

ECO BEVERAGE INDUSTRY

Energy Efficiency • Water Efficiency • Thermal Recovery • Cleaner Production

Technology Compendium For Energy, Resource Efficiency & Cleaner Production For Beverage Manufacturing Sector

Prepared by CII for Research and Innovation Circle of Hyderabad (RICH)
as part of the RAMP Telangana Greening of MSME Initiative

AUGUST 2026



Confederation of Indian Industry



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 sitespecific 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), the Beverage Industry Environmental Roundtable (BIER) 2023 Benchmarking Study, the Ministry of Food Processing Industries (MoFPI), Government of India (Sector Profile — Beverages), and the Shakti Foundation's Widening of PAT Sectors — Beverage report. 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.

Acknowledgement

This compendium has been developed as part of the Greening of MSMEs in Telangana under RAMP Program to conduct Resource Efficiency and Cleaner Production (RECP) Assessments and implement measures in MSMEs from Telangana state.

The Confederation of Indian Industry (CII) gratefully acknowledges the guidance, support, and contributions of the following stakeholders:

- Ministry of MSME, Government of India, for extending strategic direction and support under the RAMP Programme
- Industries & Commerce Department, Government of Telangana, for facilitating implementation and enabling ecosystem support within the State
- Research and Innovation Circle of Hyderabad (RICH), for driving innovation-led approaches to MSME ecosystem in Telangana
- World Bank, for financial and technical support to the RAMP Programme
- Industry associations and sector bodies, including the Beverage Industry Environmental Roundtable (BIER) and the Ministry of Food Processing Industries (MoFPI), for domain knowledge and sectoral inputs
- Local technology providers, service providers, and MSME units across Telangana, for their active participation, data sharing, and practical insights during assessments

Table of Contents

Acknowledgement.....	i
List of Tables.....	v
List of Figures	vi
List of Abbreviations.....	vii
About the Project.....	ix
Executive Summary	xi
Technology Attractiveness Summary	xiii
1. Beverage Landscape	1
1.1 India's Beverage Landscape.....	1
1.2 Non-Alcoholic Beverages in India	1
1.3 Alcoholic Beverages in India	1
1.4 State-Level Overview - Telangana.....	1
1.5 Energy Consumption Profile for Beverage Industry	6
2. Financial Mechanism and Support Schemes	5
2.1 Technology Upgradation and Green Incentives.....	5
2.2 Telangana State Incentives (For Units in Telangana).....	5
2.3 General Central Government Subsidies	5
2.4 Marketing and Export Support	6
2.5 Eligible Equipment under MSME GIFT Scheme: Beverage Sector	6
3. Beverage Manufacturing Processes by Category	9
3.1 Non-Alcoholic Beverages (Carbonated Drinks, Juices, Packaged Water)	9
3.2 Dairy-Based Beverages (Flavoured Milk, Lassi, Buttermilk, Milk Drinks).....	9
3.3 Alcoholic Beverages (Context Only – Predominantly Large-Scale)	10
4. Technologies For Energy Efficiency.....	11
4.1 Energy Efficiency Measures- Nil and Low Investment	12
4.1.1 LED Lighting with Occupancy & Daylight Controls	12
4.1.2 Steam Trap Survey & Preventive Maintenance	13
4.1.3 Boiler Combustion Optimisation (O2 Trim)	13
4.1.4 Condensate Recovery.....	14
4.1.5 Thermal Insulation.....	15
4.1.6 Compressed Air Leak Detection	15
4.1.7 Compressed Air Pressure Optimisation.....	16
4.1.8 Energy Sub-metering	17
4.2 Energy Efficiency Measures- Medium and High Investment	17
4.2.1 IE3 / IE4 MOTORS	17
4.2.2 VFD on Motors	18

4.2.3 DG Synchronisation.....	19
4.2.4 Refrigeration with Floating Head Pressure.....	19
4.2.5 Optimisation of Cooling Tower.....	20
4.2.6 Regenerative Plate Heat Exchanger	21
4.3 Emerging & Future-Ready Technology.....	22
4.3.1 Multi-Effect Evaporator (MEE) — Juice/Dairy Concentration.....	22
4.3.2 Mechanical Vapour Recompression (MVR)	23
4.3.3 Aseptic Cold-Fill Processing	24
4.3.4 Ozone-Based CIP Sanitation.....	24
4.3.5 Industrial Heat Pumps for Low-Temperature Process Heat / Hot Water	25
4.3.6 Heat Recovery from Air Compressors.....	26
4.3.7 Energy Management System (EMS)	26
5. Technologies For Renewable Energy	29
5.1 Renewable Energy Measures- High Investment	29
5.1.1 Solar PV	29
5.1.2 Solar Thermal Heater	30
5.1.3 Biomass Boiler	30
6. Technologies for Resource Efficiency.....	31
6.1 Resource Efficiency Measures	32
6.1.1 Water Sub-metering.....	32
6.1.2 CIP Final Rinse Reuse.....	32
6.1.3 UF/NF Water Treatment	33
6.1.4 MBR + RO Water Reclamation	33
6.2 Resource Efficiency – Waste & Packaging	34
6.2.1 Lightweighting of PET Bottles.....	34
6.2.2 Recycled PET (rPET) Incorporation	35
6.2.3 Circular-Economy Packaging Practices (Take-Back, EPR Compliance, Source Segregation)	35
6.2.4 Bio-Based / Compostable Packaging Materials (Pilot Scale)	36
7. Conclusion and Roadmap	37
7.1 Summary.....	37
7.2 Recommended Priority Actions	37
7.3 Implementation Roadmap.....	38
7.4 About the RECP Assessment Process	39
7.5 Final Outlook.....	39
8. Bibliography.....	41

List of Tables

Table 1	Technology Summary for the Beverage Sector	xiii
Table 2	Telangana — Key State Indicators	2
Table 3	Key Raw Materials for Beverage Processing in Telangana	2
Table 4	PMFME Production Clusters Relevant to Beverages	2
Table 5	Beverage & Dairy Companies with Presence in Telangana	3
Table 6	BIER Benchmarking Study Performance Overview	4
Table 7	Water Use Ratio (WUR) Benchmark	4
Table 8	Energy Use Ratio (EUR) Benchmark	4
Table 9	Greenhouse Gas Emissions Ratio (ER) Benchmark	4
Table 10	Eligible Equipment List Under MSME GIFT Scheme	7
Table 11	Energy Efficiency Measures in Beverage Manufacturing	11
Table 12	Emerging and Future Ready Technologies in Beverage Manufacturing	22
Table 13	Renewable Energy Measures in Beverage Manufacturing	29
Table 14	Resource Efficiency Measures	31
Table 15	Priority Actions	37

List of Figures

Figure 1	Energy Consumption Breakdown of a Typical Beverage Plant	3
Figure 2	LED Lights with Smart Control System	12
Figure 3	Steam Trap Survey	13
Figure 4	Boiler Combustion Optimisation	14
Figure 5	Condensate Recovery	14
Figure 6	Thermal Insulation	15
Figure 7	Compressed Air Leak Detection	16
Figure 8	Compressed Air Pressure Reduction	16
Figure 9	Energy Sub-Metering	17
Figure 10	IE4 Motors	18
Figure 11	VFD Working	18
Figure 12	DG Synchronisation	19
Figure 13	Refrigeration with Floating Head Pressure	20
Figure 14	Cooling Tower Optimisation	20
Figure 15	Regenerative Plate Heat Exchanger	21
Figure 16	Multi-Effect Evaporator	23
Figure 17	Mechanical Vapour Recompression	23
Figure 18	Aseptic Cold Fill Processing	24
Figure 19	Ozone Based CIP Sanitation	25
Figure 20	Heat Pump	25
Figure 21	Heat Recovery from Air compressor	26
Figure 22	Energy Management System	27
Figure 23	Solar PV	29
Figure 24	Solar Thermal Heater	30
Figure 25	Biomass Boiler	30
Figure 26	Water Sub-Metering	32
Figure 27	CIP Final Rinse Reuse	32
Figure 28	UF/NF Water Treatment	33
Figure 29	MBR + RO Water Reclamation	34
Figure 30	Lightweighting of PET Bottles	34
Figure 31	Turning Waste into new Bottles	35
Figure 32	Circular-Economy Packaging Practices	36
Figure 33	Bio Based Packaging Materials	36

List of Abbreviations

Abbreviation	Definition
BEE	Bureau of Energy Efficiency
CIP	Cleaning-in-Place
DG	Diesel Generator
EC Fan	Electronically Commutated Motor fan
FSSAI	Food Safety and Standards Authority of India
GHG	Greenhouse Gas
HACCP	Hazard Analysis and Critical Control Points
IE1/IE2/IE3/IE4	International motor efficiency classes
IGBT	Insulated Gate Bipolar Transistor
IoT	Internet of Things — networked digital sensing and control technology
kWh	Kilowatt-hour
LPG	Liquefied Petroleum Gas
MBR	Membrane Bioreactor
MT	Metric Tonne (1,000 kg)
NF	Nanofiltration — membrane process removing dissolved salts and organics
NG	Natural Gas
Nm ³	Normal cubic meter
PF	Power Factor
PHE	Plate Heat Exchanger
PV	Photovoltaic
RO	Reverse Osmosis
SEC	Specific Energy Consumption
TDS	Total Dissolved Solids
TPH	Tonnes Per Hour
UF	Ultrafiltration
UHT	Ultra-High Temperature
UV	Ultraviolet
VFD	Variable Frequency Drive

About the Project

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 operationalise 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

The Industries Department, Government of Telangana, and RICH have entrusted CII to implement the "Greening of MSMEs" program in Telangana".

Executive Summary

The beverage manufacturing sector encompassing carbonated soft drinks, juices, packaged water, and dairy-based beverages — is a significant and growing segment of MSME manufacturing. Production is inherently energy- and water-intensive, relying on steam and hot water for pasteurisation and cleaning-in-place (CIP), electricity for refrigeration, compressed air, reverse osmosis (RO)/filtration and filling lines, and substantial freshwater volumes for process and utility use. These characteristics make the sector well suited to structured, technology-led energy and resource efficiency improvement.

This compendium presents 32 proven technology interventions for MSME beverage manufacturing units, organised across four categories: energy efficiency (nil/low investment), energy efficiency (medium/high investment), renewable energy integration, and resource (water) efficiency. For each technology, the compendium sets out the working principle, indicative MSME-scale investment, payback period, and annual CO₂ reduction potential, to support unit-level decision-making and investment planning.

Energy consumption in a typical beverage manufacturing unit is dominated by a handful of utility systems steam generation and distribution, refrigeration and cold storage, compressed air, and electrically driven pumps and agitators each of which carries well-documented and quantifiable loss mechanisms. On the thermal side, unmanaged steam trap populations typically lose 5–10% of live steam annually, untuned boilers commonly run 1–3 % below achievable combustion efficiency, and bare or degraded insulation on steam piping and valves can account for heat losses exceeding 90% of the equivalent insulated case. On the electrical side, conventional lighting, fixed-speed motors on variable-torque loads, and continuously loaded compressors and refrigeration plant routinely operate well outside their optimum efficiency band. Because these loss mechanisms are common across the sector and the corrective technologies are commercially mature, the savings identified in this compendium are readily achievable rather than aspirational.

Taken together, the technology set assessed indicates that MSME beverage manufacturing units can realistically target a 15–20% reduction in electrical energy consumption, a 20–30% reduction in thermal energy (fuel and steam) consumption, and a 15–25% reduction in specific freshwater consumption, through systematic adoption of the measures detailed in this compendium. These reductions translate directly into lower utility costs, reduced greenhouse gas emissions, and reduced exposure to future increases in energy tariffs, fuel prices, and water-related compliance costs.

The nil/low-investment category comprising eight technologies including compressed air pressure and leak management, steam trap surveys, boiler combustion tuning, condensate recovery, insulation upgrades, LED lighting retrofits, and energy sub-metering requires little to no capital outlay and typically pays back within 6 months to 2 years. These measures should be treated as immediate priorities, since they combine the shortest payback periods with negligible implementation risk and require no process downtime or production-line modification.

The medium and high-investment categories introduce technologies with materially higher savings intensity per unit but longer payback horizons, typically 1.5 to 4 years. These include variable frequency drives on high-duty motors such as RO high-pressure pumps and filling line drives (20–50% energy reduction on variable-torque loads), diesel generator synchronisation for fleets running on standby or partial grid supply, floating head pressure control on refrigeration plant, and regenerative plate heat exchangers on pasteurisation lines, which can recover 80–90% of process heat and reduce combined heating and cooling utility demand by 15–30%. These interventions are best scheduled to coincide with planned equipment replacement or capacity expansion, where the incremental cost of specifying the efficient technology is small relative to a like-for-like replacement.

Renewable energy integration solar photovoltaic systems for captive electricity generation, solar thermal systems for process hot water and preheat, and biomass fuel substitution in boilers offers the sector a pathway to structurally reduce dependence on grid electricity and fossil fuel, offsetting 15–30% of annual electricity demand or 40–90% of conventional fuel consumption depending on the technology and site conditions, with paybacks of 3–5 years under current MSME-scale capital costs.

On the resource efficiency side, water sub-metering, CIP final-rinse water reuse, and membrane filtration (UF/NF) upgrades address the sector's substantial freshwater intensity at relatively low capital cost, while advanced water reclamation using MBR combined with RO polishing offers a longer-term pathway to 80–95% water recovery for units facing water scarcity, rising freshwater tariffs, or tightening effluent discharge norms.

In combination, the technologies presented in this compendium constitute a practical, phased, and financially grounded roadmap near-term operational and monitoring measures to capture quick wins at minimal cost, medium-term capital upgrades aligned with equipment renewal cycles, and longer-term renewable energy and advanced water reclamation investments to secure structural cost stability and decarbonisation. Adopted systematically, this roadmap enables MSME beverage manufacturing units to materially reduce operating costs, strengthen resilience to energy and water price volatility, and improve competitiveness in increasingly efficiency- and sustainability-conscious domestic and export markets.

Key Findings

Based on cluster-level assessments and sector benchmarking, MSME beverage manufacturing units can typically achieve the following resource-saving potential through systematic adoption of the technologies covered in this compendium:

Resource	Reduction Potential	Primary Drivers
Electrical energy	15 – 20%	LED lighting, compressed air optimisation, VFDs, refrigeration controls
Thermal energy (fuel/steam)	20 – 30%	Steam trap repair, O ₂ trim, condensate recovery, insulation, heat recovery
Freshwater consumption	15 – 25%	CIP rinse reuse, membrane filtration, water sub-metering, MBR + RO reclamation

Technology Landscape

The 32 technologies are distributed across categories as follows:

Category	No. of Technologies	Investment Range	Typical Payback
Energy Efficiency — Nil/Low Investment	8	Nil – ₹5 lakhs	Immediate – 3 years
Energy Efficiency — Medium/High Investment	6	₹4 – 12 lakhs	1.5 – 3 years
Future Ready	7	₹25 – 60 lakhs	3 – 5 years
Renewable Energy	3	₹10 – 60 lakhs	3 – 5 years
Resource (Water and Waste) Efficiency	8	₹1.5 – 60 lakhs	1.5 – 5 years

Priority Quick Wins

The following nil/low-investment measures offer the fastest returns and should be prioritised first:

- Compressed air header pressure optimisation — nil cost, immediate savings
- Compressed air leak detection & repair, and steam trap survey & repair — both under 1 year payback
- Boiler combustion tuning (O₂ trim) and thermal insulation upgrades — 1–1.5 years payback
- LED lighting retrofit with occupancy/daylight controls, and condensate recovery — 1.5–2 years payback

Strategic Direction

A phased approach, nil/low-investment measures in the first 6 months, medium-investment upgrades (VFDs, refrigeration controls, membrane filtration) over 6–18 months, and high-investment capital projects (regenerative heat recovery, solar PV and thermal, biomass boilers, advanced water reclamation) over 18–48 months allows MSME beverage manufacturers to capture savings progressively while managing capital outlay. Continuous energy and water monitoring, periodic RECP reassessment, and alignment with national best-practice standards will sustain gains and support long-term competitiveness, cost stability, and decarbonisation.

Technology Attractiveness Summary

Table 1 Technology Summary for the Beverage Sector

Category	Measure	Investment Tier	Key Benefit	Indicative Payback
Energy Efficiency				
Lighting	Switch-off Culture, Occupancy/Daylight Sensing & LED Retrofit	Nil/Low	Connected lighting load reduction of 40–60% versus conventional fixtures	6–14 months
Thermal Utility	Steam Trap Survey & Repair	Nil/Low	Eliminates continuous live-steam loss	< 6 months
Thermal Utility	Boiler Combustion Tuning (O ₂ Trim Control)	Nil/Low	Improved boiler thermal efficiency, typically 1–3 percentage points	< 12 months
Thermal Utility	Condensate Recovery & Return to Boiler Feed Tank	Nil/Low	Reduction in fuel required to raise feed water temperature	12–18 months
Thermal Utility	Insulation Upgrade – Steam Piping, Valves, Flanges, Deaerator	Nil/Low	Reduction in radiant/convective heat loss	6–12 months
Compressed Air	Compressed Air Leak Detection & Repair	Nil/Low	Direct reduction in compressor run-hours/loading	< 6 months
Compressed Air	Compressed Air Header Pressure Optimisation	Nil/Low	Direct reduction in compressor specific power consumption	Immediate (nil-cost)
Monitoring	Energy Sub-Metering & KPI Benchmarking	Nil/Low	Identification of abnormal consumption trends	12–18 months
Medium and High Investment				
Electrical	Energy Efficient Motors (IE3 or IE4 or IE5)	Medium	High-efficiency motors with lower losses, heat and vibration; 25–40% energy saving	1.5–3 years
Motors & Drives	VFD Retrofit on Key Motors (RO High-Pressure Pump, Syrup Agitators, Filling Line Drive)	Medium	Energy reduction through speed control for variable-torque loads	18–30 months
Standby Power	Load-Based DG Synchronisation/Sizing Panel	Medium	Reduced specific fuel consumption	24–30 months
Refrigeration	VFD + Floating Head Pressure Control on Refrigeration Compressor Plant	Medium	Reduced compressor specific power consumption	24–36 months
Cooling Tower Optimisation	VFD-based fan and pump control, high-efficiency motors and fans, automated temperature control, optimised water distribution, fill/nozzle maintenance	Medium	Reduces electricity consumption and improves cooling performance	12–24 months
Thermal Processing	Regenerative Plate Heat Exchanger (PHE) Heat Recovery on Pasteurizer	High	90–95% regeneration efficiency, reducing heating and cooling demand	36–48 months

Category	Measure	Investment Tier	Key Benefit	Indicative Payback
Emerging & Future-Ready				
Thermal Processing	Multi-Effect Evaporator (MEE) — Juice/Dairy Concentration	High Investment	Delivers up to 75% energy savings compared to single-effect evaporation.	3–5 years
Thermal Processing	Mechanical Vapour Recompression (MVR)	High Investment	Shifts energy input from thermal fuel to electricity	3–4 years
Thermal Processing	Aseptic Cold-Fill Processing	High Investment	Eliminates reheating of the entire filled/sealed package	4–6 years
Sanitation/CIP	Ozone-Based CIP Sanitation	Medium Investment	Eliminates heating energy, steam cost, and warm-up wait time entirely	2–3 years
Industrial Heat Pumps for Low-Temperature Process Heat / Hot Water	COP 3–5; replaces boiler-raised hot water below ~90°C with 60–75% less primary energy per unit of heat	High Investment	Reduces fuel and primary energy consumption while lowering GHG emissions.	2.5–4 years
Heat Recovery from Air Compressors	Recovers up to 80–94% of compressor motor input as usable heat for process/boiler feed water preheat	Medium Investment	Convert waste heat from compressors into useful process heat, reducing fuel consumption and operating costs.	1–2 years
Energy Management System (EMS) / Utility Optimisation Platform	Plant-wide real-time visibility and automated set-point optimization, typically unlocks a further 5–12% saving on top of point measures	Medium Investment	Energy Management System (EMS) monitors real-time energy flow to reduce wastage	1.5–3 years
Renewables				
Solar	Solar Photovoltaic (PV) for Captive Electricity Generation	Renewable	Offsets grid-purchased or DG-generated electricity	4–6 years
Solar	Solar Heater for Hot Water & Process Preheat	Renewable	Reduces boiler/water-heater fuel consumption	3–5 years
Biomass	Biomass Fuel Substitution in Boiler	Renewable	Substitution of fossil fuel with regional biomass fuel	2–4 years
Resource Efficiency – Water				
Monitoring	Water Sub-Metering & Leak Detection	Nil/Low	Identification of underground/in-line leaks	6–12 months
CIP / Cleaning	CIP Final-Rinse Water Reuse (as pre-rinse)	Nil/Low	Direct reduction in fresh water draws per CIP cycle	12–18 months
Water Treatment	Membrane Filtration Upgrade (UF/ NF) for Process Water Treatment	Medium	Improved water recovery ratio and reduced reject volume	24–36 months
Advanced Treatment	Advanced Water Reclamation – MBR + RO Polishing Train	High	High-quality permeate enabling broader water reuse	4–6 years

Category	Measure	Investment Tier	Key Benefit	Indicative Payback
Resource Efficiency – Waste & Packaging				
Packaging	Lightweighting of PET Bottles	Medium	8–20% reduction in resin and embodied carbon per bottle	6–18 months
Packaging	Recycled PET	Medium	Reduced virgin resin demand and associated GHG emissions	Cost-neutral to 1 year
Packaging	Circular-Economy Packaging Practices	Medium	Reduced packaging waste and improved material recovery	Varies – largely operational
Packaging	Compostable Packaging Materials	Medium	Reduced fossil-plastic dependence	Product/context dependent

Beverage Landscape

01

1.1 India's Beverage Landscape¹

India's beverage industry is made up of two broad segments,

1. Non-alcoholic drinks (water, juices, tea, coffee, carbonates, and functional beverages)
2. Alcoholic drinks (beer, spirits, wine, and RTD beverages).

Both segments are expanding at a healthy pace, supported by a young population, rising incomes, faster urbanisation, and a growing appetite for premium and health-oriented products.

1.2 Non-Alcoholic Beverages in India

India's non-alcoholic beverages market was valued at USD 14.95 billion in 2024 and is projected to grow at a CAGR of 7.36% through 2030. A separate estimate places 2023 market value at USD 30,846.6 million, rising to USD 64,248.9 million by 2033 (CAGR 7.66%, 2024–2033) — the variation reflects differing scope across data providers. Combined at-home and out-of-home revenue is projected at USD 19.74 billion in 2025, with total volume expected to reach 34.87 billion litres the same year.

Tea is the largest category within India's non-alcoholic beverage market, valued at USD 12.14 billion in 2023 and forecast to reach USD 24.07 billion by 2033 (CAGR 7.13%). Bubble/sparkling water is the fastest-growing category, expected to touch USD 0.918 billion by 2033 at a CAGR of 13.74%. Packaged water leads in volume terms, while juices and nectars see steady, health-driven demand.

- Carbonated soft drinks — broad mainstream demand, strong retail penetration
- Bottled/package water — largest volume category, fastest urban-rural growth
- RTD teas & coffees — rising with café culture and convenience demand
- Juices & pulp-based concentrates — favoured by health-conscious consumers
- Sports & energy drinks — growing with active/urban lifestyles
- Dairy substitutes & functional drinks — emerging premium categories

1.3 Alcoholic Beverages in India

India's alcoholic beverage market was estimated at USD 39.30 billion in 2024 and is projected to grow to USD 68.75 billion by 2034, at a CAGR of 5.8% (2025–2034). India ranks as the fifth-largest alcohol beverage market globally and the industry contributes close to 2% of the country's nominal GDP. Total consumption volume reached an estimated 11.6 billion litres in 2024, with per-capita consumption at 4.9 litres (8.1 litres among male consumers), expected to rise to around 6 litres per capita by 2030.

1.4 State-Level Overview - Telangana²

Telangana, located in southern India, shares borders with Maharashtra and Chhattisgarh to the north, Karnataka to the west, and Andhra Pradesh to the south and east. The State's food processing industry contributes an additional 12.5% in value to agricultural produce marketed in Telangana, and processes approximately 25% of the State's agricultural and allied sector output, a base that also underpins its beverage-related processing activity (fruit pulp, dairy, and spice-derived drinks).

¹ [https://mofpi.gov.in/sites/default/files/KnowledgeCentre/Sector%20Profile/Sector_Profile_Beverages%20\(1\).pdf](https://mofpi.gov.in/sites/default/files/KnowledgeCentre/Sector%20Profile/Sector_Profile_Beverages%20(1).pdf)

² https://wfindia.s3.ap-south-1.amazonaws.com/website_images/pdf/1694687520_50830546.pdf

Table 2 Telangana — Key State Indicators

Indicator	Value
State Capital	Hyderabad
Geographic Area	112,077 sq. km
Population (Census 2011)	35.20 million
Warehouse Capacity	4.45 lakh MT
Cold Storage Capacity	4.10 lakh MT
Food Processing Industries (registered)	3,989
Share of Registered FPI Factories in India	9.62%

Telangana's agricultural output provides a strong raw-material base for fruit-based, dairy-based, and spice-infused beverage processing. The State is among India's leading producers of several beverage-relevant crops and dairy products.

Table 3 Key Raw Materials for Beverage Processing in Telangana

Commodity	Telangana's Position	Production (2021-22)
Mango	5th largest producer in India	1,165.12 thousand tonnes
Sweet Orange	2nd largest producer in India	603.72 thousand tonnes
Turmeric	2nd largest producer in India	330.26 thousand tonnes
Tamarind	5th largest producer in India	12.66 thousand tonnes
Rice	4th largest producer in India	10,217 thousand tonnes
Milk	Major dairy-producing state	5,765 thousand tonnes

These raw materials support beverage applications such as fruit juices and pulp-based drinks (mango, sweet orange), dairy-based beverages (milk, lassi, flavoured milk), turmeric-based functional drinks including Haldi Doodh (Golden Turmeric Milk) and turmeric extracts/oleoresins used as beverage colourants, and rice-based beverages such as rice milk and rice-based fermented drinks.

Under the Pradhan Mantri Formalisation of Micro Food Processing Enterprises Scheme (PMFME), Telangana has designated district-level production clusters. The following clusters are directly relevant to beverage processing:

Table 4 PMFME Production Clusters Relevant to Beverages

Cluster Category	Districts
Milk-based products	Sangareddy, Suryapet, Yadadri Bhuvanagiri
Mango-based products	Jagitial, Nagarkurnool, Mancherial
Sweet Orange-based products	Nalgonda
Turmeric-based products	Nizamabad

Several national beverage manufacturers and dairy processors operate manufacturing units in Telangana, reflecting the State's raw-material advantage and industrial infrastructure.

Table 5 Beverage & Dairy Companies with Presence in Telangana

Company	Location	Segment
Varun Beverages Ltd.	Sangareddy	Carbonated soft drinks & beverages (PepsiCo franchisee)
Parle Agro Private Limited	Sangareddy	Fruit-based drinks (Frooti, Appy)
Tata Consumer Products Limited	Sangareddy	Tea, packaged beverages
Creamline Dairy Products Ltd.	Hyderabad	Milk & dairy-based beverages
Dodla Dairy Ltd.	Rangareddy	Milk & dairy-based beverages
Chandana Milk Products	Vikarabad	Milk & dairy-based beverages
Karimnagar Milk Producer Company Ltd	Karimnagar	Milk & dairy-based beverages
Vallabha Milk Products Pvt Ltd	Yadadri Bhuvanagiri	Milk & dairy-based beverages

1.5 Energy Consumption Profile for Beverage Industry

Beverage manufacturing is a resource and energy-intensive industry, with several unit operations contributing significantly to both electrical and thermal energy demand. Understanding where energy is consumed is essential for identifying efficiency opportunities and reducing operating costs.

The pie chart illustrates the typical distribution of electrical energy consumption in a beverage manufacturing facility. **Refrigeration** is the largest energy consumer, accounting for **27%** of total electricity use, followed by **air compression (17%)**, **lighting (14%)**, and **other motors (12%)**. **Fluid pumps** contribute **10%**, while **miscellaneous equipment** accounts for **7%** and the **water treatment plant** for **5%**. **Conveyors** and **blowers** each consume **3%**, whereas **hydraulic pumps** represent the smallest share at **2%**. The distribution highlights that refrigeration and compressed air systems together account for nearly **44%** of the plant's electricity consumption, indicating significant opportunities for energy efficiency improvements through high-efficiency refrigeration systems, compressor optimisation, leak reduction, and advanced control strategies.

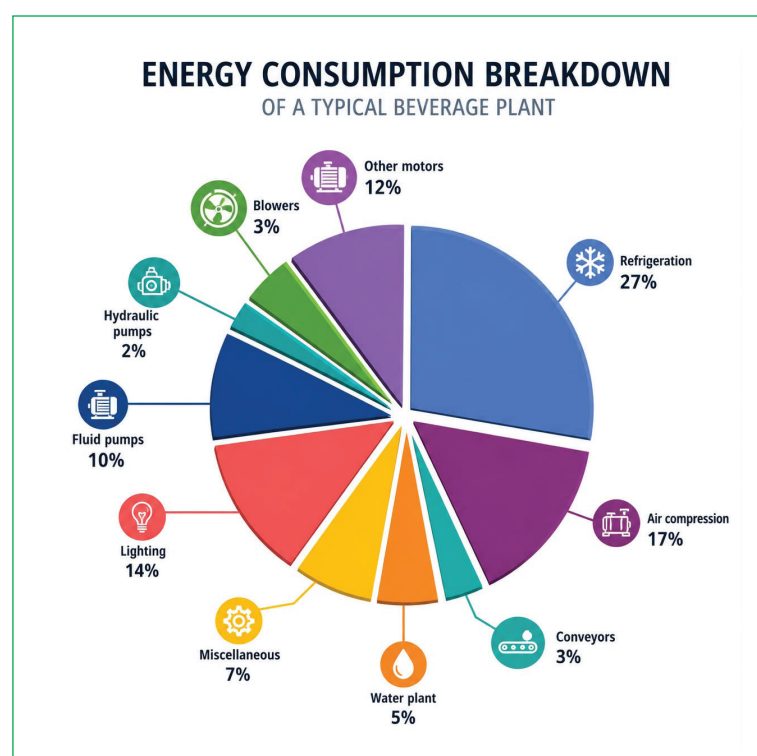


Figure 1 Energy Consumption Breakdown of a Typical Beverage Plant³

³ <https://shaktifoundation.in/wp-content/uploads/2017/06/widening-of-pat-sectors-beverage.pdf>

These operations collectively account for a substantial share of a plant's total electricity and thermal energy consumption. Thermal processes such as pasteurisation, sterilisation, and boiler operation typically dominate thermal energy use, while refrigeration, compressed air, and packaging machinery are major contributors to electrical demand.

The **2023 Beverage Industry Environmental Roundtable (BIER) Benchmarking Study** presents environmental performance data collected from **16 participating companies and partner associations**, covering **1,530 facilities** across six continents in which more than 400 industries are present in Asia, for the 2022 reporting year. The benchmark indicates continuous improvements in sustainability performance, with beverage production increasing from **278 to 305 billion litres** between 2017 and 2022, while the **Water Use Ratio (2.58 to 2.38 L/L)**, **Energy Use Ratio (0.70 to 0.62 MJ/L)**, and **Emissions Ratio (57.32 to 44.46 g CO₂e/L)** all improved, demonstrating enhanced resource efficiency and reduced environmental impact across the beverage industry.⁴

Table 6 BIER Benchmarking Study Performance Overview

Parameter	Unit	2017	2020	2022
Total Companies Reporting	Number	15	16	16
Total Facility Count	Number	1,587	1,564	1,530
Total Production	Billion L	278	282	305
Total Water Use	Billion L	718	676	725
Total Energy Use	Billion MJ	195	195	188
Total Emissions	Million Metric Tonnes CO ₂ e	15.41	14.59	13.52

Table 7 Water Use Ratio (WUR) Benchmark

Beverage Sector	Unit (L/L)	2017	2020	2022
Overall Industry	L/L	2.58	2.40	2.38
Brewery	L/L	3.32	3.04	3.11
Distillery	L/L	35.86	31.16	28.51
Winery	L/L	3.87	4.04	3.98
Bottling (All)	L/L	1.91	1.81	1.77

Table 8 Energy Use Ratio (EUR) Benchmark

Beverage Sector	Unit (MJ/L)	2017	2020	2022
Overall Industry	MJ/L	0.70	0.69	0.62
Brewery	MJ/L	1.09	1.05	0.87
Distillery	MJ/L	12.71	14.85	13.81
Winery	MJ/L	2.11	1.32	1.56
Bottling (All)	MJ/L	0.39	0.38	0.36

Table 9 Greenhouse Gas Emissions Ratio (ER) Benchmark

Beverage Sector	Unit (g CO ₂ e/L)	2017	2020	2022
Overall Industry	g CO ₂ e/L	57.32	51.73	44.46
Brewery	g CO ₂ e/L	91.70	74.33	67.76
Distillery	g CO ₂ e/L	768.73	731.57	689.57
Winery	g CO ₂ e/L	89.10	77.31	97.78
Bottling (All)	g CO ₂ e/L	34.51	33.97	31.67

⁴ [http://info.us.anteagroup.com/hubfs/BIER%20Downloads/2023-BIER-Benchmarking-Executive-Summary-Report%20\(2\).pdf](http://info.us.anteagroup.com/hubfs/BIER%20Downloads/2023-BIER-Benchmarking-Executive-Summary-Report%20(2).pdf)

Financial Mechanism and Support Schemes

02

Beverage MSMEs can access a combination of central government financial support, green-finance facilities, food-processing schemes, export and marketing support, and Telangana State incentives to support technology upgradation, energy efficiency, resource efficiency, cleaner production and business expansion. The applicability of each scheme depends on the enterprise category, project type, location, eligible project cost, financing structure and prevailing scheme guidelines. MSMEs should confirm current eligibility and application conditions with the implementing agency or financial institution concerned before committing investment.

2.1 Technology Upgradation and Green Incentives

MSE-GIFT (Green Investment and Financing for Transformation): The scheme provides a 2% per annum interest subvention on eligible term loans for eligible Udyam-registered Micro and Small Enterprises adopting approved green technologies, subject to the prevailing scheme guidelines.

MSE-SPICE (Scheme for Promotion and Investment in Circular Economy): Provides credit-linked capital subsidy support for eligible circular-economy projects, including appropriate waste recovery, recycling and resource-efficiency investments, subject to applicable eligibility conditions and subsidy ceilings.

MSME Sustainable (ZED) Certification: The Zero Defect Zero Effect framework supports MSMEs in improving product quality, environmental performance, resource efficiency and sustainable production practices. Eligible units should refer to the prevailing ZED guidelines for applicable financial assistance.

2.2 Telangana State Incentives (For Units in Telangana)

Beverage manufacturing units located in Telangana can explore incentives available under the **Telangana MSME Policy 2024** and associated State Government industrial-support mechanisms.

Depending on enterprise category, investment level, location and project type, eligible units may receive support relating to:

- Investment and capital-related incentives
- Power and utility-related support
- Interest-related assistance
- Reimbursement of eligible statutory charges
- Infrastructure and industrial development support
- Cleaner-production and environmental initiatives
- Skill development and employment generation
- Additional support for eligible women, SC/ST and other priority categories

Beverage MSMEs should verify the applicable incentive based on their enterprise classification, project location, investment level, date of establishment, nature of activity and eligibility category.

Applications and approvals may be facilitated through the Telangana State Industrial Project Approval and Self-Certification System (TG-iPASS) and the relevant Industries & Commerce Department procedures.

2.3 General Central Government Subsidies

PM Formalisation of Micro Food Processing Enterprises (PMFME)

Eligible individual micro food-processing units can access a credit-linked capital subsidy of **35% of eligible project cost, subject to a maximum of ₹10 lakh per unit**. A minimum beneficiary contribution of 10% is generally required, with the balance financed through bank credit.

The scheme is particularly relevant to micro beverage units involved in fruit-based, dairy-based and other processed beverage products.

Creation/Expansion of Food Processing and Preservation Capacities (CEFPPC) under PMKSY

The scheme supports eligible projects for the creation, expansion and modernisation of food-processing and preservation capacity. It can be relevant to beverage units undertaking capacity expansion, modernisation and installation of improved processing and preservation systems.

Pradhan Mantri Kisan Sampada Yojana (PMKSY)

PMKSY provides support for infrastructure and capacity creation across the food-processing value chain, including eligible cold-chain, processing and preservation infrastructure. Beverage units handling fruit pulp, juices, dairy products and other perishable raw materials may explore applicable components.

Production Linked Incentive Scheme for Food Processing Industry (PLISFPI)

The scheme supports eligible food-processing enterprises and identified product categories and may be relevant to qualifying branded food and beverage manufacturers. Eligibility should be assessed against the prevailing scheme guidelines and notified product categories.

Animal Husbandry Infrastructure Development Fund (AHIDF)

Eligible dairy and animal-product value-chain enterprises can explore financial support for infrastructure development and value addition. This may be particularly relevant to units involved in milk processing and dairy-based beverages where the project meets the scheme eligibility requirements.

Other MSME Support Schemes

Eligible beverage MSMEs may also explore PMEGP, MSME Innovative, National SC-ST Hub and other applicable Ministry of MSME programmes, depending on the nature of the enterprise and proposed investment.

2.4 Marketing and Export Support

Market development and export readiness are important for beverage MSMEs seeking to expand beyond local and domestic markets. Eligible enterprises can explore the following support mechanisms:

Procurement and Marketing Support (PMS) Scheme: Supports eligible MSMEs in improving market access through activities such as participation in trade fairs and exhibitions, packaging and other approved marketing activities.

International Cooperation (IC) Scheme: Eligible MSMEs seeking international market exposure may obtain support for approved international exhibitions, trade fairs, buyer-seller interactions and other internationalisation activities, subject to the prevailing scheme guidelines.

Export Promotion: Beverage MSMEs can utilise support and market-development opportunities provided through relevant export-promotion bodies, sector associations and the Directorate General of Foreign Trade (DGFT), particularly for processed food, fruit-based products and other eligible beverage categories.

Branding and Market Development: MSMEs should consider investment in packaging improvement, product certification, labelling compliance, digital marketing, participation in trade fairs and buyer-seller meets to strengthen market access and export readiness.

2.5 Eligible Equipment under MSME GIFT Scheme: Beverage Sector

The MSE-GIFT scheme provides interest-subvention support for eligible green technologies listed under the applicable technology framework. For beverage MSMEs, the following technology areas may be relevant for evaluation, subject to confirmation against the latest approved MSE-GIFT technology catalogue and project eligibility.

Table 10 Eligible Equipment List Under MSME GIFT Scheme

No.	Equipment / Technology	Energy Saving Min (%)	Max (%)	Sector	Key Advantage
1	Automatic Rinsing, Filling & Capping Machine for PET Bottles	10	15	Food Processing	Improves productivity & quality, easy to operate & control
2	Automatic Rinsing, Filling & Capping Machine for Glass Bottles	10	15	Food Processing	Improves productivity & quality, easy to operate & control
3	Shrink Sleeve Inserting Machine	10	15	Food Processing	Improves productivity & quantity, easy to operate
4	Air Dryer – Refrigerated Air Compressor Type	30	40	Food Processing	Precise dewpoint control, fault indication
5	Cone Filling Machines (with VFD controls)	20	35	Food Processing	Adjustable filling volume, easy CIP cleaning
6	Tetra Pak Milk Pasteurisation (PLC temperature control)	50	60	Food Processing	Safe production, no pressure dip, reduced product loss
7	Tetra Pak Milk Homogeniser (serial cooling system)	25	30	Food Processing	Reduced maintenance & energy cost, low noise
8	Automatic Volumetric Liquid Filling Machine with VFD	15	30	Food Processing	Vibration-free, self-centering nozzle avoids foaming
9	Semi Automatic Screw Capping Machine	10	20	Food Processing	Easy operation, no cross-contamination
10	Semi Automatic ROPP Cap Sealing Machine	15	20	Food Processing	Accurate functioning, durable, cost-effective
11	Automatic Single Head Screw Capping Machine	15	30	Food Processing	Low noise, low power consumption
12	Automatic Single Head ROPP Cap Sealing Machine (AC drive)	15	30	Food Processing	High efficiency, low electricity consumption
13	Automatic Multi Head Screw Capping Machine	15	30	Food Processing	Low noise, quick in-feed worm setting
14	Automatic ROPP Cap Sealing Machine	15	30	Food Processing	Longer working life, low maintenance
15	Automatic Dosing Cup Placement & Pressing Machine (AC drive)	15	30	Food Processing	Low maintenance, reliable performance
16	Automatic Filling-Plugging-Capping Machine (PLC)	10	25	Food Processing	Fully automatic, compact, user-friendly
17	Screw Packaged Chilling Unit	10	20	Food Processing	Efficient chilling for beverage processing
18	Rotary Piston Filling & Sealing Machine	20	30	Packaging	Compact, versatile, easy operation
19	Double Chamber Vacuum Packaging Machine	15	20	Packaging	Efficient sealed packaging

No.	Equipment / Technology	Energy Saving Min (%)	Max (%)	Sector	Key Advantage
20	Falling Film Chillers	20	22	Dairy	Continuous chilling near freezing point; pre-chills process water
21	Ice Bank Tank (IBT)	25	30	Dairy	Direct cooling, low energy consumption
22	Thermal Energy Storage for Bulk Milk Coolers (BMC)	15	20	Dairy	Ice-based cooling without grid dependency, preserves freshness
23	Tube Ice Plant	10	15	Ice Making	Continuous freezing/ harvesting, steady ice supply
24	Methane Capture Technology	-	-	Dairy	Effluent treatment energy recovery, saves fuel/electricity

Beverage Manufacturing Processes by Category

03

Beverage processing steps differ meaningfully by product category, particularly around ingredient handling, thermal treatment and finishing. Separate process descriptions are provided below for the three broad categories, as recommended by the reviewer.

3.1 Non-Alcoholic Beverages (Carbonated Drinks, Juices, Packaged Water)

- **Raw material procurement & storage:** water, sugar, fruit concentrates, flavours/colours, CO₂ and packaging materials are qualified against specification sheets (Brix, acidity, microbial load) and stored under FIFO/FEFO discipline.
- **Water treatment:** multimedia filtration, activated carbon, reverse osmosis, UV/ozone disinfection and mineral adjustment produce consistent product-grade water (often >90% of final product volume).
- **Syrup preparation & mixing:** sugar dissolution in jacketed vessels, followed by addition of flavours, acids, preservatives and functional additives under controlled agitation; in-process checks on Brix, pH and viscosity.
- **Filtration/clarification:** micro/ultrafiltration for juices and teas; centrifugation for pulp separation in fruit-based drinks.
- **Thermal treatment:** conventional pasteurisation (72–95°C) or UHT (135–150°C, seconds) depending on shelf-life format.
- **Carbonation (where applicable):** CO₂ injection into chilled product under controlled pressure to set fizz level.
- **Filling, packaging, labelling/coding and QC:** automated PET/glass/can filling lines with fill-volume, seal and torque checks; batch/date coding for traceability; storage and distribution under appropriate temperature control.

3.2 Dairy-Based Beverages (Flavoured Milk, Lassi, Buttermilk, Milk Drinks)

- **Raw milk reception & chilling:** milk is tested for fat, SNF, adulterants and microbial load at reception, then rapidly chilled to 4–6°C in plate chillers to arrest bacterial growth — refrigeration load here is a major electrical energy driver.
- **Standardisation & separation:** cream separators adjust fat content to product specification; skim/cream streams are routed to different product lines.
- **Homogenisation:** high-pressure homogenisers reduce fat globule size for a stable, uniform product — a significant motor-driven electrical load.
- **Blending/flavouring:** sugar, flavours, stabilisers and functional ingredients are blended in jacketed vessels under controlled temperature.
- **Thermal treatment:** pasteurisation (short shelf-life, chilled distribution) or UHT/aseptic processing (135–150°C, ambient shelf-stable distribution) — UHT lines carry substantial regenerative heat-recovery potential between incoming raw and outgoing treated product.
- **Aseptic or hygienic filling:** cartons, pouches or PET bottles, with in-line seal integrity checks; chilled or ambient storage depending on process route.
- **Cleaning-in-place (CIP):** dairy lines require frequent, multi-stage CIP cycles (rinse – caustic – rinse – acid – final rinse) due to milk-fouling; this is typically the single largest water and hot-water consumer in a dairy-beverage plant, making CIP final-rinse reuse and regenerative heat recovery particularly high-value interventions for this sub-sector.

3.3 Alcoholic Beverages (Context Only – Predominantly Large-Scale)

Alcoholic beverage manufacturing (beer, spirits, wine, RTD) is included here only for context, since India's alcoholic beverage industry is overwhelmingly composed of large, licence-controlled distilleries, breweries and wineries rather than MSME-scale units; the technology and roadmap content in this compendium is therefore oriented towards non-alcoholic and dairy-based beverage MSMEs.

- **Fermentation:** yeast-driven conversion of sugars (malted grain wort for beer, molasses/grain mash for spirits, crushed grape must for wine) under controlled temperature — typically the most energy-intensive biological step, requiring cooling.
- **Distillation (spirits):** column or pot-still distillation is highly steam-intensive and is the dominant thermal energy load in a distillery.
- **Maturation/ageing (spirits, some wines):** extended storage in casks/tanks, generally with modest utility load beyond warehouse climate control.
- Filtration, blending and dilution to bottling strength, followed by bottling/canning, labelling and case packing on high-speed lines similar in principle to non-alcoholic filling lines.

Energy Conservation and Resource Efficiency Context

Given the substantial electrical and thermal energy demands associated with beverage manufacturing, energy conservation and resource efficiency have become central priorities for the industry, driven by rising utility costs, regulatory pressure, and growing consumer expectations around sustainability. Beverage plants are increasingly adopting a structured approach to energy management, benchmarking consumption against production output (typically expressed as energy use per litre or per unit case produced) to identify inefficiencies and track improvement over time.

On the thermal side, heat recovery systems are widely implemented to capture waste heat from pasteurisers, sterilisers, and boiler flue gases, which can then be reused for preheating incoming water or process fluids, significantly reducing fuel consumption. Insulation of hot water and steam lines, along with regular boiler tuning and maintenance, further minimises thermal losses. On the electrical side, variable-frequency drives (VFDs) on pumps, compressors, and fans allow motor speed to match actual process demand rather than running at fixed full capacity, yielding notable energy savings. Optimising compressed air systems—by fixing leaks, right-sizing compressors, and reducing operating pressure where possible—is another common efficiency measure, as pneumatic systems are historically prone to significant energy wastage.

Refrigeration and chilling systems, essential for product cooling and cold storage, are similarly optimised through improved insulation, efficient compressor technology, and smart control systems that adjust cooling loads based on real-time demand rather than constant operation. Water conservation is closely linked to energy efficiency in this context, since water treatment, heating, and pumping are energy-intensive; recycling of rinse water, condensate recovery, and closed-loop cooling systems help reduce both water withdrawal and the associated energy footprint.

Beyond individual equipment upgrades, many beverage manufacturers pursue broader resource efficiency strategies such as ISO 50001 energy management system certification, real-time energy monitoring through SCADA or building management systems, and periodic energy audits to identify further reduction opportunities. Renewable energy integration—including solar photovoltaic installations, biomass boilers—is also gaining traction as plants seek to lower their carbon footprint alongside operating costs. Collectively, these energy conservation and resource efficiency measures not only reduce environmental impact but also strengthen the long-term competitiveness and regulatory resilience of beverage manufacturing operations.

Technologies For Energy Efficiency

04

Table 11 Energy Efficiency Measures in Beverage Manufacturing

Category	Measure	Investment Tier	Key Benefit	Indicative Payback
Energy Efficiency				
Lighting	Switch-off Culture, Occupancy/Daylight Sensing & LED Retrofit	Nil/Low	Connected lighting load reduction of 40-60% versus conventional fixtures	6-14 months
Thermal Utility	Steam Trap Survey & Repair	Nil/Low	Eliminates continuous live-steam loss (commonly 5-10% of failed traps in an unmanaged population per annum)	< 6 months
Thermal Utility	Boiler Combustion Tuning (O2 Trim Control)	Nil/Low	Improved boiler thermal efficiency, typically 1-3 percentage points versus an untuned unit	< 12 months
Thermal Utility	Condensate Recovery & Return to Boiler Feed Tank	Nil/Low	Reduction in fuel required to raise feed water to saturation temperature (each 6°C rise in feed water temperature is approximately equivalent to a 1% reduction in fuel consumption, as a general planning rule)	12-18 months
Thermal Utility	Insulation Upgrade — Steam Piping, Valves, Flanges, deaerator	Nil/Low	Reduction in radiant/convective heat loss, typically 90%+ compared to a bare surface at equivalent temperature	6-12 months
Compressed Air	Compressed Air Leak Detection & Repair	Nil/Low	Direct reduction in compressor run-hours/loading for the same downstream demand	< 6 months
Compressed Air	Compressed Air Header Pressure Optimisation	Nil/Low	Direct reduction in compressor specific power consumption	Immediate (nil-cost)
Monitoring	Energy Sub-Metering & KPI Benchmarking	Nil/Low	Enables identification of abnormal consumption trends (equipment degradation, control drift) before they compound	12-18 months
Medium and High Investment				
Electrical	Energy Efficient Motors (IE3 or IE4 or IE5)	Medium	High-efficiency motors with superior materials, longer insulation & bearing life, lower waste heat and vibration, increased reliability (25-40% energy saving)	1.5-3 years
Motors & Drives	VFD Retrofit on Key Motors (RO High-Pressure Pump, Syrup Agitators, Filling Line Drive)	Medium	Energy reduction following the cube law relationship between speed and power for variable-torque loads (pumps, fans)	18-30 months

Category	Measure	Investment Tier	Key Benefit	Indicative Payback
Standby Power	Load-Based DG Synchronisation/ Sizing Panel	Medium	Reduced specific fuel consumption (litres of diesel per kWh generated) across the DG fleet	24-30 months
Refrigeration	VFD + Floating Head Pressure Control on Refrigeration Compressor Plant	Medium	Reduced compressor specific power consumption per unit of refrigeration duty (kW/TR), particularly significant during cooler ambient periods	24-36 months
Cooling Tower Optimisation	VFD-based fan and pump control, high-efficiency motors and fans, automated temperature control, optimised water distribution, fill/ nozzle maintenance.	Medium	Reduces electricity consumption of cooling tower fans and pumps, improves cooling performance	12-24 Months
Thermal Processing	Regenerative Plate Heat Exchanger (PHE) Heat Recovery on Pasteurizer	High	Regeneration efficiency of 90-95% is achievable in a well-designed system, substantially reducing both steam/hot-water demand at the heating section and chilled-water/ glycol demand at the cooling section	36-48 months

4.1 Energy Efficiency Measures- Nil and Low Investment

4.1.1 LED Lighting with Occupancy & Daylight Controls

Technology Overview: Modern LED lighting systems combine high-efficiency LED luminaires with intelligent occupancy and daylight sensing to minimise electricity consumption while maintaining the required illumination levels in production, warehouse and utility areas. The technology provides high luminous efficacy, long service life and seamless integration with building management systems.

Working Principle: LEDs generate light through electroluminescence within a semiconductor junction, converting a much larger proportion of electrical energy into visible light than conventional lamps. Occupancy sensors switch or dim lighting based on personnel presence, while daylight sensors continuously adjust output according to available natural light, ensuring that lighting energy closely follows actual demand.



Figure 2 LED Lights with Smart Control System

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹3–5 lakh	1.5–2 years	15–25 tCO ₂ e/year

4.1.2 Steam Trap Survey & Preventive Maintenance

Technology Overview: A steam trap management programme ensures efficient condensate removal without allowing live steam to escape. Regular inspection using ultrasonic and temperature-based diagnostics maintains steam system efficiency and reduces fuel losses.

Working Principle: Steam traps automatically remove condensate and non-condensable gases while preventing live steam loss, ensuring efficient heat transfer and maintaining steam quality. They operate using differences in temperature, density, or pressure between steam and condensate. Faulty steam traps can be identified using ultrasonic testing and temperature measurements, enabling timely maintenance and preventing steam wastage.

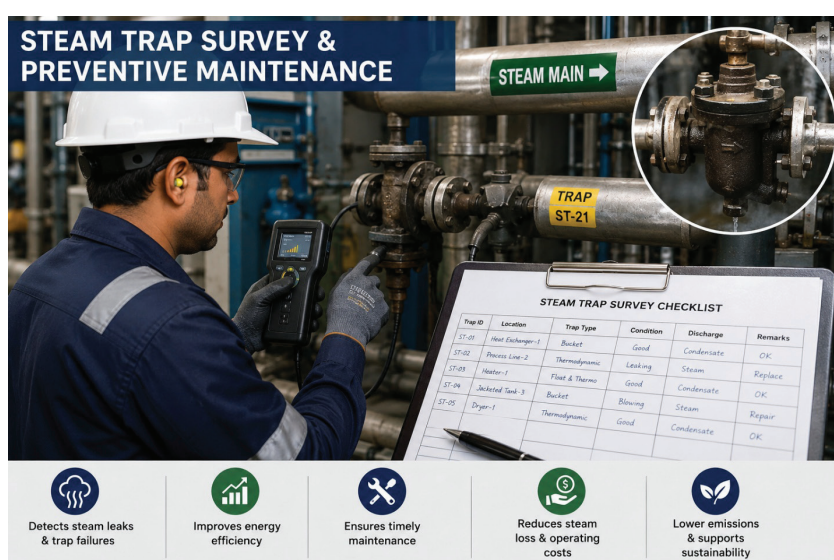


Figure 3 Steam Trap Survey

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹1 – 2 lakhs (survey + trap replacement, ~50 traps)	< 1 year	20 – 40 tCO ₂ e / year

4.1.3 Boiler Combustion Optimisation (O₂ Trim)

Technology Overview: Oxygen trim control continuously optimises the air-to-fuel ratio to maximise combustion efficiency and minimise flue gas losses. The technology is widely adopted in high-efficiency industrial boilers.

Working Principle: An oxygen (O₂) analyser continuously measures residual oxygen in the boiler flue gas and sends the signal to the combustion control system. The controller automatically adjusts the air and fuel supply to maintain the optimum excess air level, improving combustion efficiency, reducing fuel consumption, and minimising stack losses and emissions.

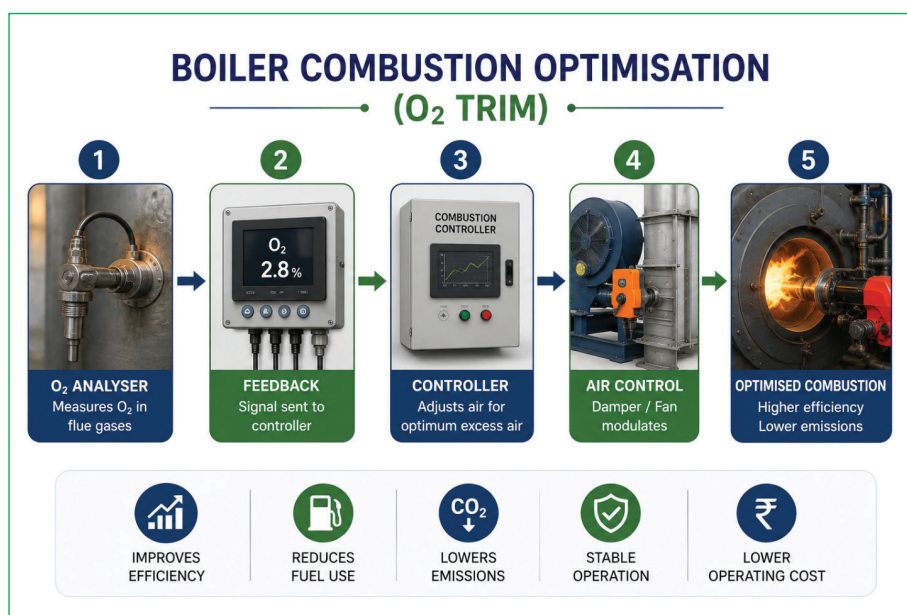


Figure 4 Boiler Combustion Optimisation

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹4 – 6 lakhs (for a 2–5 TPH boiler)	1 – 1.5 years	30 – 50 tCO ₂ e / year

4.1.4 Condensate Recovery

Technology Overview: Condensate recovery systems return hot condensate to the boiler feedwater system, recovering sensible heat, treated water and boiler chemicals while reducing make-up water demand.

Working Principle: Condensate at saturation temperature returns from process heat exchangers/steam traps to a collection tank where the return-line pressure is below the condensate's saturation pressure, a fraction flashes to low-pressure steam, which is separated in a flash vessel and routed to LP steam headers while the remaining condensate (typically 80–95°C) is pumped via a condensate/booster pump to the feedwater tank or deaerator. Since feedwater enthalpy is raised by direct reuse of this sensible heat, the boiler requires proportionally less fuel input to achieve the enthalpy rise from feedwater to saturated steam (ΔH), reducing specific fuel consumption per unit of steam generated.

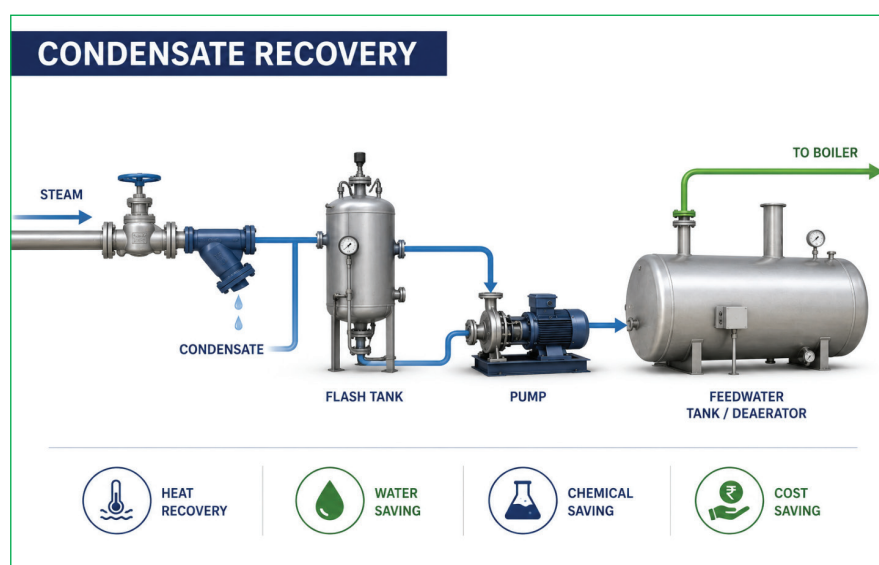


Figure 5 Condensate Recovery

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹5 – 8 lakhs (<i>pipings, pumps, flash vessel</i>)	1.5 – 2 years	40 – 60 tCO ₂ e / year

4.1.5 Thermal Insulation

Technology Overview: High-performance insulation minimises heat losses from steam pipelines, valves, flanges and hot process equipment, improving thermal efficiency and workplace safety.

Working Principle: Low thermal conductivity insulation materials reduce conductive, convective and radiative heat transfer from hot surfaces, thereby retaining useful thermal energy within the process.

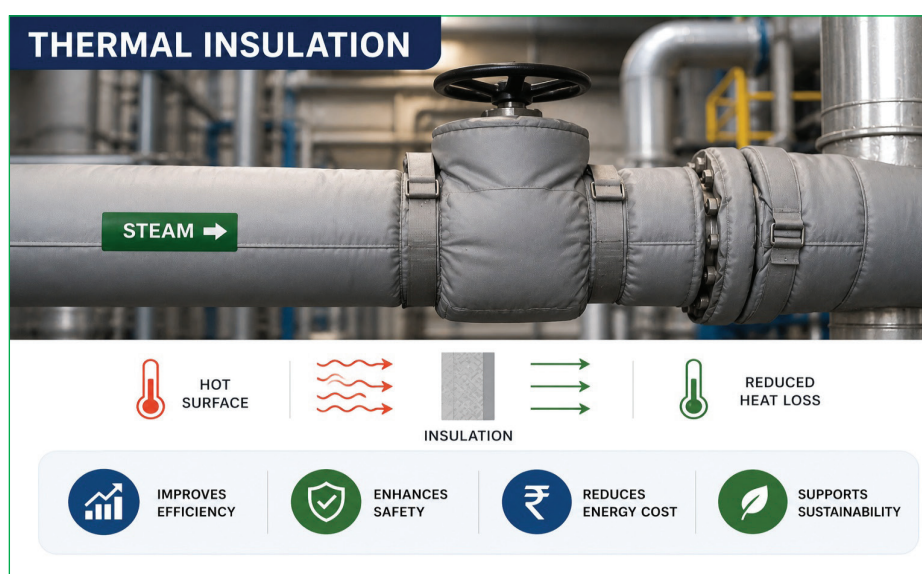


Figure 6 Thermal Insulation

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹2 – 4 lakhs (<i>pipelines, valves, flanges</i>)	1 – 1.5 years	25 – 35 tCO ₂ e / year

4.1.6 Compressed Air Leak Detection

Technology Overview: Leak management programmes identify and eliminate compressed air losses using ultrasonic detectors and systematic maintenance.

Working Principle: Ultrasonic instruments detect high-frequency noise generated by leaking compressed air, enabling rapid localisation and repair, thereby reducing compressor loading.



Figure 7 Compressed Air Leak Detection

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹1 – 1.5 lakh (survey + repairs)	< 1 year	10 – 20 tCO ₂ e / year

4.1.7 Compressed Air Pressure Optimisation

Technology Overview: Pressure optimisation reduces compressor energy consumption by operating at the minimum pressure required for reliable process performance.

Working Principle: The compressed air system pressure is optimised based on end-use requirements and distribution losses, reducing unnecessary compressor load and artificial demand. As a rule of thumb, each 1 bar reduction in system pressure can reduce compressor energy consumption by approximately 6–8%, provided the reduced pressure meets process requirements.

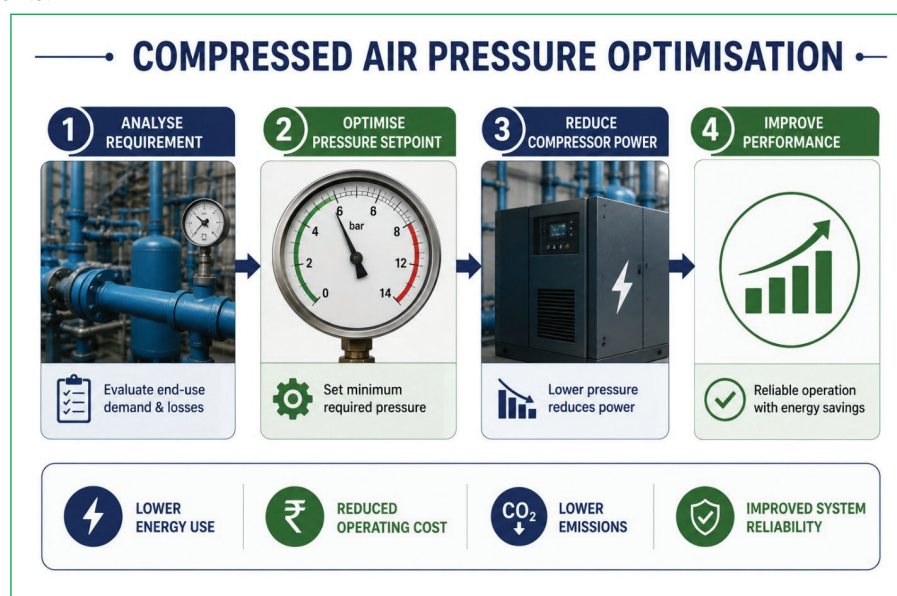


Figure 8 Compressed Air Pressure Reduction

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹0.5 – 1 lakh (controller retuning, minor piping changes)	< 6 months	8 – 15 tCO ₂ e / year

4.1.8 Energy Sub-metering

Technology Overview: Sub-metering provides equipment-level energy monitoring for performance benchmarking and continuous improvement.

Working Principle: Digital meters continuously record utility consumption, enabling KPI tracking, abnormal consumption detection and data-driven maintenance.

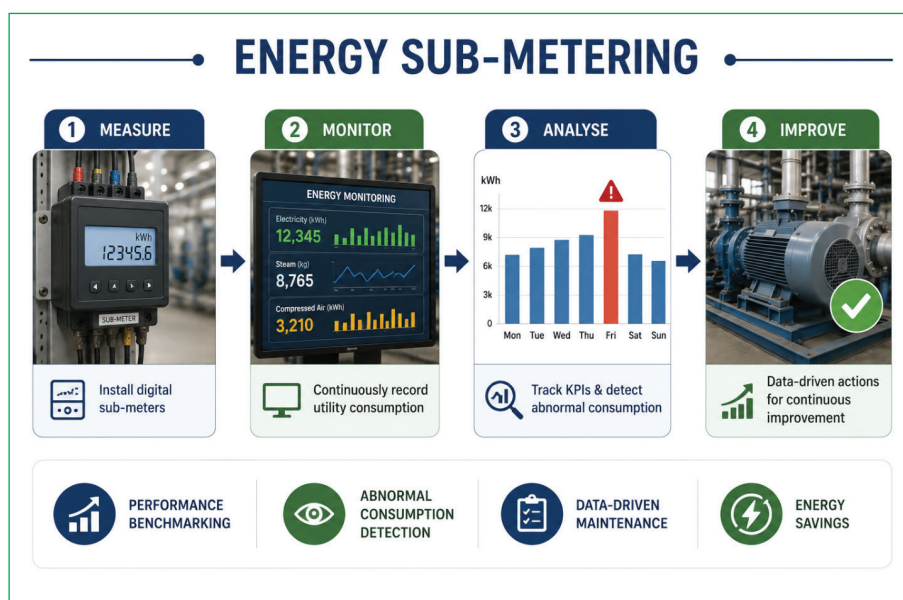


Figure 9 Energy Sub-Metering

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹3 – 5 lakhs (meters + monitoring software, 10–15 points)	2 – 3 years	5 – 10% of facility consumption (enabler for further savings)

4.2 Energy Efficiency Measures- Medium and High Investment

4.2.1 IE3 / IE4 MOTORS

Technology Overview: IE3 (Premium Efficiency) and IE4 (Super Premium Efficiency) motors are high-efficiency induction motors built with improved core materials, optimized winding design, and reduced friction losses, offering significant energy savings over standard IE1/IE2 motors.

Working Principle: IE3/IE4 motors reduce internal losses, copper losses, iron losses, friction & windage losses, and stray load losses through the use of superior electrical steel, higher quality copper/aluminium windings, optimized rotor design, and improved bearing systems. This results in higher operating efficiency across the load range, lower heat generation, and reduced energy consumption for the same output, especially in continuously running moto

3.2.2 IE3 / IE4 MOTORS

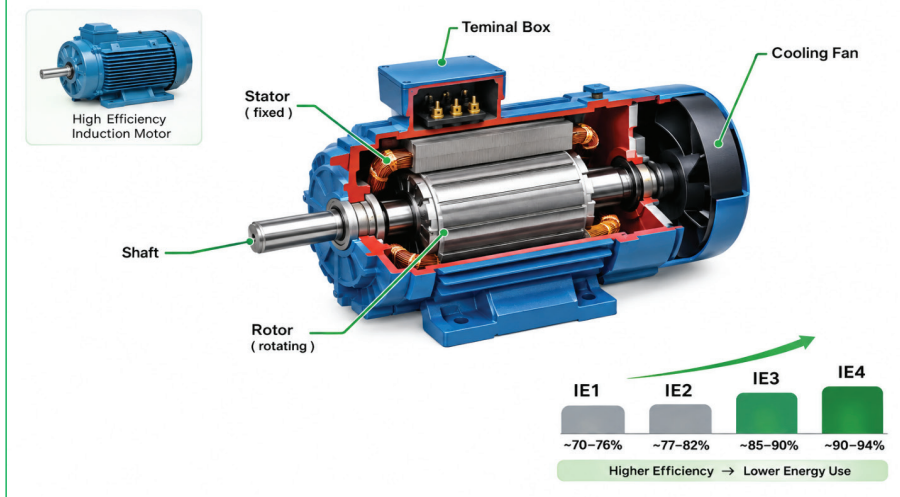


Figure 10. IE4 Motors

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹3 – 6 lakhs (5–8 motors, 15–75 HP range)	1.5 – 3 years	20 – 40 tCO ₂ e / year

4.2.2 VFD on Motors

Technology Overview: Variable Frequency Drives regulate motor speed according to process demand, significantly reducing electricity consumption in pumps, fans and agitators.

Working Principle: A Variable Frequency Drive (VFD) converts fixed-frequency AC power into variable frequency and voltage using Pulse Width Modulation (PWM), allowing the motor speed to match process demand. This reduces energy consumption, especially in variable torque applications such as pumps and fans, where energy savings of **20–50%** can typically be achieved.

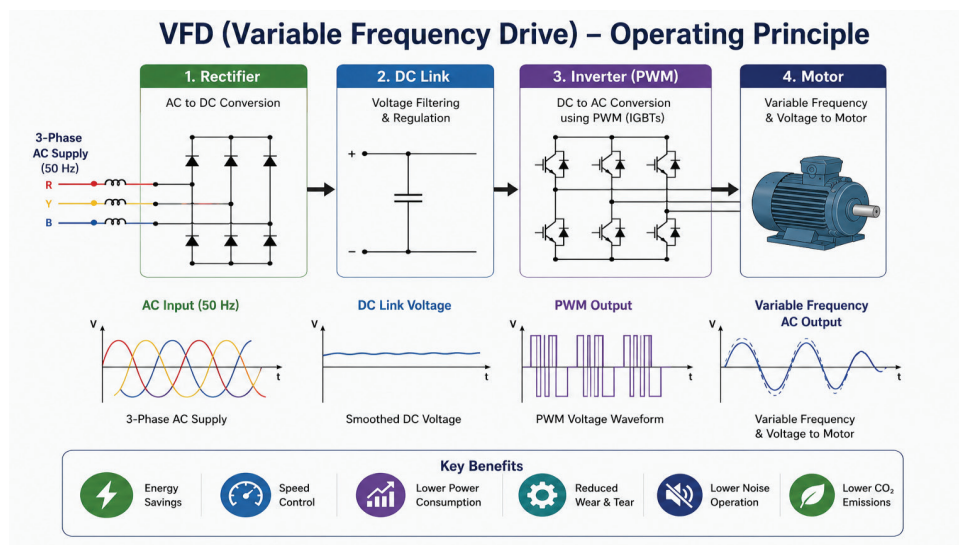


Figure 11 VFD Working

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹4 – 7 lakhs (5–8 motors, 15–75 HP range)	1.5 – 2.5 years	25 – 45 tCO ₂ e / year

4.2.3 DG Synchronisation

Technology Overview: Generator synchronisation optimises loading across multiple diesel generators to improve fuel efficiency.

Working Principle: A synchronisation panel automatically matches the voltage, frequency, and phase of multiple generators before connecting them in parallel. This enables balanced load sharing, allows generators to operate near their optimum efficiency, and can reduce diesel consumption by **5–15%**, depending on the load profile and operating conditions.

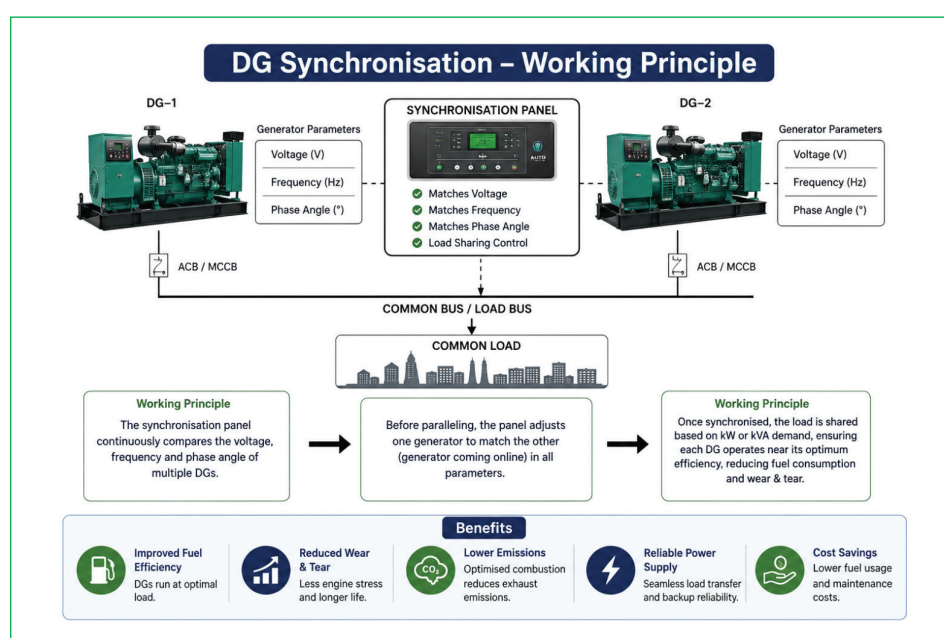


Figure 12 DG Synchronisation

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹5 – 8 lakhs (sync panel + controls, 2–3 DG sets)	2 – 3 years	15 – 25 tCO ₂ e / year

4.2.4 Refrigeration with Floating Head Pressure

Technology Overview: Floating head pressure control reduces refrigeration compressor power by lowering condensing pressure during favourable ambient conditions.

Working Principle: The refrigeration system automatically adjusts the condensing (head) pressure based on ambient temperature, while Variable Frequency Drives (VFDs) optimise compressor speed to match the cooling load. Lower condensing pressure reduces compressor power consumption, typically achieving **2–10% energy savings**, depending on ambient conditions.

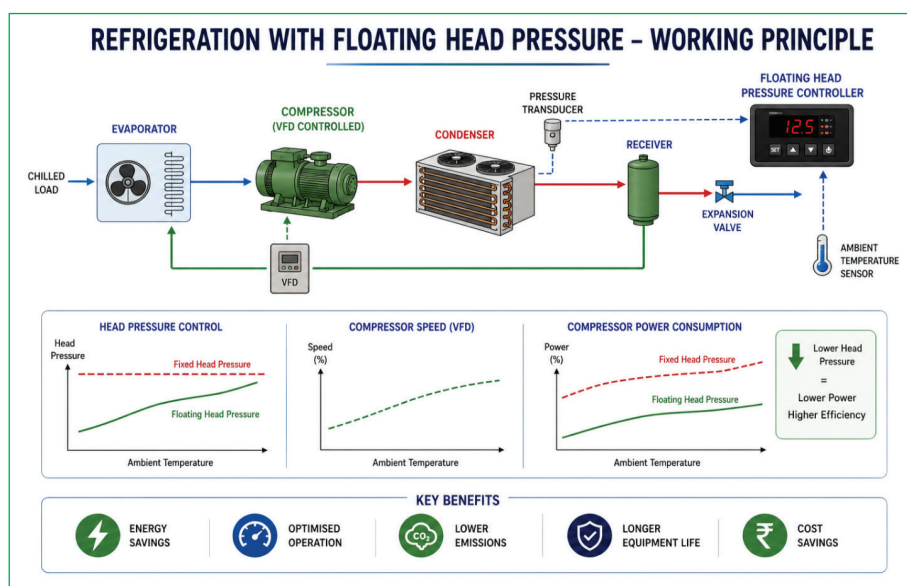


Figure 13 Refrigeration with Floating Head Pressure

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹6 – 10 lakhs (controls + VFD retrofit)	2 – 2.5 years	30 – 50 tCO ₂ e / year

4.2.5 Optimisation of Cooling Tower

Technology Overview: Cooling tower optimisation through VFD-based fan and pump control, high-efficiency motors and fans, automated temperature control, optimised water distribution, fill/nozzle maintenance and conductivity-based blowdown control.

Working Principle: The cooling tower fan speed and circulating-water flow are automatically adjusted according to the actual cooling load and required water temperature. Proper airflow and uniform water distribution improve heat transfer, while optimising cycles of concentration reduces unnecessary blowdown and make-up water. Regular cleaning of fills, nozzles and drift eliminators maintains efficient tower operation.

These measures Reduce electricity consumption of cooling tower fans and pumps, improves cooling performance and temperature control, reduces water and chemical consumption, minimises maintenance requirements and increases the overall efficiency and reliability of the cooling system.

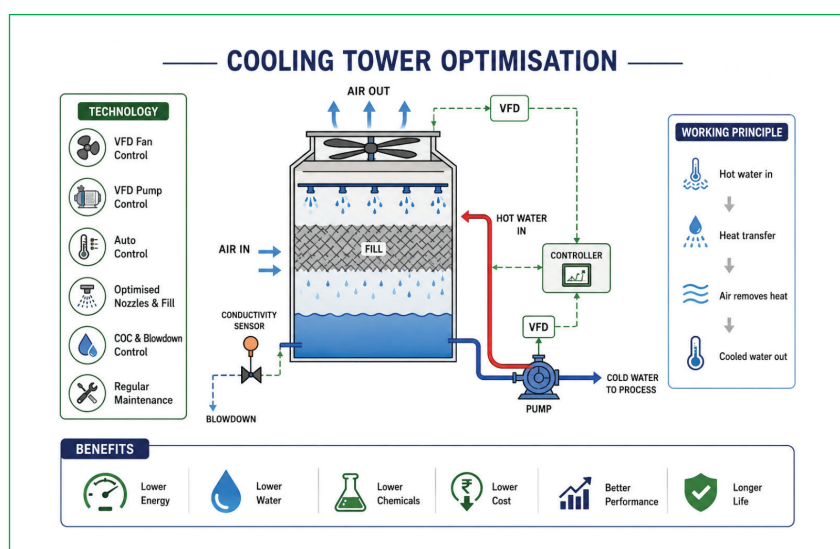


Figure 14 Cooling Tower Optimisation

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹6 – 10 lakhs (controls + VFD retrofit)	2 – 2.5 years	30 – 50 tCO ₂ e / year

4.2.6 Regenerative Plate Heat Exchanger

Technology Overview: Plate heat exchangers recover heat from pasteurised product to preheat incoming product, significantly reducing heating and cooling utilities.

Working Principle: A regenerative plate heat exchanger transfers heat from the outgoing hot product to the incoming cold product through thin corrugated stainless-steel plates in a counter-current flow. This recovers thermal energy, reducing steam and refrigeration demand, with up to 80–90% heat recovery and 15–30% energy savings in pasteurisation processes.

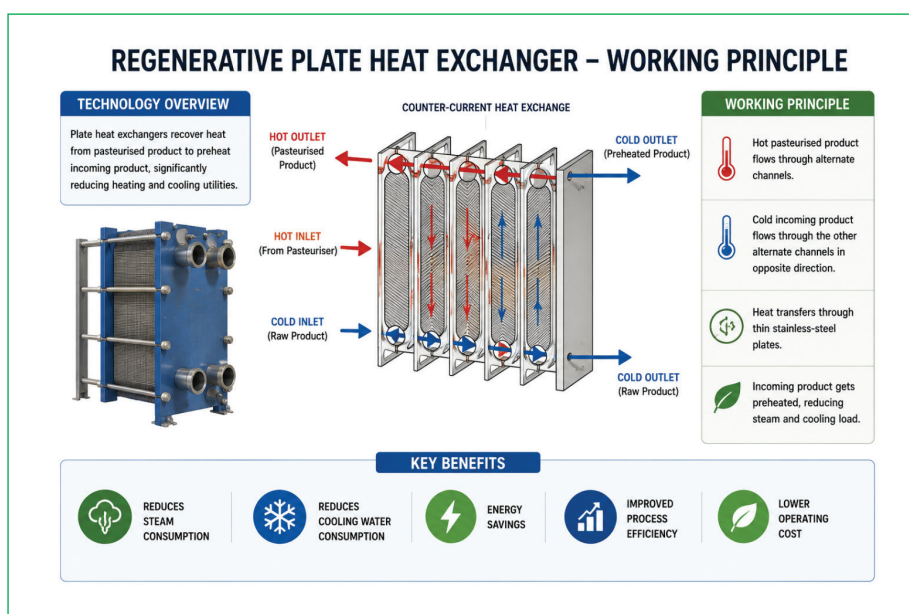


Figure 15 Regenerative Plate Heat Exchanger

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹8 – 12 lakhs (regenerative PHE section)	1.5 – 2 years	50 – 80 tCO ₂ e / year

4.3 Emerging & Future-Ready Technology

Table 12 Emerging and Future Ready Technologies in Beverage Manufacturing

EMERGING & FUTURE-READY				
Thermal Processing	Multi-Effect Evaporator (MEE) — Juice/Dairy Concentration	High Investment	Delivers up to 75% energy savings compared to single-effect evaporation.	3–5 years
Thermal Processing	Mechanical Vapour Recompression (MVR)	High Investment	Shifts energy input from thermal fuel to electricity	3–4 years
Thermal Processing	Aseptic Cold-Fill Processing	High Investment	Eliminates reheating of the entire filled/sealed package	4–6 years
Sanitation/CIP	Ozone-Based CIP Sanitation	Medium Investment	Eliminates heating energy, steam cost, and warm-up wait time entirely	2–3 years
Industrial Heat Pumps for Low-Temperature Process Heat / Hot Water	COP 3–5; replaces boiler-raised hot water below ~90°C with 60–75% less primary energy per unit of heat	High Investment	Reduces fuel and primary energy consumption while lowering GHG emissions.	2.5–4 years
Heat Recovery from Air Compressors	Recovers up to 80–94% of compressor motor input as usable heat for process/boiler feed water preheat	Medium Investment	Convert waste heat from compressors into useful process heat, reducing fuel consumption and operating costs.	1–2 years
Energy Management System (EMS) / Utility Optimisation Platform	Plant-wide real-time visibility and automated set-point optimization, typically unlocks a further 5–12% saving on top of point measures	Medium Investment	Energy Management System (EMS) monitors real-time energy flow to reduce wastage	1.5–3 years

4.3.1 Multi-Effect Evaporator (MEE) — Juice/Dairy Concentration

Technology Overview: Concentrates juice, dairy, or process liquids by evaporating water across multiple sequential vessels instead of a single evaporation stage.

Working Principle: A series of evaporator vessels are connected in sequence, each running at progressively lower pressure and boiling point. Live steam heats only the first effect, the vapor it produces is piped into the second effect as its heating source, and so on through subsequent effects. Liquid flow may be forward-feed, backward-feed, or parallel-feed depending on product viscosity and heat sensitivity, with concentration increasing as the liquid moves through each stage. Delivers up to 75% energy savings compared to single-effect evaporation, with wide application across dairy (milk, whey, lactose, protein concentration) and beverages (fruit juices, coffee extract, tea concentrates), while also preserving flavor, color, and nutrition through gentle heating.

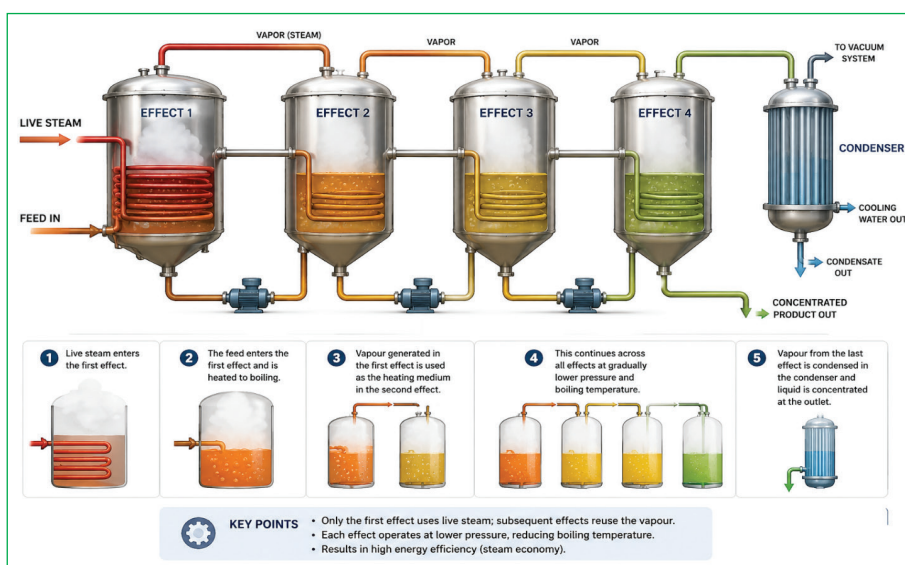


Figure 16 Multi-Effect Evaporator

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹40 – 80 lakhs	3 – 5 years	60 – 120 tCO ₂ e / year

4.3.2 Mechanical Vapour Recompression (MVR)

Technology Overview: An electrically driven evaporation system that eliminates most external steam demand by reusing the evaporator's own vapor as its heat source.

Working Principle: A blower/compressor draws in the low-pressure vapor leaving the evaporator and mechanically compresses it, which raises both its pressure and temperature. This now-superheated vapor is fed back into the evaporator's heating chamber, condensing against the product stream and driving further evaporation. Live steam is needed only for start-up; once the system reaches steady state, the compressor alone sustains heating, shifting energy input from thermal fuel to electricity. A juice plant retrofit case study achieved over 70% reduction in annual steam consumption. Compressors typically consume only 15–25 kWh of electricity per ton of water evaporated.

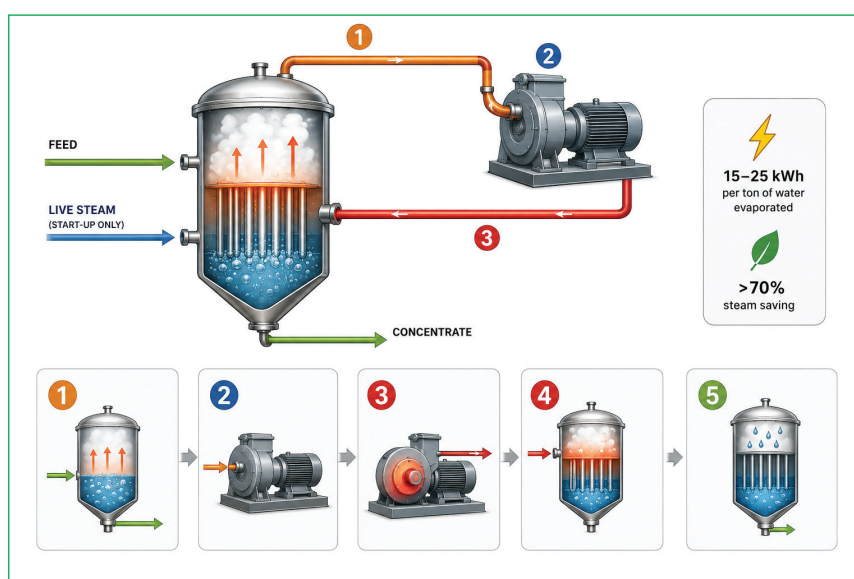


Figure 17 Mechanical Vapour Recompression

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹60 – 120 lakhs	3 – 4 years	100 – 200 tCO ₂ e / year

4.3.3 Aseptic Cold-Fill Processing

Technology Overview: A sterile filling process that avoids reheating the packaged product for shelf stability, replacing hot-fill or retort methods.

Working Principle: The beverage first undergoes UHT heating at about 135–150°C for a few seconds. The hot treated product then passes through a regenerative heat exchanger, where its heat is transferred to the incoming cold product, reducing fresh heating demand. The treated product is subsequently cooled to the required filling temperature. Meanwhile, empty packages are sterilised separately using H₂O₂ or UV. The cooled product is then filled into the sterile packages inside an aseptic chamber with sterile air and immediately sealed.

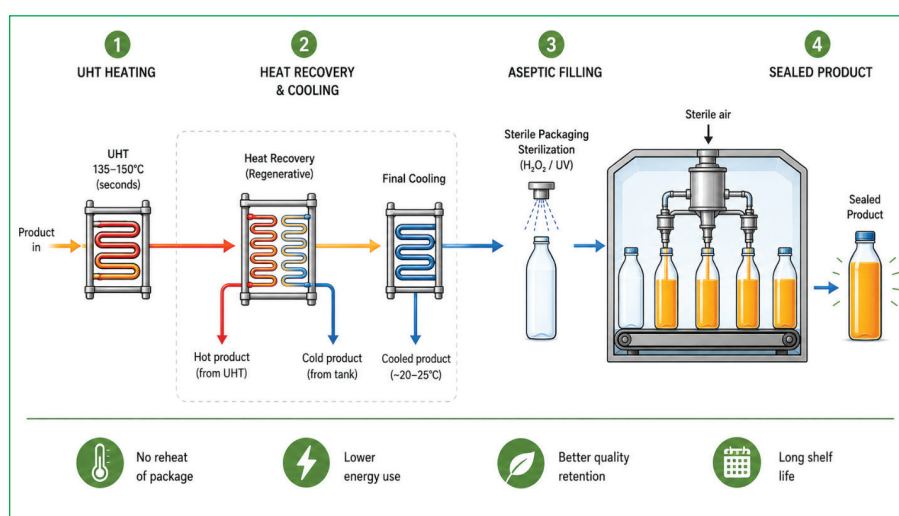


Figure 18 Aseptic Cold Fill Processing

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹1.5 – 3 crores	4 – 6 years	150 – 300 tCO ₂ e / year

4.3.4 Ozone-Based CIP Sanitation

Technology Overview: Replaces hot-water and chemical sanitation cycles in Clean-in-Place systems with on-site generated ozonated water.

Working Principle: Ozone is generated on-site (via corona discharge or UV light acting on air/oxygen) and dissolved into ambient-temperature water. This ozonated water replaces the final rinse/sanitization step in a CIP cycle, oxidizing and rupturing microbial cell walls on contact, effective even at cold tap-water temperature, unlike heat- or chemical-based sanitizing. Excess ozone decomposes back into oxygen within minutes, leaving no residue. This eliminates heating energy, steam cost, and warm-up wait time entirely. Ozone is roughly 3,000 times more powerful an oxidant than chlorine and penetrates biofilm layers chlorine cannot reach, with no chemical residue or storage/handling burden since it decomposes back into oxygen after use.

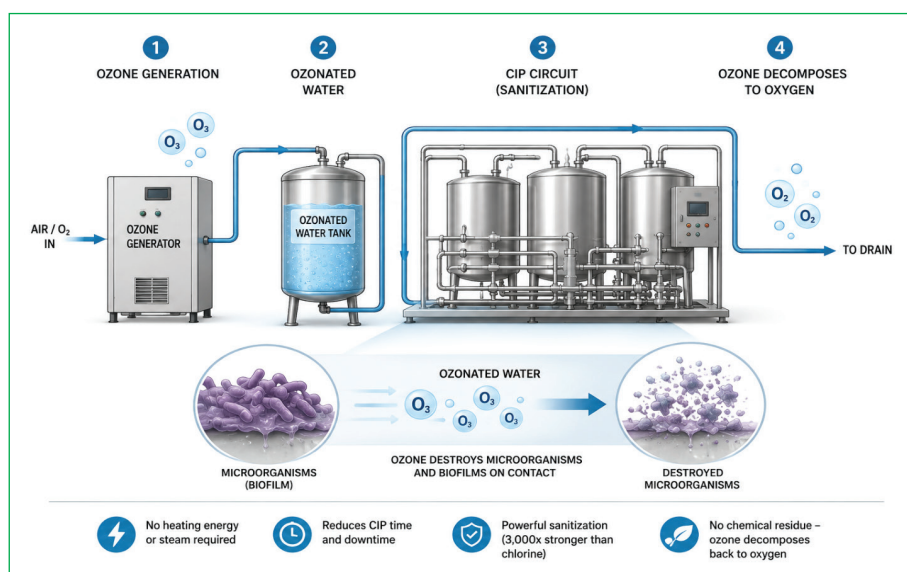


Figure 19 Ozone Based CIP Sanitation

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹10 – 18 lakhs	2 – 3 years	15 – 30 tCO ₂ e / year

4.3.5 Industrial Heat Pumps for Low-Temperature Process Heat / Hot Water

Technology Overview: Electrically driven industrial heat pumps that supply process hot water and low-temperature process heat (below approximately 90°C) as a lower-carbon, higher-efficiency alternative to raising hot water with a fossil-fuel boiler.

Working Principle: A heat pump extracts low-grade heat from a source such as ambient air, waste process water or exhaust air, and uses a vapour-compression refrigeration cycle to upgrade that heat to a useful process temperature, delivering it via a condenser to the plant's hot-water circuit. Because most of the delivered heat is 'moved' rather than generated from fuel combustion, industrial heat pumps typically achieve a coefficient of performance (COP) of 3–5, meaning 60–75% less primary energy is needed per unit of heat delivered compared with a boiler.

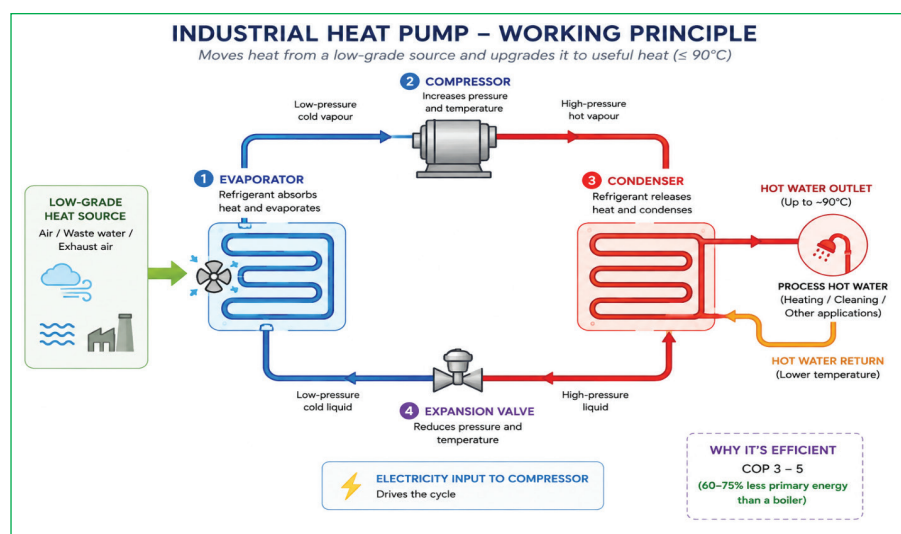


Figure 20 Heat Pump

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹25–40 lakh (heat pump unit sized for process hot-water demand)	2.5–4 years	80–150 tCO ₂ e/year

4.3.6 Heat Recovery from Air Compressors

Technology Overview: A heat-recovery system captures the waste heat generated during air-compression and cooling and converts it into useful thermal energy. The system can be installed on oil-injected as well as oil-free rotary screw compressors. Instead of rejecting heat to the atmosphere, the recovered heat can be used for boiler feedwater pre-heating, process hot water, CIP applications, washing, drying or space heating.

Working Principle: During compression, a large portion of the electrical energy supplied to the compressor is converted into heat. In conventional systems, this heat is removed through the oil cooler, aftercooler or ventilation system and discharged to the surroundings. A heat-recovery exchanger intercepts this hot oil, compressed air or cooling air and transfers the heat to water or another useful heating medium. The heated water can then be supplied to the required process, while the cooled compressor medium returns to the compressor cooling circuit.

Typically, around 90–95% of the compressor’s electrical input ultimately appears as heat, although the practically recoverable fraction depends on compressor type, operating conditions and temperature requirements. Well-designed systems can recover up to 80–94% of the compressor input energy as useful heat, significantly reducing the requirement for boiler fuel or other heating energy.

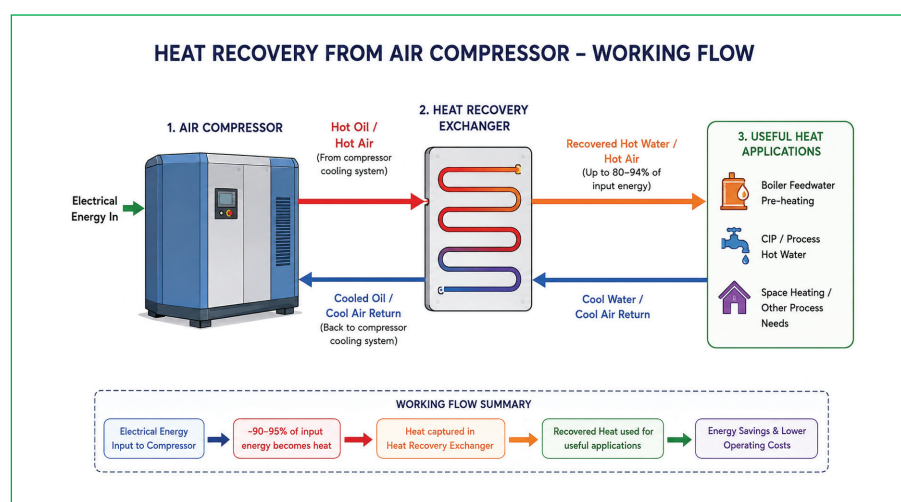


Figure 21 Heat Recovery from Air compressor

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹4–8 lakh (heat-recovery exchanger and piping integration)	1–2 years	30–60 tCO ₂ e/year

4.3.7 Energy Management System (EMS)

Technology Overview: A plant-wide digital platform that aggregates real-time data from energy sub-meters, utility equipment and process sensors into a single dashboard, with automated set-point optimisation layered on top of manual point measures.

Working Principle: The EMS continuously ingests meter and sensor data, applies analytics and, where integrated with the plant’s control system, automatically adjusts equipment set points (such as compressor loading sequence, chiller staging or boiler firing rate) to the most efficient combination for the current load. This closed-loop optimisation, combined with plant-wide visibility that surfaces further improvement opportunities, typically unlocks a further 5–12% saving on top of the individual point measures already implemented.

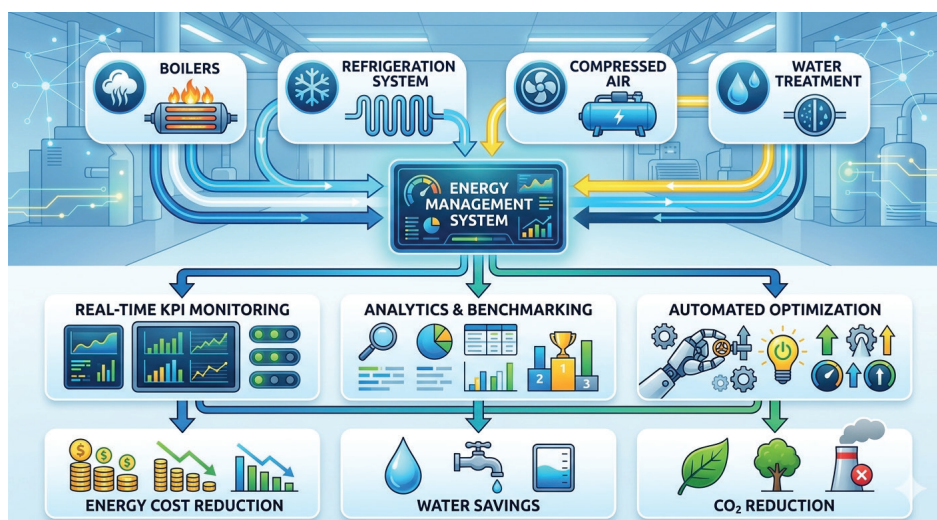


Figure 22 Energy Management System

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹15–25 lakh (software platform, sensor integration and commissioning)	1.5–3 years	50–100 tCO ₂ e/year

Technologies For Renewable Energy

05

Table 13 Renewable Energy Measures in Beverage Manufacturing

Renewable				
Solar	Solar Photovoltaic (PV) for Captive Electricity Generation	Renewable	Direct offset of grid-purchased or DG-generated electricity during daylight hours against process loads such as compressors, pumps, refrigeration, and lighting	4-6 years
Solar	Solar Heater for Hot Water & Process Preheat	Renewable	Direct reduction in specific fuel consumption at the boiler/water heater for the equivalent temperature rise achieved solar-side	3-5 years
Biomass	Biomass Fuel Substitution in Boiler	Renewable	Substitution of fossil fuel spend with a typically lower-cost regional biomass fuel, subject to local price/availability	2-4 years

5.1 Renewable Energy Measures- High Investment

5.1.1 Solar PV

Technology Overview: Solar photovoltaic systems generate clean electricity from sunlight for captive consumption.

Working Principle: Photovoltaic (PV) cells convert sunlight directly into DC electricity, which is then converted into AC electricity by grid-connected inverters for captive use. Solar PV systems reduce grid electricity consumption and can typically meet 15–30% of a facility's annual electricity demand, depending on available rooftop area and solar irradiation.

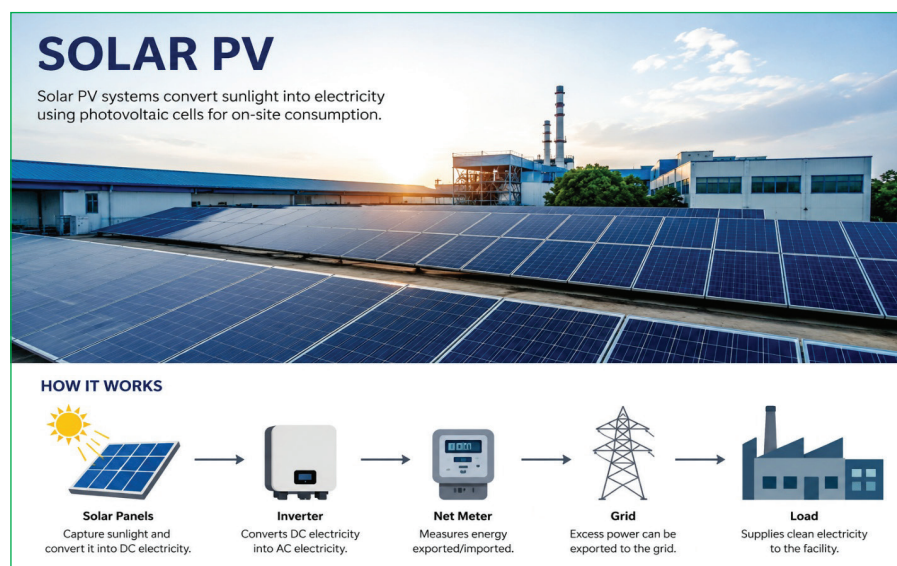


Figure 23 Solar PV

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹35 – 45 lakhs (per 100 kWp rooftop, CAPEX model)	3 – 4 years	100 – 120 tCO ₂ e / year (per 100 kWp)

5.1.2 Solar Thermal Heater

Technology Overview: Solar thermal collectors provide renewable heat for process hot water and boiler feedwater preheating.

Working Principle: Solar collectors absorb solar radiation and transfer the heat to circulating water or a heat transfer fluid. The heated fluid is then used for process heating or hot water applications, reducing conventional fuel consumption by **40–70%**, depending on the application and solar availability.

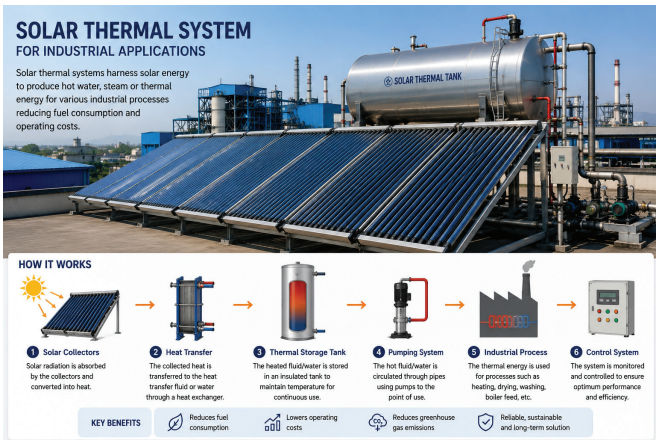


Figure 24 Solar Thermal Heater

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹10 – 15 lakhs (100–150 m ² collector area)	3 – 5 years	20 – 35 tCO ₂ e / year

5.1.3 Biomass Boiler

Technology Overview: Biomass-fired boilers replace fossil fuels with renewable biomass residues for steam generation.

Working Principle: Biomass is combusted in a high-efficiency boiler to generate heat, which is transferred to boiler tubes to produce steam for process applications. Replacing fossil fuels with biomass can reduce fuel costs and lower CO₂ emissions by 70–90%, depending on the biomass type and source.

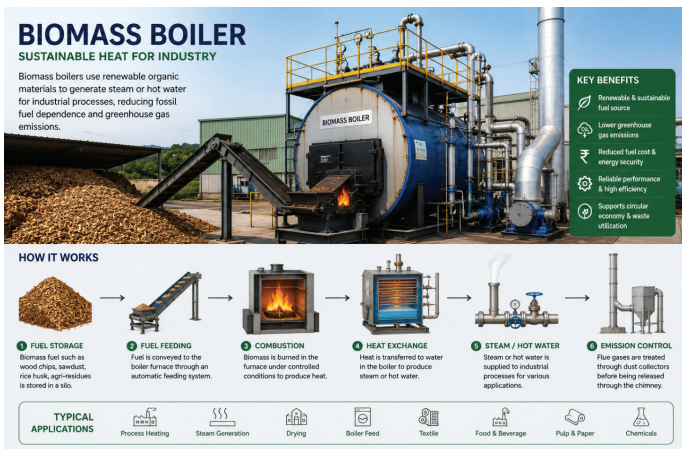


Figure 25 Biomass Boiler

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹40 – 60 lakhs (2–4 TPH biomass boiler)	3 – 4 years	200 – 400 tCO ₂ e / year

Technologies for Resource Efficiency

06

Table 14 Resource Efficiency Measures

Resource Efficiency-Water				
Nil				
Category	Measure	Investment Tier	Key Benefit	Indicative Payback
Monitoring	Water Sub-Metering & Leak Detection	Nil/Low	Identification of underground/in-line leaks not visible to routine inspection	6-12 months
CIP / Cleaning	CIP Final-Rinse Water Reuse (as pre-rinse)	Nil/Low	Direct reduction in fresh water draws per CIP cycle	12-18 months
Medium				
Water Treatment	Membrane Filtration Upgrade (UF/NF) for Process Water Treatment	Medium	Improved water recovery ratio (reduced reject volume) relative to conventional media filtration/backwash	24-36 months
High				
Advanced Treatment	Advanced Water Reclamation — Membrane Bioreactor (MBR) + RO Polishing Train	High	High and consistent permeate quality, enabling reuse across a broader range of process/utility duties than conventional secondary treatment	4-6 years
Resource Efficiency- Waste & Packaging				
Lightweighting of PET Bottles	Reduce bottle weight through design optimisation while maintaining required strength, performance and product shelf-life.	Medium	8–20% reduction in resin (and embodied carbon) per bottle	6–18 months
Recycled PET	Replace a portion of virgin PET with food-grade recycled PET to reduce virgin plastic consumption and associated GHG emissions.	Medium	Reduced virgin resin demand, aligns with EPR/ BIS norms and export buyer expectations	Cost-neutral to 1 year (subject to pricing)
Circular-Economy Packaging Practices	Strengthen packaging collection, segregation, recycling and EPR systems to improve material recovery and reduce packaging waste.	Medium	Reduced packaging waste to landfill, EPR compliance cost avoidance	Varies – largely operational
Bio-Based / Compostable Packaging Materials	Evaluate bio-based or certified compostable packaging alternatives through controlled pilot trials for suitable applications.	Medium	Reduced fossil-plastic dependence for select formats, brand differentiation	Product/context dependent

6.1 Resource Efficiency Measures

6.1.1 Water Sub-metering

Technology Overview: Water metering enables detailed monitoring of water consumption and rapid identification of abnormal usage.

Working Principle: Flow meters installed at major process areas continuously measure and record water consumption, enabling water balance analysis, leak detection, and identification of high-consumption areas. Effective water sub-metering can typically achieve **5–15% water savings** through improved monitoring and management.



Figure 26 Water Sub-Metering

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹1.5 – 3 lakhs (10–15 metering points)	1.5 – 2 years	Indirect (enables 5–15% water-linked energy savings)

6.1.2 CIP Final Rinse Reuse

Technology Overview: Reuse of final rinse water reduces freshwater demand during cleaning-in-place operations.

Working Principle: The relatively clean final rinse water from a CIP cycle is collected and reused as the initial pre-rinse in the next cleaning cycle. This reduces freshwater consumption and wastewater generation, typically achieving **15–30% water savings** in CIP operations.

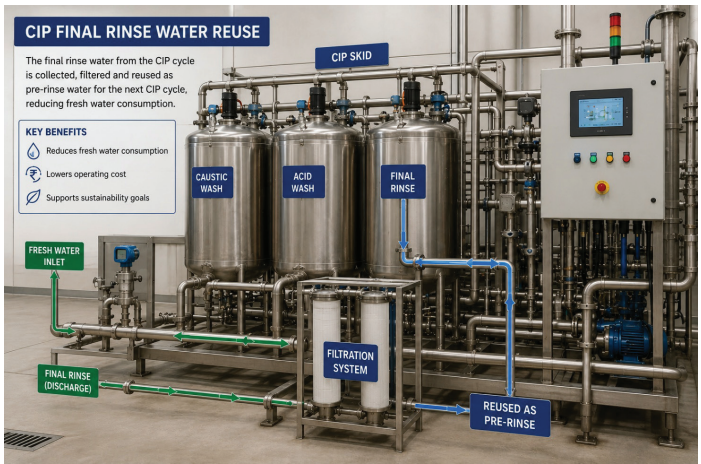


Figure 27 CIP Final Rinse Reuse

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹3 – 5 lakhs (storage tank, piping, controls)	1.5 – 2 years	10 – 20 tCO ₂ e / year

6.1.3 UF/NF Water Treatment

Technology Overview: Advanced membrane filtration improves water recovery and product water quality.

Working Principle: UF/NF systems use pressure-driven membranes to separate suspended solids, microorganisms, and dissolved contaminants from water. UF removes fine particles and bacteria, while NF additionally removes dissolved salts and organic compounds. The crossflow filtration process minimises membrane fouling and enables high water recovery (typically 90–95% for UF), reducing freshwater consumption and wastewater generation.

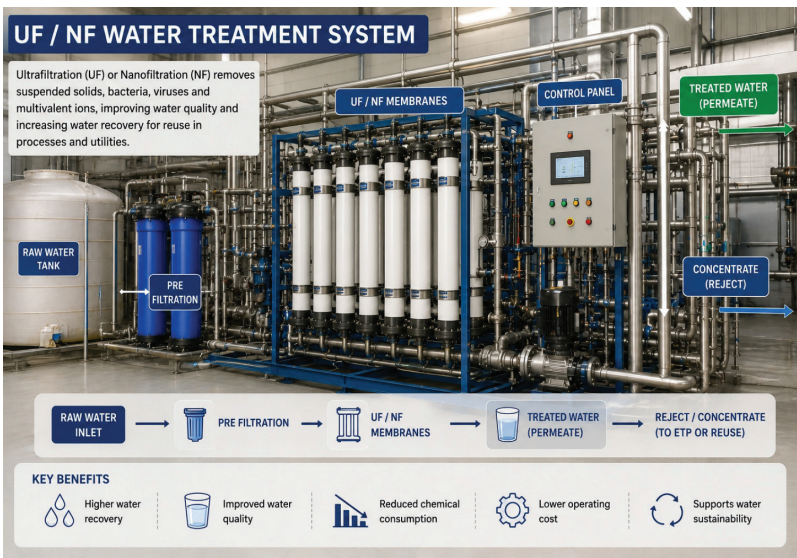


Figure 28 UF/NF Water Treatment

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹15 – 25 lakhs (skid-mounted UF/NF system)	3 – 4 years	Indirect (reduced raw water pumping & treatment load)

6.1.4 MBR + RO Water Reclamation

Technology Overview: MBR coupled with RO produces high-quality reclaimed water suitable for reuse.

Working Principle: The MBR system uses biological treatment to remove organic pollutants, followed by membrane filtration to produce high-quality, solids-free water. The treated water is then purified through Reverse Osmosis (RO), which removes dissolved salts and impurities to produce high-purity water suitable for reuse in process applications, boiler feed, or cooling towers. The combined MBR + RO system can achieve 80–95% water recovery, significantly reducing freshwater demand and wastewater discharge.

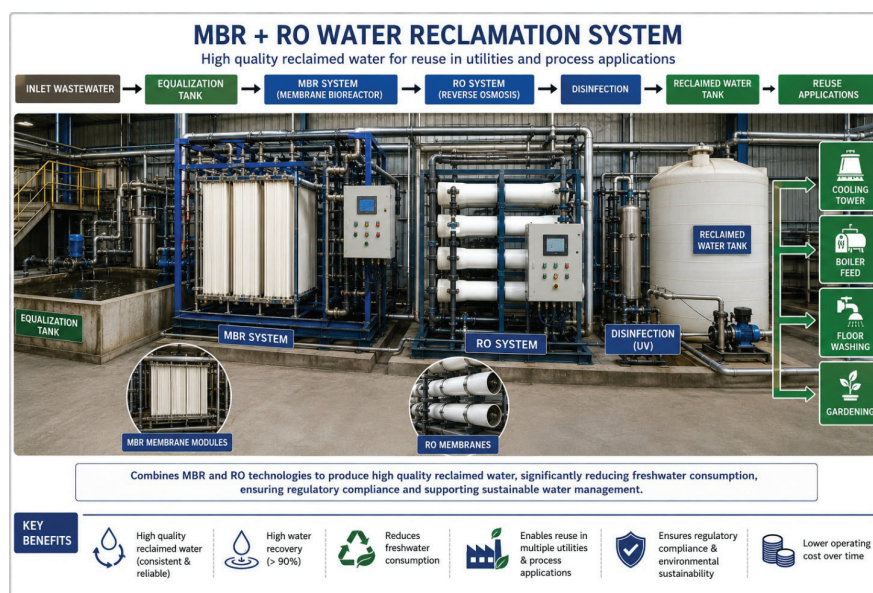


Figure 29 MBR + RO Water Reclamation

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual CO ₂ Reduction Potential
₹40 – 60 lakhs (MBR + RO train)	4 – 5 years	Indirect (reduced freshwater intake energy)

6.2 Resource Efficiency – Waste & Packaging

6.2.1 Lightweighting of PET Bottles

Technology Overview: Redesign of PET bottle wall thickness, base and neck geometry, supported by finite-element structural analysis, to reduce the resin used per bottle while maintaining the mechanical strength needed for filling, handling and distribution.

Working Principle: Structural simulation identifies areas of the bottle carrying unnecessary excess material versus areas that are load-bearing during filling, capping, palletising and transport. New preform and mould designs redistribute material accordingly, often combined with improved neck-finish standards and base designs such as petaloid or champagne bases, cutting resin (and embodied carbon) per bottle by 8–20% without compromising bottle integrity.

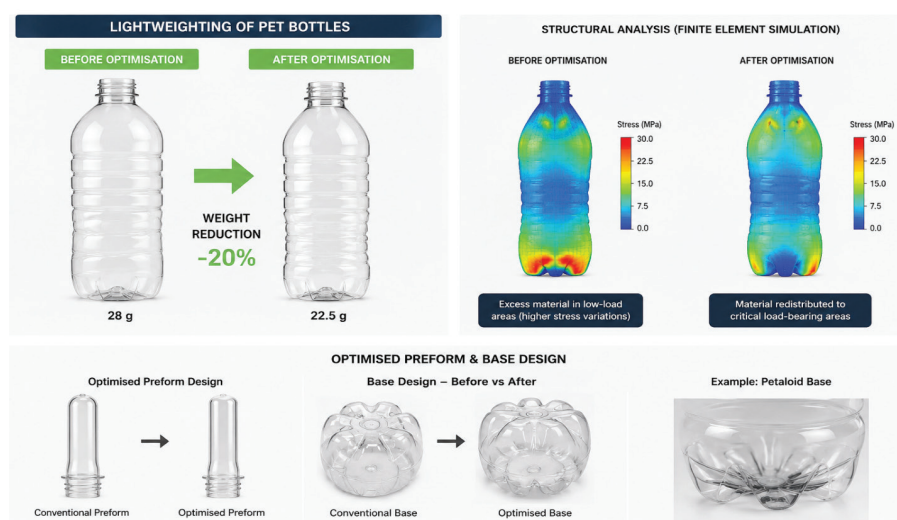


Figure 30 Lightweighting of PET Bottles

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual Waste/Resin Reduction Potential
₹5–10 lakh (mould modification/ new preform tooling)	6–18 months	8–20% resin reduction per bottle

6.2.2 Recycled PET (rPET) Incorporation

Technology Overview: Substitution of a proportion of virgin PET resin in bottle preforms with food-grade recycled PET, sourced from certified recyclers, to reduce virgin plastic demand while meeting food-contact safety requirements.

Working Principle: Post-consumer PET is collected, sorted, washed and reprocessed by a certified recycler into food-grade rPET pellets or flakes, which are then blended with virgin resin at a qualified ratio in the preform injection-moulding process. Bottle performance is validated against the same mechanical and barrier specifications as virgin-resin bottles, reducing virgin resin demand and aligning with Extended Producer Responsibility (EPR) and BIS norms as well as export buyer sustainability expectations.

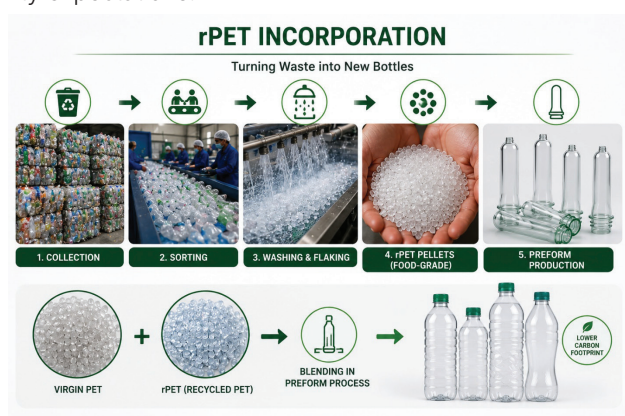


Figure 31 Turning Waste into new Bottles

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual Waste/Resin Reduction Potential
Cost-neutral to ₹5 lakh (supply-chain qualification and blending trials)	Cost-neutral to 1 year (subject to rPET pricing)	25–50% virgin resin reduction (blend-ratio dependent)

6.2.3 Circular-Economy Packaging Practices (Take-Back, EPR Compliance, Source Segregation)

Technology Overview: A structured programme covering packaging take-back schemes, formal Extended Producer Responsibility (EPR) compliance, and source segregation of packaging waste at the point of generation within the facility.

Working Principle: Take-back arrangements with distributors and recyclers create a return pathway for used packaging, while on-site source segregation into distinct waste streams (PET, HDPE, cardboard, shrink film) preserves material value and recyclability compared with mixed waste. These streams are tracked and reported to meet EPR obligations, reducing the volume of packaging waste sent to landfill and avoiding EPR non-compliance costs.



Figure 32 Circular-Economy Packaging Practices

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual Waste/Resin Reduction Potential
Largely operational (segregation bins, tracking and reporting systems)	Varies – largely operational	20–40% reduction in packaging waste to landfill

6.2.4 Bio-Based / Compostable Packaging Materials (Pilot Scale)

Technology Overview: Trial introduction of bio-based or compostable packaging formats — such as plant-derived films, labels or secondary packaging — for select product lines, as a longer-term alternative to fossil-derived plastics.

Working Principle: Bio-based materials are derived wholly or partly from renewable feedstocks (such as PLA from corn starch or sugarcane-based polyethylene) rather than petroleum, while compostable formats are engineered to break down under defined composting conditions. Pilot trials assess barrier performance, shelf-life impact, cost and consumer acceptance for the selected format before any wider rollout decision.



Figure 33 Bio Based Packaging Materials

Benefits:

Estimated Investment (MSME)	Estimated Payback Period	Annual Waste/Resin Reduction Potential
₹3–8 lakh (pilot trial materials, testing and line trials)	Product/context dependent	Reduced fossil-plastic dependence (pilot-scale, format dependent)

Conclusion and Roadmap

07

7.1 Summary

The beverage manufacturing sector spanning carbonated soft drinks, juices, packaged water, and dairy-based beverages is a significant and growing segment of MSME manufacturing, characterised by intensive use of thermal energy (steam and hot water for pasteurisation, CIP, and utilities), electrical energy (refrigeration, compressed air, RO/ filtration, and filling lines), and water. The sector accordingly presents a strong and readily actionable opportunity for energy efficiency, resource efficiency, and cleaner production.

Based on cluster-level assessments and sector benchmarking, MSME beverage manufacturing units demonstrate the potential to achieve:

- 15–20% reduction in electrical energy consumption
- 20–30% reduction in thermal energy consumption
- 15–25% reduction in specific freshwater consumption through the systematic adoption of proven technologies and operational improvements.

This compendium presents 32 technology interventions across four key categories:

- Energy efficiency measures — nil/low investment (lighting, steam traps, combustion tuning, condensate recovery, insulation, compressed air, sub-metering)
- Energy efficiency measures — medium/high investment (VFDs, DG synchronisation, refrigeration controls, regenerative heat exchangers)
- Renewable energy integration (solar PV, solar thermal, biomass boilers)
- Resource efficiency measures (water sub-metering, CIP rinse reuse, membrane filtration, advanced water reclamation)

These interventions range from no-cost operational and monitoring measures (compressed air pressure optimisation, steam trap repair, sub-metering) to medium-investment upgrades (VFD retrofits, refrigeration floating head control) and high-impact capital investments (regenerative pasteuriser heat recovery, solar PV, biomass boiler conversion, and MBR + RO water reclamation).

7.2 Recommended Priority Actions

For MSME beverage manufacturing units, the following priority interventions are recommended based on ease of implementation, financial attractiveness, and energy/resource-saving potential:

Table 15 Priority Actions

Priority	Technology	Energy Savings	Payback	Investment
1	Compressed air header pressure optimisation	6–8% compressor energy per bar reduced	Immediate	Nil
2	Steam trap survey & repair	5–10% of failed-trap steam loss eliminated	< 1 year	Low
3	Compressed air leak detection & repair	10–20 tCO ₂ e/year; direct run-hour reduction	< 1 year	Low
4	Boiler combustion tuning (O ₂ trim)	1–3 % thermal efficiency	1–1.5 years	Low
5	Thermal insulation upgrade (steam lines/valves)	90%+ reduction in surface heat loss	1–1.5 years	Low

Priority	Technology	Energy Savings	Payback	Investment
6	LED lighting with occupancy/daylight controls	40–60% lighting load reduction	1.5–2 years	Low
7	Condensate recovery to boiler feed	~1% fuel saved per 6°C feedwater rise	1.5–2 years	Low
8	VFD retrofit on key motors (RO pumps, agitators)	20–50% motor energy (variable-torque loads)	1.5–2.5 years	Medium
9	Regenerative plate heat exchanger (pasteuriser)	15–30% pasteurisation energy; 80–90% heat recovery	1.5–2 years	High
10	Solar rooftop PV for captive generation	15–30% of annual grid electricity offset	3–4 years	High

7.3 Implementation Roadmap

A phased implementation strategy is recommended to ensure financial feasibility and smooth operational transition:

Phase 1 (0–6 Months):

- Compressed air header pressure optimisation
- Compressed air leak detection and repair
- Steam trap survey and preventive maintenance
- Boiler combustion tuning (O₂ trim)
- Thermal insulation of steam piping, valves and flanges
- LED lighting retrofit with occupancy/daylight sensing
- Condensate recovery and return to boiler feed
- Energy and water sub-metering with KPI benchmarking
- CIP final-rinse water reuse as pre-rinse

Outcome: Immediate cost savings with minimal capital investment.

Phase 2 (6–18 Months):

- VFD retrofit on key motors — RO high-pressure pumps, syrup agitators, filling line drives
- Right-sizing/dewpoint cycling of compressed air dryers
- Load-based DG synchronisation and sizing panel
- Refrigeration compressor VFD and floating head pressure control
- Membrane filtration (UF/NF) upgrade for process water treatment

Outcome: Structured reduction in electrical energy, fuel, and freshwater intake.

Phase 3 (18–48 Months):

- Regenerative plate heat exchanger heat recovery on pasteurisers
- Solar rooftop PV for captive electricity generation
- Solar thermal heating for process hot water/preheat
- Biomass fuel substitution in boilers
- Advanced water reclamation — MBR + RO polishing train

Outcome: Maximum energy and water savings, decarbonisation, and long-term utility cost stability.

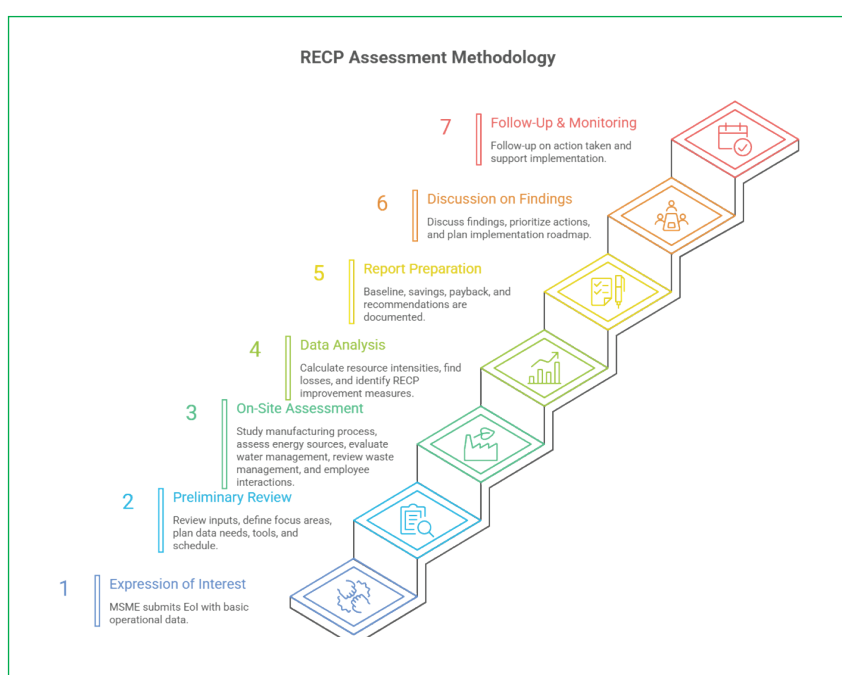
Ongoing Actions

- Continuous energy and water monitoring and benchmarking
- Periodic energy audits and reassessments
- Integration of digital energy and water management systems
- Alignment with national best-practice standards and sustainability targets

7.4 About the RECP Assessment Process

RECP assessment follows a systematic, step by step approach to evaluate how efficiently an MSME utilizes its resources and to identify opportunities for reducing resource use, improving operational efficiency, and minimizing environmental impact. The focus is on reduction of energy, water, raw materials, waste, and emissions and helping units adopt cleaner and more sustainable practices.

The methodology adopted for conducting the assessment is outlined below



7.5 Final Outlook

The beverage manufacturing sector stands at a critical juncture where energy and water efficiency are no longer optional but a strategic necessity. Rising utility costs, tightening environmental and effluent discharge norms, and evolving customer and export-market expectations are driving the need for cleaner and more resource-efficient production systems.

By adopting a phased, technology-driven approach, MSME beverage manufacturing units can:

- Reduce operating costs significantly across steam, electricity, compressed air, and water
- Improve product quality and process consistency
- Lower greenhouse gas emissions and freshwater withdrawal
- Strengthening competitiveness in domestic and export markets

The technologies and roadmap presented in this compendium provide a practical, financially viable, and scalable pathway for the beverage manufacturing cluster to transition toward energy-efficient, resource-efficient, and sustainable manufacturing.

1. **Widening of PAT Sectors – Beverage** (Shakti Foundation)
<https://shaktifoundation.in/wp-content/uploads/2017/06/widening-of-pat-sectors-beverage.pdf>
2. **2023 BIER Benchmarking Executive Summary Report** (Beverage Industry Environmental Roundtable, via Antea Group)
[http://info.us.anteagroup.com/hubfs/BIER%20Downloads/2023-BIER-Benchmarking-Executive-Summary-Report%20\(2\).pdf](http://info.us.anteagroup.com/hubfs/BIER%20Downloads/2023-BIER-Benchmarking-Executive-Summary-Report%20(2).pdf)
3. **Sector Report/Study** (World Foundation India / WFIndia, hosted on AWS S3)
https://wfindia.s3.ap-south-1.amazonaws.com/website_images/pdf/1694687520_50830546.pdf
4. **Sector Profile – Beverages**, Ministry of Food Processing Industries (MoFPI), Government of India
[https://mofpi.gov.in/sites/default/files/KnowledgeCentre/Sector%20Profile/Sector_Profile_Beverages%20\(1\).pdf](https://mofpi.gov.in/sites/default/files/KnowledgeCentre/Sector%20Profile/Sector_Profile_Beverages%20(1).pdf)

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.

Mr. Srinivas Cherla

Director of Sustainability
E: dir-sa-rich@telangana.gov.in

Mr. Kishore Kumar Gadam

Senior Project Manager, Sustainability,
E: srpm-citsa-rich@telangana.gov.in

Mr. U Guru Sri Charan

Project Manager, Sustainability
E: pm-citsa-rich@telangana.gov.in



RICH, T-Hub Foundation, Plot No 1/C, Sy No 83/1, Raidurgam Panmaktha,
Hyderabad Knowledge City, Hyderabad, Telangana – 500081

cmanager-rich@telangana.gov.in

