unit 2), Kolhapur

Problem statement: The existing SCR-based induction furnace exhibited high specific energy consumption (656 kWh/MT) due to lower electrical efficiency and higher system losses.

Solution Implemented: The unit had installed three induction furnaces, one of them, the induction furnace II is of 500 kg capacity for melting. The calculated specific energy consumption was 656 kWh per MT of melting, which was higher in comparison to that of furnaces in similar category.

The SCR has a firing signal to turn it on. To turn it off the current flow in the power circuit must be reversed. The semiconductor physics of the SCR makes it ideal for use in low and medium frequencies from 50/60 Hz and less up to max 10 kHz. Above this frequency it is not possible it´s use in an economical and reliable way.

Figure 4:IGBT Module



Table 13:Comparison of Performance Indicators

Sr. No	Implementation Details	Unit	Before	After
1	Capacity of furnace (kg)	kg	500	500
2	No. of batches per day	Nos	27	27
3	Minutes per batch		52	52
4	Production of Furnace	MT/day	13.5	13.5
5	Operating hours per day		23.4	23.4
6	Specific Energy Consumption	kWh/MT	656	602.1
7	Annual Production	MT/Year	3994	3994
8	Annual Consumption	kWh/Year	26,20,064	24,04,787
9	Annual Savings	kWh	2,15,276	
10	Energy Savings	TOE/Year	18.5	
11	Annual Reduction In CO_2 At 0.82 Emission Factor*	Mt	17.6	

**Fy2019 Emission factor by CEA*

It was recommended to replace the existing induction furnace with a new IGBT-based Induction furnace. New IGBT furnace have better specific energy consumption than conventional one. The IGBT has a control signal to turn it on or off. The semiconductor physics of the IGBT makes it ideal for Medium & High Frequency Switching applications from 500 Hz to 100 kHz. They cannot be used in frequencies higher than 100 kHz.

Annual Electricity Savings 2,15,276 kCal	Annual Energy Savings 18.5 TOE	Annual GHG Savings 17.6 T CO_2

Case Study 4: Replacement of FO Fired Reheating Furnace with Piped Natural Gas Fired Reheating Furnace - Gold Metal Extrusion, Jamnagar

The company took a key initiative towards energy efficiency and use of clean energy for production in the year 2018 by installing energy efficient natural gas fired re-heating furnace with waste heat recovery system. The new furnace was equipped with a temperature-based controller, a waste heat recovery system and energy efficient gas burners. With this initiative, the company was able to save substantially in terms of energy cost. The new furnace also ensured better and consistent heating leading to enhanced quality.

Figure 5:Replacement of FO-Fired Reheating Furnace with PNG-Fired Reheating Furnace



Table 14:Comparison of Performance Indicators

Sr. No.	Parameter	Unit	Baseline	Post Implementation
1	Productivity	kg/h	1,500	1,500
2	Operating hours per day	h/d	6	6
3	Operating days per year	d/y	300	300
4	Annual production	t/y	2,700	2,700
5	Hourly fuel consumption (baseline)	l/h	67.5	-
6	Specific fuel consumption (baseline)	l/kg	0.045	-
7	GCV (Gross Calorific Value)	kcal/kg	10,100	10,750
8	Specific gravity		0.96	0.8
9	Raw material input temperature	°C	35	35
10	Product final temperature	°C	720	720
11	Specific heat of Brass	kcal/kg°C	0.0912	0.0912
12	Hourly gas consumption (post implementation)	m3/hr	-51	
13	Specific energy consumption	kcal/kg	436	366
14	Furnace Direct Efficiency	%	14.30%	21.40%
15	Annual energy consumption	kcal/y	1,17,80,64,000	986,850,000
16	Annual energy saving	kcal/y	-	38,85,84,000
17	Annual fuel saving	l/y	-	40,076
18	PNG oil cost	Rs/l		34
19	Annual Monetary Saving	Rs in lakhs	-	13.63
20	Investment	Rs in lakhs	-	12
21	Simple Payback	y	-	0.88
22	Annual energy saving	toe/y	-	38.85
23	Annual GHG emission reduction	tCO2/y	-	140.9

Emission factor of furnace oil = 2.68 kgCO2/kg, Natural Gas = 1.87 kgCO2 /m3 is as per IPCC guidelines 2006

Annual Thermal Savings	Annual Energy Savings	Annual GHG Savings
38,85,84,000 kCal	38.85 TOE	141 T CO_2

Case Study 5: Replacement of Coal Pit Furnace with Gas Fired Melting Furnace - Jamnagar Cluster

Problem statement: The coal-fired pit furnace had low thermal efficiency (15–17%), resulting in high fuel consumption, longer melting time, and increased emissions.

Solution implemented:

Brass melting foundry units are using high grade coal as fuel for melting purpose. The conventional coal has low efficiency of around 15-17%, and it generally takes 1.5 to 2 hours for the material to melt completely. It was observed that the coal fired pit furnace has poor efficiency due to poor combustion space, improper location and size of burners and improper capacity of blower system etc. Also, there is no waste heat recovery system to recover the heat losses from hot flue gasses in pit furnaces. Coal has been traditionally used as the most common form of energy.

Use of natural gas as fuel as replacement of coal leads to cleaner and healthier production. Piped gas line is available in some parts of the country which can be used as fuel for the pit furnaces. Natural gas as fuel not only allows a better environment for the unit; but also provides significant improvement in the furnace internal environment. Natural gas firing, if controlled in a proper fashion, can lead to optimum specific fuel consumption and burning loss. Also, the efficiency of the furnace improves significantly, leading to a longer furnace life.

Figure 6:Fuel Switching from Coal to Natural Gas for Brass Melting

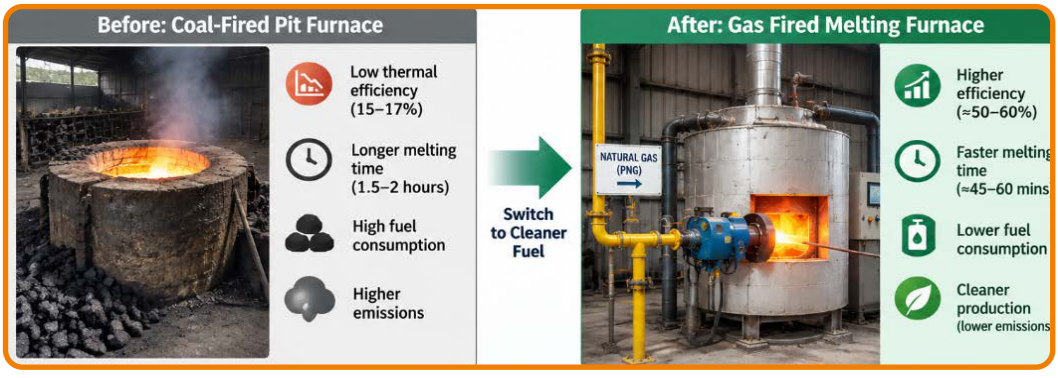


Table 15:Comparison of Performance Indicators

Sl. No.	Parameter	Unit	Baseline	Post Implementation
1	Productivity	kg/h	400	400
2	No. of heats per day	heats/d	6	6
3	Number of days	d/y	300	300
4	Annual production	t/y	720	720
5	Fuel consumption per cycle	kg/heat	38	-
6	Specific fuel consumption	kg/t	0.0950	-
7	GCV of Coal	kcal/kg	7,200	-
8	Raw material input temperature	°C	35	35
9	Product final temperature	°C	990	990
10	Specific heat of Brass	kcal/kg°C	0.0912	0.0912
11	Sensible Heat absorbed by the Material	kcal	34,838.4	34,838.4
12	Latent heat fusion of Brass	kcal/kg	40.15	40.15
13	Latent heat of molten Brass material	kcal	16,060	16,060
14	Total heat absorbed in Brass molten material	kcal	50,898.4	50,898.4
15	Hourly gas consumption	m^3/h	-	23
16	GCV of PNG	$kcal/m^3$	-	8,600
17	Specific energy consumption	m^3/kg	-	0.058
18	Furnace Direct Efficiency	%	18.6%	25.7%
19	Annual energy consumption	kcal/y	49,24,80,000	35,60,40,000
20	Total connected load	hp	-	5
21	Total electricity consumption	kWh/y	-	25,652
22	Cost of electricity	Rs/kWh	-	8
23	Annual energy saving	kcal/y	-	11,43,79,211
24	Annual fuel saving	t/y	-	15.9
25	Cost of coal	Rs/t		32,000
26	Annual Monetary Saving	Rs in lakhs	-	5
27	Investment	Rs in lakhs	-	6
28	Simple Payback	y	-	1.2
29	Annual energy saving	toe/y	-	11.44
30	Annual GHG emission reduction	tCO_2/y	-	37.51

Emission factor of coal = 2.57 kg of CO2 /kg from IPCC Guidelines 2006

Annual Electrical Savings 25,652 kWh	Annual Energy Savings 11.44 TOE	Annual GHG Savings 37.51 T CO_2

Case Study 6: VFD Installation on Compressors and Fettling Motors - Grey Iron Foundry, Kolhapur

Unit Profile:

Unit Type	Grey Cast Iron Foundry - Automotive Components
Location	Kolhapur Industrial Area, Maharashtra
Annual Production Capacity	1,200 MT of castings per annum
Workforce	85 persons (direct)
Annual Energy Consumption (Baseline)	Electrical: 8.5 Lakh kWh/year; Total Energy Cost: INR 72 Lakh/year
Key Problem Identified	Compressors running at fixed speed irrespective of demand; excess electrical load in fettling shop

Baseline Scenario

The unit was operating two reciprocating air compressors (each 75 kW) on fixed-speed drive. The actual compressed air demand varied significantly across shifts – peak demand was 60% higher than average demand. Compressors were running at full load during low-demand periods, leading to excessive energy consumption. Additionally, eight fettling machines (each 11 kW) were operating at fixed speed without load-responsive control.

Solution Implemented

Variable Frequency Drives (VFDs) were installed on both 75 kW air compressors and on four of the eight 11 kW fettling machine motors. VFDs modulate motor speed in response to actual compressed air pressure and fettling load requirements, eliminating excess energy consumption during partial-load conditions. Pressure set points were optimized, and an air leak detection and repair survey was conducted simultaneously, reducing leakage from an estimated 28% to below 8%.

Investment and Payback Analysis

VFD Installation - 2 × 75 kW Compressors	INR 6.4 Lakh
VFD Installation - 4 × 11 kW Fettling Motors	INR 1.8 Lakh
Air Leak Audit and Repair	INR 0.6 Lakh
Total Capital Investment	INR 8.8 Lakh
Annual Energy Savings - Compressors	1,02,000 kWh/year
Annual Energy Savings - Fettling Motors	28,000 kWh/year
Total Annual Energy Savings	1,30,000 kWh/year
Annual Cost Savings @ INR 8.50/kWh	INR 11.05 Lakh/year
Simple Payback Period	~9.6 months
CO_2 Emission Reduction	107 MT CO_2/year

Annual Electrical Savings 1,30,000 kWh	Annual Energy Savings 11.18 TOE	Annual GHG Savings 107 T CO_2

Case Study 7: Waste Heat Recovery from Heat Treatment Furnace - SG Iron Foundry, Coimbatore

Unit Profile:

Unit Type	SG (Ductile) Iron Foundry - Pump and Valve Components
Location	Coimbatore District, Tamil Nadu
Annual Production Capacity	2,500 MT of castings per annum
Workforce	150 persons (direct)
Annual Energy Consumption (Baseline)	Thermal: 2,800 GJ/year (LPG); Electrical: 15 Lakh kWh/year
Key Problem Identified	Heat treatment furnace flue gas temperature at 450–500°C; no heat recovery; fresh LPG used to preheat components

Baseline Scenario

The unit operated two batch-type box furnaces for annealing operations on SG iron castings. Flue gases were exhausted at approximately 480°C – representing significant thermal energy being wasted to atmosphere. Fresh LPG was being used for pre-heating casting charges before entry into the main furnace, adding to fuel costs.

Implemented Technology

A recuperative waste heat recovery (WHR) system was installed on both box furnaces. Metallic recuperators extracted heat from furnace flue gases at 480°C and transferred it to incoming combustion air, preheating the air to approximately 280°C. This significantly reduced the LPG consumption required to maintain furnace temperature. An automatic temperature control system with PID controllers was also installed to prevent overheating.

Figure 7:Waste Heat Recovery from Heat Treatment Furnace



Investment and Payback Analysis

WHR Recuperators (2 nos.) - Supply and Installation	INR 14.0 Lakh
PID Temperature Control System - 2 Furnaces	INR 4.5 Lakh
Insulation Upgrade - Furnace Walls and Roof	INR 3.2 Lakh
Total Capital Investment	INR 21.7 Lakh
Annual LPG Savings (estimated)	32,000 kg LPG/year (18% reduction)
Annual Cost Savings on Fuel @ INR 80/kg	INR 25.6 Lakh/year
Annual thermal energy saving (kcal)	352,000,000
Additional Electricity Savings (PID control)	INR 1.2 Lakh/year
Total Annual Cost Savings	INR 26.8 Lakh/year
Simple Payback Period	~9.7 months
CO_2 Emission Reduction	~88 MT CO_2e/year

Annual Thermal Savings	Annual Energy Savings	Annual GHG Savings
352,000,000 kWh	35.2 TOE	88 T CO_2

Case Study 8: LED Lighting Retrofit and APFC System Installation - M/s Bhagyanagar Alloy Castings Pvt. Ltd.

Unit Profile:

Unit Type	Ferrous foundry (Grey Iron), induction melting, jobbing and machine components
Location	Balanagar–Jeedimetla industrial cluster, Hyderabad, Telangana
Annual Production Capacity	5,000 MT of castings/year
Workforce	110
Annual Electricity Consumption (Baseline)	42 lakh kWh/year (4.2 million kWh)
Key Problem Identified	Extensive use of energy-inefficient HID/HPSV high-bay lighting across the shop floor, combined with a low average power factor (0.82) attracting recurring low-PF penalty charges from the Identified DISCOM.

Baseline Scenario:

The unit's moulding, melting, fettling, and storage areas were illuminated using conventional metal halide and HPSV fixtures, resulting in high electricity consumption, poor illumination levels, frequent lamp failures, and increased maintenance requirements. The lighting system also experienced delays in restarting after power fluctuations, affecting shop-floor operations. In addition, the absence of an Automatic Power Factor Correction (APFC) system led to an average power factor of only 0.82, attracting utility penalties and increasing overall electricity costs. Together, inefficient lighting and poor power factor management contributed to avoidable energy expenditure and reduced electrical system efficiency.

Baseline Performance Indicators

- Total Connected Lighting Load: ≈72 kW (180 HID/tube fixtures)
- Average Power Factor: 0.82 (against DISCOM incentive threshold of 0.90)
- Low-PF Penalty: ≈INR10.2 lakh/year
- Average Illumination at Fettling Stations: 90–110 lux (against a recommended 200-300 lux)

Implemented Technology

The unit replaced all conventional HID/HPSV lighting fixtures with energy-efficient LED high-bay luminaires and LED tube lights across production, utility, and storage areas, significantly reducing lighting power consumption while improving illumination levels for shop-floor operations and inspection activities. Simultaneously, an Automatic Power Factor Correction (APFC) panel was installed at the main LT panel to automatically maintain power factor above 0.97 by compensating for reactive power demand from induction furnaces and motors. The retrofit was completed without production disruption and resulted in lower electricity consumption, elimination of power factor penalties, improved lighting quality, and enhanced overall electrical system efficiency.

Investment and Payback Analysis

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
LED high-bay/tube retrofit (180 fixtures) + Automatic Power Factor Correction (APFC) panel	28	25.7	1.1

Annual Electricity Savings 1,94,000 kWh	Annual Energy Savings 16.7 TOE	Annual GHG Savings 139 T CO_2

Case Study 9: Digital Twin for Optimized Furnace Charging - M/s Bhavani Precision Castings Pvt. Ltd.

Unit Profile

Location	Coimbatore, Tamil Nadu
Sector / Sub-sector	Foundry - Ferrous Casting (Grey Iron & SG Iron)
Products Manufactured	Grey iron and SG iron castings for automotive & pump industry
Annual Production Capacity	6,000 MT of castings/year
Number of Employees	145
Major Energy Sources	Grid Electricity (induction melting); HSD for DG backup
Connected Load	1,250 kVA

Baseline Scenario:

The unit operates two medium-frequency induction furnaces (1,000 kg and 1,500 kg capacity) for melting cast iron. Charge mix preparation and furnace operation were based primarily on operator experience without real-time process simulation or optimization tools.

Induction melting accounted for nearly 70% of the plant's electricity consumption. Variations in charge composition and melting practices resulted in inconsistent energy consumption, higher melt losses, and extended melting cycles.

Baseline Performance Indicators:

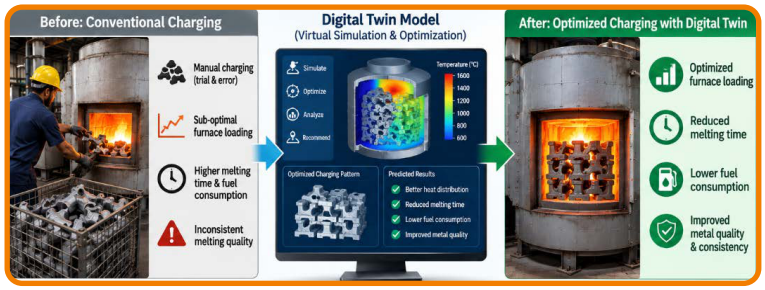
- Specific Energy Consumption (SEC): 665 kWh/MT
- Melt Loss: 4.6%
- Average Melt Cycle Time: 97 minutes/heat

Implemented Technology / Solution

The unit implemented a cloud-based Digital Twin platform integrated with the existing induction furnace PLC/SCADA through IoT-enabled sensors and an edge gateway. The system continuously monitors furnace parameters such as power consumption, bath weight, and temperature, and uses a thermal-electrical model to optimize charge mix, predict melt time, and monitor energy performance in real time. Historical and live data are analyzed through a web-based dashboard, enabling operators to make informed decisions and promptly address process deviations.

Following installation, baseline data was used to calibrate the model, and the solution was integrated with production planning systems. The digital twin enabled standardized charging practices, real-time performance monitoring, and predictive analytics. As a result, melt cycle time reduced from 97 to 79 minutes per heat, specific energy consumption decreased from 665 to 570 kWh/MT, and melt loss reduced from 4.6% to 3.0%, leading to improved operational efficiency and production consistency.

Figure 8:AI-Enabled Digital Twin for Furnace Charge Optimization



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
Digital Twin platform (IoT sensors, gateway, software licence, ntegration & training)	42	68	0.6

Annual Electricity Savings 5,40,000 kWh	Annual Energy Savings 46.4 TOE	Annual GHG Savings 387 T CO_2

Case Study 10: Scrap Bundling / Briquetting for Melting Operations- M/s Shree Ganesh Alloys & Castings

Unit Profile

Company Name	M/s Shree Ganesh Alloys & Castings
Location	Rajkot, Gujarat
Sector / Sub-sector	Foundry - Ferrous Casting (Grey Iron)
Products Manufactured	Automotive and machine-tool components (grey iron castings)
Annual Production Capacity	4,800 MT of castings/year
Number of Employees	98
Major Energy Sources	Grid Electricity (induction melting); HSD for DG backup
Connected Load	950 kVA

Baseline Scenario

The unit was charging loose steel scrap, turnings, borings, and sheet-metal cuttings directly into the induction furnace without any densification. Due to the low bulk density of the scrap, multiple charging additions were required for each heat, resulting in increased heat losses, higher melt losses, and longer melting cycles.

Baseline Performance Indicators:

- Specific Energy Consumption (SEC): 700 kWh/MT
- Melt Loss: 6.5%
- Average Charging Additions: 6-7 per heat

Implemented Technology / Solution

The unit installed a hydraulic scrap baling/briquetting press to densify loose turnings, borings, and sheet-metal scrap before charging into the induction furnace. The compact, high-density bundles reduced the number of charging additions and associated heat losses. The charging sequence was optimized, and operators were trained on scrap segregation and bale handling practices. As a result, charging frequency, melt time, specific energy consumption, and melt losses were significantly reduced, while furnace productivity and scrap-yard management improved.

Figure 9:Scrap Briquetting



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
Hydraulic scrap baling /briquetting press with material handling	58	76	0.8

Annual Electricity Savings	Annual Energy Savings	Annual GHG Savings
3,84,000 kWh	33 TOE	275 T CO_2

Case Study 11: Replacement of Cupola Furnace with Induction Furnace- M/s Vishwakarma Foundry Works

Unit Profile

Company Name	M/s Vishwakarma Foundry Works
Location	Belagavi, Karnataka
Sector / Sub-sector	Foundry - Ferrous Casting (Grey Iron Pipe Fittings)
Products Manufactured	Cast-iron pipe fittings and manhole covers
Annual Production Capacity	5,500 MT of castings/year
Number of Employees	210
Major Energy Sources	Metallurgical coke (cupola melting - baseline); Grid Electricity (post-conversion)
Connected Load	1,800 kVA (post-conversion, revised sanctioned load)

Baseline Scenario

The unit was operating a cold-blast cupola furnace for melting cast iron using metallurgical coke as fuel. The process involved high coke consumption, frequent furnace relining, and significant emissions, resulting in higher operating costs and maintenance requirements.

Baseline Performance Indicators:

- Coke Consumption: 180 kg/MT of hot metal
- Annual Coke Consumption: 990 MT/year
- Metal Yield: ~3% lower than induction melting
- Relining Downtime: 30-35 days/year

Implemented Technology / Solution

The unit replaced the existing cupola furnace with two medium-frequency induction furnaces (1,500 kg capacity each) equipped with digital power and process controls. The new system enabled precise temperature and chemistry control, eliminated coke consumption and combustion-related emissions, and improved metal yield and furnace availability. The project included electrical infrastructure upgrades, furnace installation, and operator training, resulting in enhanced product quality, lower maintenance requirements, and improved operational efficiency.

Figure 10: Comparison of both Furnaces



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
Two induction furnace units with electrical infrastructure with material handling upgrade and civil works (replacing cupola + scrubber)	210	95	2.2

Annual Electricity Savings	Annual Thermal Savings	Annual Energy Savings	Annual GHG Savings
34,10,000 kWh	6,930,000,000 kCal	400 TOE	528 T CO_2

Case Study 12: Replacement of Conventional Cooling Tower Fan Blades with FRP Fan Blades- M/s Musi Precision Foundries Pvt. Ltd.

Unit Profile

Company Name	M/s Musi Precision Foundries Pvt. Ltd.
Location	Nacharam Industrial Estate, Hyderabad, Telangana
Sector / Sub-sector	Ferrous foundry (Grey Iron), induction melting with water-cooled furnace coil/panel cooling system
Annual Production Capacity	7,500 MT of castings/year
Number of Employees	190
Annual Energy Consumption (Baseline)	58 lakh kWh/year (5.8 million kWh)
Key Problem Identified	Heavy, corrosion-prone cast aluminium cooling tower fan blades driving high motor loading and recurring vibration-related maintenance on the induction furnace cooling circuit.

Baseline Scenario

The unit operated two induced-draft cooling towers for cooling induction furnace coils and power panels, each equipped with conventional aluminium fan blades driven by 15 kW motors. Due to their heavy weight and inefficient aerodynamic design, the fans consumed high levels of electricity while operating continuously throughout the melting process. Over time, exposure to a humid and chemically treated environment caused blade corrosion, imbalance, vibration, and frequent maintenance issues, resulting in periodic downtime and increased operating costs. Since reliable cooling is critical for safe induction furnace operation, the unit continued using the existing system despite its high energy consumption and maintenance burden.

Baseline Performance Indicators:

- Cooling Tower Fan Motor Loading: 14.2–14.6 kW against 15 kW rated capacity, per tower (2 towers)
- Combined Cooling Tower Fan Energy Consumption: ≈2,20,000 kWh/year
- Fan Blade Material and Life: Cast aluminium, 2–3 years average life due to corrosion pitting
- Unscheduled Maintenance Stoppages: 4–5 per year (bearing/blade-related)

Implemented Technology / Solution

The unit replaced the existing aluminium cooling tower fan blades with lightweight, aerodynamically designed Fibre-Reinforced Plastic (FRP) fan blades on both cooling towers. The FRP blades offer lower weight, improved airflow efficiency, and superior resistance to corrosion, enabling the cooling towers to deliver the required cooling performance with reduced motor power consumption. The retrofit was completed using the existing motor, gearbox, and hub assembly without major modifications. Following installation, motor loading and vibration levels decreased significantly, resulting in lower electricity consumption, improved cooling tower reliability, reduced maintenance requirements, and enhanced overall cooling system performance.

Figure 11: Conventional blades to FRP Blades



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
FRP fan blade replacement (2 cooling towers, 6 blades each) on induction furnace cooling circuit	9	7.8	1.12

Annual Electricity Savings	Annual Energy Savings	Annual GHG Savings
65,000 kWh	5.6 TOE	46.5 T CO_2

Case Study 13: Sand Reclamation System - M/s Rajkot Precision Castings Pvt. Ltd.

Unit Profile

Company Name	M/s Rajkot Precision Castings Pvt. Ltd.
Location	Rajkot, Gujarat
Sector / Sub-sector	Ferrous Foundry - Grey Iron & SG Iron Castings
Products Manufactured	Automotive components, pump and valve castings, agricultural implement parts
Annual Production Capacity	9,600 MT of castings per year
Number of Employees	145
Major Energy Sources	Electricity (induction melting furnace), Furnace oil (core baking oven), Diesel (DG set - backup)
Connected Load	1,850 kVA

Baseline Scenario

M/s Rajkot Precision Castings Pvt. Ltd. operates a green sand moulding line with two medium-frequency induction furnaces for producing grey iron and SG iron castings. Prior to the intervention, used moulding sand was recovered through basic mechanical screening, with no dedicated sand reclamation system in place.

This resulted in high fresh sand consumption, increased waste sand generation, and inconsistent sand quality, leading to casting defects such as sand inclusions and blow holes. The unit also faced rising sand procurement and disposal costs, along with increasing environmental compliance requirements.

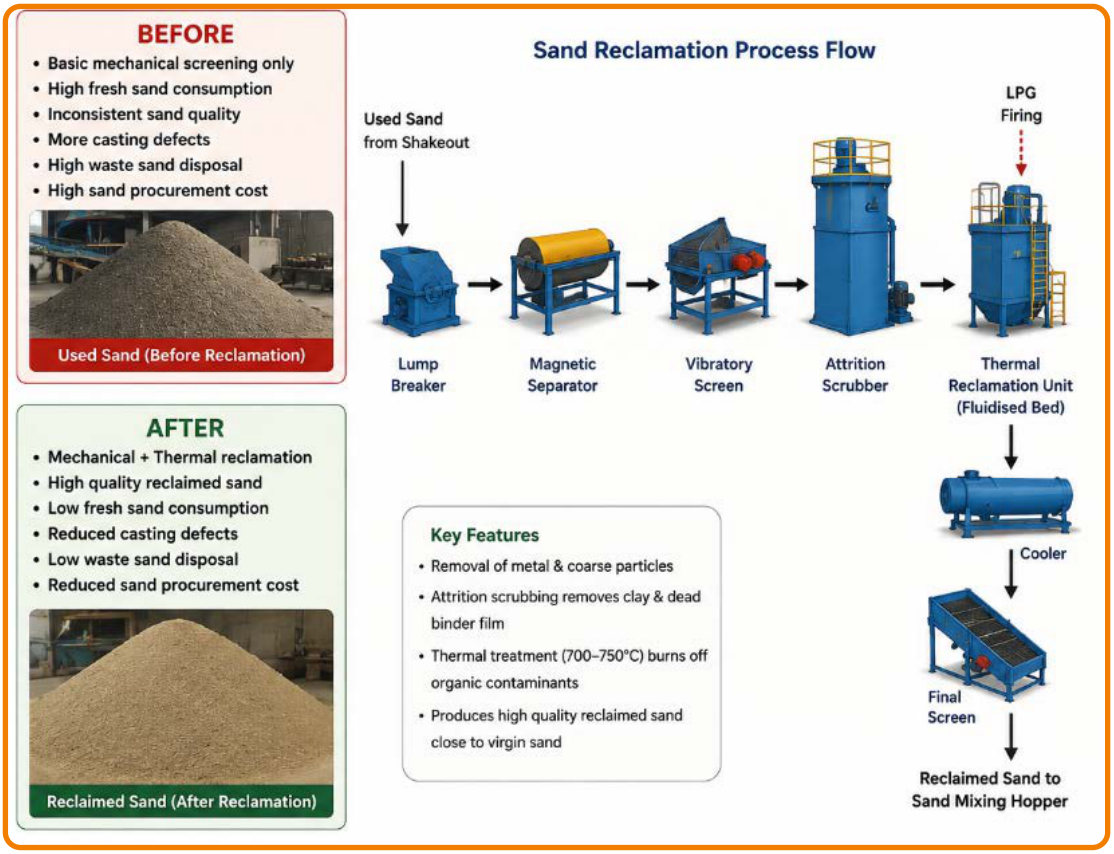
Baseline Performance Indicators:

- Fresh Sand Consumption: 620 kg per MT of casting
- Reclamation Efficiency: approximately 35% (manual screening only, no attrition/thermal treatment)
- Waste Sand Disposal: 3,100 MT per year
- Sand Procurement Cost: INR 900 per MT (annual fresh sand cost ≈ INR 53.6 lakh)

Implementation Methodology

The unit installed a 5 TPH mechanical-cum-thermal sand reclamation system integrated with the existing sand handling circuit. The system recovers and restores spent moulding sand by removing metallic impurities, residual binders, and organic contaminants through mechanical scrubbing and thermal treatment, producing reclaimed sand with properties comparable to virgin sand. The reclaimed sand is reused in the moulding process, significantly reducing fresh sand consumption and waste generation. Following implementation, sand reclamation efficiency increased to 85%, while improved sand quality enhanced mould consistency and reduced casting rejection rates from 5.5% to 3.2%, resulting in both economic and environmental benefits.

Figure 12:Sand Reclamation System



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
5 TPH Mechanical-cum Thermal Sand Reclamation plant with attrition scrubber, fluidised-bed reclaimer and automated sand handling	145	42	3.5

Annual Electricity Savings	Annual Energy Savings	Annual GHG Savings
95,000 kWh	8.2 TOE	78 T CO_2

Case Study 14: High-Efficiency Bag Filter System - M/s Kolhapur Alloy Castings Pvt. Ltd.

Unit Profile

Company Name	M/s Kolhapur Alloy Castings Pvt. Ltd
Location	Kolhapur, Maharashtra
Sector / Sub-sector	Ferrous Foundry - Cupola-based Grey Iron Castings
Products Manufactured	Machine tool castings, textile machinery parts, industrial pump castings
Annual Production Capacity	7,200 MT of castings per year
Number of Employees	110
Major Energy Sources	Metallurgical coke (cupola furnace), Electricity, Furnace oil (core shop)
Connected Load	950 kVA

Baseline Scenario

It operates a divided-blast cupola furnace for grey iron melting and was using an ageing wet scrubber-cum-cyclone system for emission control. Over time, the system's efficiency declined, resulting in stack particulate emissions of approximately 380 mg/Nm³, exceeding regulatory limits and creating environmental compliance concerns. High dust levels in the shakeout and fettling areas adversely affected workplace conditions, while the scrubber's high water consumption, sludge generation, and increased ID fan power requirement contributed to higher operating costs and reduced overall efficiency.

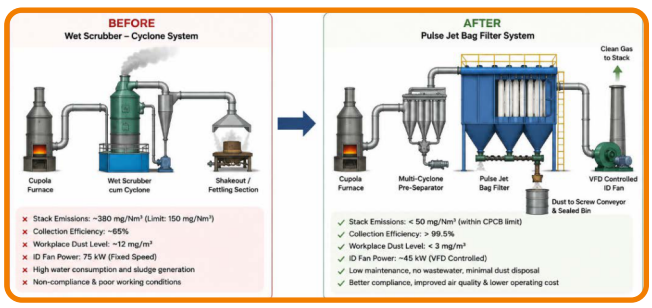
Baseline Performance Indicators:

- Stack Particulate Emissions: 380 mg/Nm³ (against CPCB limit of 150 mg/Nm³)
- Dust Collection Efficiency: approximately 65%
- Workplace Dust Levels: approximately 12 mg/m³ near shakeout/fettling, exceeding permissible occupational limits
- ID Fan Power Consumption: 75 kW (continuous duty)

Implementation Methodology

The unit replaced its existing wet scrubber with a 35,000 Nm³/hr pulse-jet bag filter system equipped with a multi-cyclone pre-separator and PTFE-coated filter bags for efficient particulate removal. The system was integrated with the cupola furnace and shakeout dust extraction network, while an energy-efficient VFD-controlled ID fan was installed to optimize airflow and reduce power consumption. The bag filter automatically collects and removes dust through a pulse-jet cleaning mechanism, ensuring consistent performance and compliance with emission standards. Following implementation, stack particulate emissions were brought well within regulatory limits, workplace air quality improved significantly, and fan energy consumption was reduced.

Figure 13: Upgradation of Emission Control systems



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
35,000 Nm³/hr Pulse-Jet Bag Filter System with multi-cyclone pre-separator and VFD-controlled ID fan, replacing wet scrubber	68	15.8	4.3

Annual Electricity Savings	Annual Energy Savings	Annual GHG Savings
1,19,000 kWh	10.23 TOE	97 T CO_2

Case Study 15: Air Preheaters and Recuperators - M/s Coimbatore Metal Works

Unit Profile

Company Name	M/s Coimbatore Metal Works
Location	Coimbatore, Tamil Nadu
Sector / Sub-sector	Ferrous Foundry - Oil-fired Rotary Furnace, Grey Iron Castings
Products Manufactured	Textile machinery castings, pump and motor housings, general engineering castings
Annual Production Capacity	6,000 MT of castings per year
Number of Employees	95
Major Energy Sources Electricity	Furnace oil / LDO (rotary melting furnace), LPG (core ovens),
Connected Load	650 kVA

Baseline Scenario

It operates a furnace-oil-fired rotary furnace for melting grey iron castings. Prior to the intervention, combustion air was supplied at ambient temperature, and high-temperature flue gases were discharged directly to the atmosphere without heat recovery. As a result, significant heat was lost through the exhaust, leading to a high specific fuel consumption of 68 litres/MT of casting and a low furnace thermal efficiency of 52%. Rising fuel costs, higher emissions, and excessive heat in the melting area increased operating expenses and affected overall process efficiency.

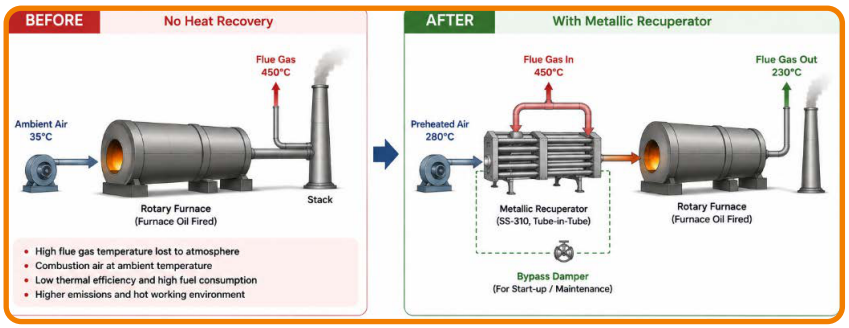
Baseline Performance Indicators:

- Specific Fuel Consumption: 68 litres of furnace oil per MT of casting (annual consumption ≈ 4,08,000 litres)
- Exhaust Gas Temperature: approximately 450°C
- Furnace Thermal Efficiency: approximately 52%
- Combustion Air Temperature: ambient (≈ 35°C), no preheating

Implementation Methodology

The unit installed a metallic recuperator (SS-310 grade) in the rotary furnace flue gas path to recover waste heat and preheat combustion air before it enters the burner. The system utilizes hot exhaust gases to raise combustion air temperature from ambient conditions to approximately 280°C, improving combustion efficiency and reducing fuel consumption. Integrated with the existing furnace during a scheduled maintenance shutdown, the recuperator reduced flue gas temperature from 450°C to 230°C, increased furnace thermal efficiency from 52% to 61%, and lowered specific fuel consumption from 68 to 58.5 litres/MT of casting, resulting in significant fuel and energy savings.

Figure 14: Waste heat recovery using Metallic Recuperator



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
Metallic Recuperator (SS-310) for Combustion Air Preheating on Oil-Fired Rotary Furnace, with insulated ducting and bypass damper	38	38.76	1.0

Annual Electricity Savings	Annual Energy Savings	Annual GHG Savings
13,61,42,220 kWh	13.6 TOE	153 T CO_2

Case Study 16: Energy Management System (EMS) - M/s Bollaram Precision Castings Pvt. Ltd.

Unit Profile

Company Name	M/s Bollaram Precision Castings Pvt. Ltd.
Unit Type	Ferrous foundry (Grey Iron), cupola and induction dual melting, general engineering castings
Location	Patancheru-Bollaram industrial area, Sangareddy district, Telangana
Annual Production	6,500 MT of castings/year
Workforce	140
Annual Energy Consumption (Baseline)	48 lakh kWh/year (4.8 million kWh)
Key Problem Identified	No real-time visibility of energy consumption across melting, molding & utility sections; billing-only metering; & recurring maximum-demand excursions above the sanctioned load.

Baseline Scenario

The unit monitored electricity consumption only through the main HT meter, with no sub-metering or real-time visibility of energy use across key equipment such as induction furnaces, compressors, blowers, and moulding systems. As a result, idle running of equipment, compressed air leakages, and unnecessary energy consumption often went unnoticed. Frequent simultaneous operation of large electrical loads also caused maximum demand exceedances, leading to utility penalties. The absence of detailed energy monitoring and analytics limited the plant's ability to identify inefficiencies, optimize operations, and control electricity costs effectively.

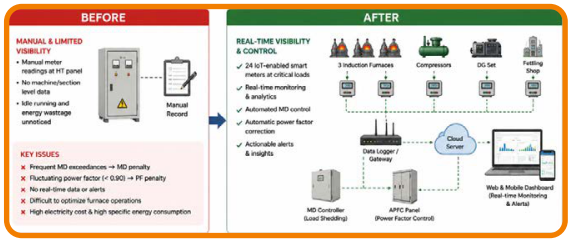
Baseline Performance Indicators:

- Metering Coverage: Main incomer only (monthly billing meter)
- Sanctioned Load / MD Excursions: Sanctioned load 950 kVA; recorded excursions up to ≈1,040 kVA
- Estimated Avoidable Electricity Loss: 5–6% of total electricity bill
- Compressed Air Leakage (baseline audit estimate): ≈18% of total compressor output

Implementation Methodology

The unit implemented an IoT-based Energy Management System (EMS) with wireless smart sensors installed on major energy-consuming equipment, including induction furnaces, compressors, moulding systems, blowers, and utility feeders. The system provides real-time monitoring, cloud-based analytics, equipment-wise energy tracking, specific energy consumption (SEC) benchmarking, and automated demand alerts through web and mobile dashboards. It enables operators to identify abnormal energy consumption, optimize load scheduling, prevent maximum demand exceedances, and monitor compressed air system performance. The EMS was installed without production interruption and has improved energy visibility, operational control, and data-driven decision-making across the plant.

Figure 15: Energy Management System (EMS) Implementation



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
IoT-based EMS (wireless sub metering, cloud dashboard, mobile alerts) across melting, molding & utility sections	18	16.4	1.1

Annual Thermal Savings	Annual Energy Savings	Annual GHG Savings
1,54,000 kWh	12.5 TOE	104 T CO_2

Case Study 17: Foundry Waste Sand Utilization in Brick Manufacturing - M/s Howrah Casting Industries

Unit Profile

Company Name	M/s Howrah Casting Industries
Location	Howrah, West Bengal
Sector / Sub-sector	Ferrous Foundry - Cupola-based Grey Iron Castings
Products Manufactured	Railway fittings, sanitary and general engineering castings
Annual Production Capacity	5,400 MT of castings per year
Number of Employees	88
Major Energy Sources	Metallurgical coke (cupola furnace), Electricity
Connected Load	580 kVA

Baseline Scenario

It manufactures grey iron castings for the railway and general engineering sectors. Prior to the intervention, a significant portion of spent foundry sand generated during moulding operations could not be reused in the process and was disposed of as waste. The sand was transported to nearby dumping sites, resulting in recurring disposal costs, land-use concerns, and dust-related environmental issues. With increasing restrictions on landfill disposal and growing regulatory pressure to adopt sustainable waste management practices, the unit sought opportunities to utilize spent foundry sand as a valuable resource rather than treating it as waste.

Baseline Performance Indicators:

- Waste Sand Generation: 2,850 MT per year
- Disposal Cost: INR 320 per MT (annual disposal cost ≈ INR 9.12 lakh)
- Utilization Rate: 0% (entire waste sand quantity landfilled)

Implementation Methodology

The unit established an on-site sand-fly ash brick and paver block manufacturing facility to utilize spent foundry sand generated from moulding operations. The process involves blending screened spent foundry sand with fly ash, cement, and aggregates to produce bricks and paver blocks that meet relevant quality standards. The facility includes a screening unit, pan mixer, hydraulic block press, and curing yard, enabling the conversion of foundry waste into value-added construction products. Integrated with the existing foundry operations, the plant utilizes approximately 2,400 MT of spent foundry sand annually and produces around 9.6 lakh bricks and blocks per year, significantly reducing landfill disposal while generating additional revenue and supporting circular economy practices.

Figure 16:Beneficial Utilisation of Spent Foundry Sand



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
On-site Spent Foundry Sand Fly Ash Brick/Paver Block Manufacturing Unit (mixer, hydraulic press, curing yard and testing facility)	62	36.5	1.7

Annual
Resource Savings
2,400 MT Spent Foundry Sand

Annual
GHG Savings (downstream emission)
144 T CO_2

Case Study 18: Solar Rooftop and Hybrid Solar Power Installation- M/s Kakatiya Casting Works Pvt. Ltd.

Unit Profile

Company Name	M/s Kakatiya Casting Works Pvt. Ltd.
Location	Kakatiya Industrial Estate, Warangal, Telangana
Annual Production	9,000 MT of castings/year
Workforce	220
Annual Energy Consumption (Baseline)	74 lakh kWh/year (7.4 million kWh)
Key Problem Identified	Complete dependence on grid electricity at industrial tariff, with a large unutilised rooftop/shed area and growing customer expectations around supplier decarbonization left unaddressed.

Baseline Scenario

The unit relied entirely on grid electricity to meet the energy requirements of induction melting, moulding, compressed air, utilities, and administrative facilities, making it highly vulnerable to rising electricity tariffs and energy cost fluctuations. Despite having substantial unused rooftop space suitable for solar installation, no renewable energy system had been deployed. Since a significant portion of the plant's electricity consumption occurred during daytime operating hours, there was considerable potential for on-site solar power utilization. In addition to increasing electricity costs, the absence of renewable energy adoption limited the unit's ability to demonstrate carbon reduction efforts and meet the growing sustainability expectations of industrial customers.

Baseline Performance Indicators:

- Grid Electricity Dependence: 100% (no captive generation)
- Available Unutilised Rooftop/Shed Area: ≈9,500 m^2
- Daytime (Solar-Window) Electricity Consumption Share: ≈65% of total consumption occurs 9 AM-5 PM
- Average Industrial Tariff: ≈INR 8.2/kWh

Implementation Methodology

The unit installed a 1 MWp grid-connected rooftop solar photovoltaic (PV) system across available shop rooftops and integrated it with the existing electrical network through a hybrid solar controller and net-metering arrangement. The system generates renewable electricity during daytime operations and supplies power directly to plant loads such as induction melting auxiliaries, moulding, compressors, and utility systems, thereby reducing dependence on grid electricity. The hybrid controller automatically manages power flow between solar, grid, and DG sources to ensure uninterrupted operation. Implemented without disruption to production activities, the solar installation significantly reduced daytime grid consumption, lowered energy costs, and supported the unit's sustainability and decarbonization objectives.

Figure 17: Rooftop Solar PV Installation with Hybrid Power Integration



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
1 MWp grid-connected rooftop solar PV system with hybrid grid-solar-DG controller	380	116	3.3

Annual Electricity Savings	Annual Energy Savings	Annual GHG Savings
15,00,000 kWh	130.7 TOE	1.088 T CO_2

Case Study 19: Closed-Loop Cooling Water Recirculation System - M/s Patancheru Green Foundries Pvt. Ltd.

Unit Profile

Location	Patancheru Industrial Cluster, Sangareddy, Telangana
Sector / Sub-sector	Ferrous Foundry - Grey Iron & SG Iron Castings
Products Manufactured	Earthmoving equipment castings, pump and motor housings
Annual Production	5,800 MT of castings per year
Number of Employees	92
Major Energy Sources	Electricity (induction furnace, compressors, cooling water pumps), Diesel (DG set – backup)

Baseline Scenario

It relied on borewell and tanker water for cooling induction furnace panels, air compressors, and DG sets through a once-through cooling system, where water was used only once and then discharged without treatment or reuse. This resulted in high freshwater consumption, increased tanker water costs during summer months, and risks of production interruptions due to water shortages. Continuous discharge of warm cooling water also created environmental concerns and made compliance with TSPCB water conservation and discharge requirements increasingly challenging.

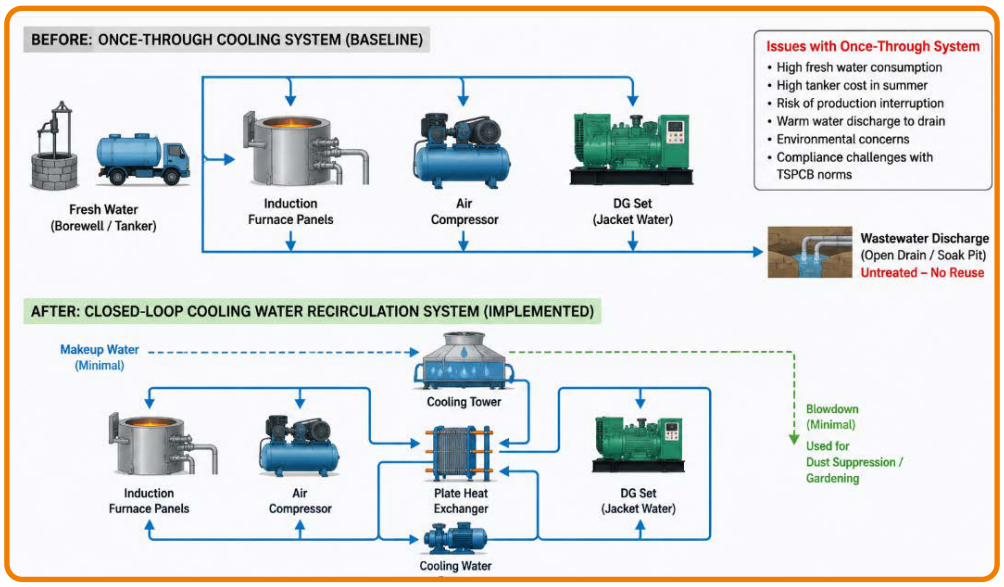
Baseline Performance Indicators:

- Fresh Water Consumption for Cooling: approximately 46 KL/day (≈ 13,800 KL/year over 300 operating days)
- Water Procurement Cost: INR 90 per KL (combined borewell pumping and tanker cost), equivalent to an annual cost of ≈ INR 12.42 lakh
- Cooling Water Recirculation Rate: 0% (single-pass, once-through system)
- Wastewater Discharge: ≈ 13,800 KL/year discharged untreated to open drain/soak pit
- Furnace Panel Cooling Water Outlet Temperature: up to 48–50°C during summer months, elevating overheating-trip risk

Implementation Methodology

The unit installed a closed-loop cooling water recirculation system comprising a plate heat exchanger, cooling tower, recirculation pumps, and automated makeup/blowdown controls. The system recovers and recirculates cooling water used in induction furnace panels, compressors, and DG sets, significantly reducing freshwater consumption and eliminating once-through discharge. Softened and chemically treated water is maintained in the closed loop to prevent scaling and corrosion, while cooling tower operation ensures efficient heat removal. Integrated with the existing cooling network, the system reduced fresh water consumption by about 87%, ensured reliable cooling performance throughout the year, and virtually eliminated wastewater discharge from cooling operations.

Figure 18: Water Conservation through Closed-Loop Cooling System



Investment and Payback

Technology Description	Investment Cost (INR Lakhs)	Annual Monetary Saving (INR Lakhs/year)	Simple Payback (Years)
Closed-Loop Cooling Water Recirculation System with Plate Heat Exchanger. Cooling Tower, Recirculation Pumps and Automated Makeup/Blowdown Control	46.0	12.8	3.6

Annual Electricity Savings	Annual Energy Savings	Annual Water Savings	Annual GHG Savings
18,000 kWh	1.55 TOE	12,000 KL/Yr.	14 T CO_2

6. Eligible Equipment under MSME Schemes

Foundry MSMEs can access several central and state government schemes to support energy efficiency improvements, technology upgradation, decarbonization, quality enhancement, and sustainable manufacturing.

1. Technology Upgradation and Green Financing (MSE-GIFT)

Under the MSE-GIFT scheme, MSMEs can avail financial support for adopting energy-efficient and cleaner production technologies. The scheme provides interest subvention and credit-risk support for eligible technology investments. Eligible technologies include energy-efficient melting furnaces, waste heat recovery systems, variable frequency drives (VFDs), compressed air system optimization, pollution-control equipment, and digital monitoring systems.

- Interest Subvention: 2% per annum for up to 5 years on eligible term loans.
- Risk Sharing Facility (RSF): Credit guarantee support for loans used for technology upgradation.
- Eligible Foundry Technologies:
  - Medium-frequency induction furnaces
  - Waste Heat Recovery Systems (WHRS)
  - VFDs for pumps, fans and compressors
  - Energy-efficient motors (IE3/IE4)
  - Compressed air optimization systems
  - Digital energy monitoring and SCADA systems

2. ADEETIE Scheme (Bureau of Energy Efficiency)

The Assistance in Deploying Energy Efficient Technologies in Industries and Establishments (ADEETIE) scheme supports MSMEs in adopting advanced energy-efficient technologies through technical assistance and concessional financing. Foundries are one of the priority sectors under the scheme.

- Interest subvention for energy-efficiency projects.
- Support for energy audits and DPR preparation.
- Assistance for adoption of advanced melting, compressed-air and waste-heat recovery technologies.
- Focus on reducing energy consumption and carbon emissions.

3. MSME Sustainable (ZED) Certification

Foundry units can improve quality, productivity, and environmental performance through the MSME Sustainable (ZED) Certification Scheme.

- Support for certification and assessment.
- Financial assistance for testing and product certification.
- Subsidy for adoption of Zero Defect–Zero Effect technologies.
- Handholding support for process improvement and sustainability initiatives.

4. Telangana State Incentives

Foundry MSMEs located in Telangana can avail incentives under state industrial policies.

- T-IDEA: Capital investment incentives for eligible MSMEs.
- T-PRIDE: Enhanced incentives for SC/ST entrepreneurs.
- Support for cleaner technologies, energy-efficient equipment, and industrial infrastructure.
- Assistance through industrial parks and cluster development initiatives.

5. Innovation and Intellectual Property Support (MSME Innovative)

Foundry MSMEs investing in casting design improvement, simulation software, automation, digitalization, and new product development can avail support under the MSME Innovative Scheme.

- Design Support:GoI contributes 75% (Micro) and 60% (Small & Medium) of project cost, up to INR40 lakh, for design and product development projects.
- IPR Support: Assistance for patent filing and protection of innovative products and manufacturing technologies

6. Subsidies for SC/ST Entrepreneurs

SC/ST-owned foundry MSMEs can avail benefits under the Special Credit Linked Capital Subsidy Scheme (SCLCSS) of the National SC-ST Hub.

- **Capital Subsidy:** 25% subsidy on investment in plant & machinery through institutional finance.
- **Maximum Subsidy:**INR25 lakh.

Eligible Equipment / Technologies for Foundry MSMEs

Table 16:List of equipment / technology eligible under MSE-GIFT Scheme

S.No.	Eligible Equipment / Technology	Energy Saving		Other Advantages
		min	max	
		A	B	
1	Heat Recovery System for Stress Relieving Furnaces	5	25	Waste heat recovery system, reduction in equipment size
2	Oil Fired Core Drying Oven	40	50	Complete combustion, easy to operate, low maintenance cost, better product quality
3	Gas fired Aluminium Melting Furnace (replace Oil Fired Furnace)	5	25	Reduction in Thermal Energy consumption
4	Gas Fired Cupola	5	10	Eco friendly, higher tapping temperature, better melt quality, reduce thermal energy consumption, de-sulphurisation not required
5	Oil Fired Rotary Furnace	10	20	Reduce initial / subsequent heating time, auto on/off control
6	Induction Furnace with Cooling Tower & Water Treatment Plant	10	25	Flexibility to produce ferrous castings, flexibility to select charge mix, better melt quality
7	Induction Ladle Refining Furnace	10	25	Value added casting, eco friendly
8	Natural Gas Based Power Generating Set	5	10	Environmental-friendly, highly efficient, low emission

9	Intensive Mixers (Molding / Core)	5	10	Reduce defective casting, better cast surface finish
10	Simultaneous Jolt / Squeeze Moulding Machine	23	30	Higher productivity, dimensional accuracy, less skill requirement
11	Spun Pipe Casting Machine	10	15	Easy to install, resistance to corrosion, high impact resistance, durable with high load taking capacity
12	Induction Hardening Equipment (100KW, 500Hz to 3KHz)	50	60	Higher productivity, consistency in quality, can lead to saving in heat-treatment operation
13	Removable Hearth Type Chamber (F/C upto 1200 deg C with Computer Compatible Temperature Controller)	5	15	Better temperature control, improve quality
14	CNC Lathe Machine	55	60	Higher productivity, dimensional accuracy, less skill requirement, improve quality
15	CNC Milling (Pattern Shop)	55	60	Higher productivity, dimensional accuracy, less skill requirement, improve quality
16	Exothermic / Insulating Sleeves (Oven for Baking Sleeves, Molding Machines, Vacuum System)	15	25	Insulating and exothermic sleeves improves feeding efficiency upto 20 and 25 respectively
17	Waste Heat Recovery System for Exhaust Gases	15	25	Utilise waste heat, reduce pollution, reduce auxiliary energy consumption
18	Automatic Pouring System	10	15	Higher-quality casting with precision pouring, eliminates underpours and wasteful overpours
19	Energy Efficient Thermal Reclamation Plant	5	10	Thermal reclamation is economical compared to mechanical reclamation
20	Energy Efficient Short Blasting Machine	10	15	Rugged design of the machine reduces fettling cost, save labour cost, tooling cost, reduce rejection
21	High Efficiency Centrifugal Fans	25	30	Long life, abrasion resistant

22	High Efficiency Power Generating Set	5	10	Able to the rated load within 10 seconds in a single step, high reliability, low life cycle cost, low operating and maintenance cost
23	Automatic FlasklessMolding Machine	10	15	Higher production efficiency, mold hardness is excess of 85
24	Core Setter and Automatic Mold Conveyor	5	15	High-precision mould transport with no shifting, distortion or displacement of moulds
25	Compact Vertical Moulding Machine	15	20	Higher production capacity upto 350 moulds/hour (uncored), PLC system for optimum production, less space requirement
26	Automatic Cold Box Core Shooter	5	15	Can shoot in volume of 5 to 20 kgs, the average cycle time is from 10 second onwards without gassing, shoot and exhaust
27	Electrically Heated Die- Heating Furnace	25	30	Uniform temperature, pollution free compared to conventional furnace, Auto controll, noise free
28	Mechanized Moulding Machines (with PLC control)	25	60	High static & high dynamic squeeze force results in high quality moulds, uniform moulds properties, reduce rejection, reduce mould preparation costs
29	Mechanical Sand Reclamation (PLC controlled)	50	60	Low running cost
30	Automatic On-line Sand Controller	50	60	Low running cost
31	Variable Speed Sand Mixer	10	30	Improved flowability, permeability,reduced operating moisture level, efficient mixing
32	Computer Controlled Sand Cooler-Mixer	5	10	Streamlined sand handling, transport equipment, and reduced maintenance, more evenly, higher efficiency of the sand, a direct reduction in the loss of the excipients
33	Liquid Metal Supply	25	30	Re-heating is avioded
34	Automatic Manganese Phosphating Plant	30	40	Innate lubrication properties, these phosphate coatings can also absorb large proportions of lubricants by their porosity.
35	Automatic Core blowing machine	15	20	Fully automatic process and PLC controlled

7. Implementation Roadmap

This implementation roadmap provides a structured pathway for MSME foundries to adopt Resource Efficient and Cleaner Production (RECP) measures in a phased manner. The roadmap prioritizes interventions based on investment requirement, ease of implementation, operational complexity, energy-saving potential, and payback period. It begins with low-cost housekeeping and operational improvements that can be implemented immediately, followed by energy-efficient equipment upgrades, process optimization measures, renewable energy integration, and long-term digitalization initiatives. The phased approach enables foundries to achieve progressive improvements in energy efficiency, resource productivity, environmental performance, and competitiveness while minimizing financial burden and operational disruption. Successful implementation will require management commitment, employee engagement, regular monitoring of key performance indicators, and effective utilization of available government support schemes and financing mechanisms. Through systematic adoption of these measures, foundries can significantly reduce energy consumption, production costs, greenhouse gas emissions, and material losses while enhancing product quality, productivity, and long-term sustainability

Table 17: ImplementationRoadmap for RECP in MSME Foundries

Phase	Timeline	Key Actions	Typical Measures	Expected Benefits
Phase I - Immediate	0-6 months	Energy audit & baseline SEC Fix air leaks; form energy team	Compressed air leak repair LED retrofit; PF correction Preventive maintenance	Quick, low-cost savings Payback under 12 months
Phase II - Short-Term	6-18 months	Install VFDs on key motors Upgrade furnace refractory	VFDs on compressors & motors IE3/IE4 motors; sub-metering	Notable energy savings Payback of 1-2 years
Phase III - Medium-Term	18-36 months	Install waste heat recovery Adopt sand reclamation	WHR on furnace exhaust Rooftop solar; SCADA	Reduced fuel & sand cost Lower emissions
Phase IV - Long-Term	Beyond 36 months	Cupola-to-induction conversion Adopt AI/digital systems	Furnace conversion; automation Digital twin; ERP integration	Long-term competitiveness Access to green financing

A phased approach lets MSME foundries fund later, capital-intensive upgrades using savings from earlier measures - improving competitiveness, sustainability and profitability over time.

8. Conclusions

The Indian Basic Metal Foundry sector plays a vital role in the manufacturing ecosystem, supplying castings to automobile, railways, agriculture, and heavy engineering industries. However, energy performance generally lags international benchmarks, and energy costs remain a significant share of manufacturing cost for MSME units.

Melting operations are the largest energy consumer, followed by compressed air, heat treatment, and fettling. Targeted measures - furnace upgrades, VFDs, and waste heat recovery - can deliver meaningful energy and cost savings with attractive payback periods.

Resource efficiency measures such as sand reclamation and water reuse reduce waste and cost, while digitalization (IoT monitoring, SCADA, predictive maintenance) improves productivity. Government schemes for interest subvention, technical assistance, and certification help lower the capital barrier to adoption.

Overall, RECP adoption is a direct lever for MSME competitiveness - reducing costs and emissions while improving productivity and market readiness.

Intervention Category	Expected Benefits
Energy Efficiency	Lower energy costs and improved SEC across furnace, compressed air and motor systems
Resource Efficiency	Less sand and water waste through reclamation and better process control
Renewable Energy	Reduced grid dependence via rooftop/hybrid solar
Digitalization	Better monitoring, fewer breakdowns, higher productivity
Circular Economy	Waste-to-value through slag, dross and scrap reuse

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Greening of MSMEs in Telangana

The Government of Telangana has taken up the "Greening of MSMEs" initiative, under the Raising and Accelerating MSME Performance (RAMP) Programme, with an intent to support MSMEs in adopting sustainable and resource-efficient industrial practices. Research and Innovation Circle of Hyderabad (RICH) is implementing the Greening of MSMEs program in Telangana with technical support and program delivery comprising awareness creation, energy audits, and handholding support being provided by CII. The initiative promotes cleaner technologies, energy and water conservation, waste reduction, and improved operational efficiency through Resource Efficient and Cleaner Production (RECP) assessments, awareness programs, and cluster-level interventions. By facilitating technical guidance and implementation support, the programme helps MSMEs reduce environmental impact, improve productivity, and enhance their competitiveness in both domestic and global markets.

Research and Innovation Circle of Hyderabad (RICH)

RICH was launched in 2017 as a first-of-its-kind initiative by the Government of Telangana. RICH was established to bridge the gap between research and real-world applications by enabling collaboration among research institutions, industry, startups, and government bodies.

RICH also serves as Hyderabad's Science and Technology City Cluster, under a national initiative led by the Office of the Principal Scientific Adviser to the Government of India. In this capacity, RICH drives multidisciplinary projects to address complex local and national challenges.

Working at the intersection of science, technology, and entrepreneurship, RICH focuses on three critical sectors "Life Sciences", "Food & Agriculture", and "Sustainability". In the Sustainability area, RICH focuses on Clean Energy Transition, Industrial Decarbonization and Circularity through strategic partnerships, pilot initiatives, and policy engagement. RICH fosters a culture of innovation that delivers scalable and transformative solutions for long-term impact.

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