



**INDUSTRY REPORT ON
SENSORS, SPECIALTY CABLES
AND HEATING SOLUTIONS IN INDIA
AND GLOBALLY**

SUBMITTED TO
TEMPSENS INSTRUMENTS INDIA LTD.

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ABBREVIATIONS USED IN THE REPORT

APAC	Asia-Pacific (implied in investment trends)	LV	Low Voltage
API	Active Pharmaceutical Ingredient	MICC	Mineral Insulated Copper Clad
BARC	Bhabha Atomic Research Centre	MIMS	Mineral Insulated Metal Sheathed
BHEL	Bharat Heavy Electricals Limited	Mn	Million
CAPEX	Capital Expenditure	MSME	Micro, Small & Medium Enterprises (policy context)
CrMo	Chromium-Molybdenum (material for heaters)	MTPA	Million Tonnes Per Annum
DCS	Distributed Control Systems	NBC	National Building Code
DCS	Distributed Control System	NiCr	Nickel-Chromium (alloy)
DRDO	Defence Research & Development Organisation	OEM	Original Equipment Manufacturer
DRI	Direct Reduced Iron	PE	Polyethylene
EN	European Norm	PFCE	Private Final Consumption Expenditure
EPC	Engineering Procurement Construction	PLC	Programmable Logic Controllers
EPD	Environmental Product Declaration	PLI	Production Linked Incentive
FR	Fire Retardant (cable context)	PSU	Public Sector Undertaking
FY	Financial Year	PTFE	Polytetrafluoroethylene (Teflon)
GCC	Gulf Cooperation Council	PV	Photovoltaic (solar PV context)
GDP	Gross Domestic Product	PVC	Polyvinyl Chloride
GH2	Green Hydrogen (context: GH2 Solar Pvt Ltd)	R&D	Research & Development
GVA	Gross Value Added (macro context)	RDSS	Revamped Distribution Sector Scheme
HVAC	Heating, Ventilation & Air Conditioning	REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
IEC	International Electrotechnical Commission Standard	RoHS	Restriction of Hazardous Substances
IIP	Index of Industrial Production	RTD	Resistance Temperature Detector
IoT	Internet of Things	SCADA	Supervisory Control and Data Acquisition
IS	Indian Standard (IS/IEC codes)	UPS	Uninterruptible Power Supply (general electrical term)
JV	Joint Venture (as in PT Tempsens Asia Jaya, Tempsens Korea Co.,Ltd.)	XLPE	Cross-Linked Polyethylene
kV	Kilo Volt		
LNG	Liquefied Natural Gas		
LS	Low Smoke (in FR-LS cables)		
LSZH	Low Smoke Zero Halogen		
LT	Low Tension		

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1. MARKET ECONOMIC OVERVIEW OF GLOBAL AND INDIAN ECONOMY

1.1 Review of Global Economy

1.1.1 Global real GDP review and outlook

The global economy is expected to grow by 3.0% in CY2025E and 3.1% in CY2026E. India is projected to grow at 6.4% in calendar year CY2025E, following 6.5% growth in CY2024. Economic activity remains broad-based, with contributions from domestic consumption, services, and investment in several large emerging markets. It is noted that disinflation is progressing and that financial conditions have eased in some regions, though the pace of monetary policy adjustments remains uneven. Since 2024–25, U.S. tariffs on Chinese goods—particularly EVs, semiconductors, battery components, and solar inputs have escalated trade tensions, though a temporary truce under the Geneva framework has limited broader tariff hikes. While legal challenges to the tariff regime create uncertainty, the CY2025E growth forecast has inched up to 3.0%, aided by pre-tariff front-loading. Nonetheless, elevated costs, fragile supply chains, and weakening demand highlight continued downside risks for global trade and growth.

Exhibit 1.1: Real GDP Growth by Select Regions & Countries – Historic and Forecast, World, CY2019 – CY2029E

Country / Region	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024	CY2025E	CY2026E	CY2027E	CY2028E	CY2029E
World	2.9%	-2.7%	6.6%	3.6%	3.5%	3.3%	3.0%	3.1%	3.2%	3.2%	3.2%
United States	2.6%	-2.2%	6.1%	2.5%	2.9%	2.8%	1.9%	2.0%	2.0%	2.1%	2.1%
China	6.1%	2.3%	8.6%	3.1%	5.4%	5.0%	4.8%	4.2%	4.2%	4.1%	3.7%
India	3.9%	-5.8%	9.7%	7.6%	9.2%	6.5%	6.4%	6.4%	6.5%	6.5%	6.5%
North America	2.2%	-3.0%	6.0%	2.8%	2.8%	2.6%	1.6%	1.7%	2.0%	2.1%	2.1%
Europe	2.0%	-5.4%	6.4%	2.4%	1.3%	1.7%	1.3%	1.4%	1.6%	1.6%	1.5%
Asia and Pacific	4.3%	-0.8%	7.2%	4.3%	5.1%	4.5%	3.9%	4.0%	4.3%	4.2%	4.2%
Middle East and Central Asia	1.9%	-2.2%	4.4%	5.5%	2.2%	2.4%	3.4%	3.5%	4.0%	3.7%	3.7%
Africa	3.1%	-1.4%	4.6%	4.3%	3.3%	3.2%	4.0%	4.3%	4.3%	4.4%	4.5%
Latin America and Caribbean	0.2%	-6.9%	7.4%	4.2%	2.4%	2.4%	2.2%	2.4%	2.7%	2.7%	2.7%

Source: IMF July 2025 forecast, Frost & Sullivan analysis

1.1.2 Inflation

Global inflation averaged 5.7% in CY2024, reflecting a continued moderation from the peak levels seen in CY2022. The trend has shown a steady decline over the past two years, from 8.6% in calendar year CY2022 to 6.6% in CY2023. The easing reflects the gradual resolution of earlier supply disruptions, normalization in commodity prices, and adjustments in monetary policy across regions.

Inflation is expected to continue its downward path, with projections at 4.3% in CY2025E and 3.6% in CY2026E. The inflation rate is estimated to stabilize closer to pre-pandemic levels, with projections of 3.3% in CY2027E and 3.2% in both CY2028E and CY2029E.

The expected decline is based on improving supply conditions, better alignment of demand and supply, and a more stable global trade environment. These trends may influence the timing and pace of monetary policy adjustments across economies.

Exhibit 1.2: Inflation Rate – Historic and Forecast, World, CY2019 – CY2029E

Country / Region	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024	CY2025E	CY2026E	CY2027E	CY2028E	CY2029E
World	3.5%	3.3%	4.7%	8.6%	6.6%	5.7%	4.3%	3.6%	3.3%	3.2%	3.2%
United States	1.8%	1.3%	4.7%	8.0%	4.1%	3.0%	3.0%	2.5%	2.1%	2.2%	2.2%
China	2.9%	2.5%	0.9%	2.0%	0.2%	0.2%	0.0%	0.6%	1.4%	1.8%	1.9%
India	4.8%	6.2%	5.5%	6.7%	5.4%	4.7%	4.2%	4.1%	4.0%	4.0%	4.0%
North America	2.0%	1.4%	4.7%	7.9%	4.2%	3.1%	3.0%	2.5%	2.2%	2.2%	2.2%
Europe	2.0%	1.2%	3.6%	10.0%	6.3%	3.6%	3.7%	2.8%	2.5%	2.5%	2.4%
Asia and Pacific	3.4%	3.2%	3.0%	6.3%	4.8%	4.3%	3.1%	2.9%	3.0%	3.1%	3.1%
Middle East	5.8%	9.9%	11.7%	13.4%	11.8%	9.3%	10.9%	10.4%	8.7%	7.7%	6.9%
Africa	9.4%	11.1%	12.3%	14.2%	18.2%	20.1%	13.8%	11.8%	8.4%	7.4%	6.4%
Latin America and Caribbean	7.6%	6.5%	9.9%	14.2%	14.8%	16.6%	7.2%	4.8%	3.9%	3.6%	3.6%

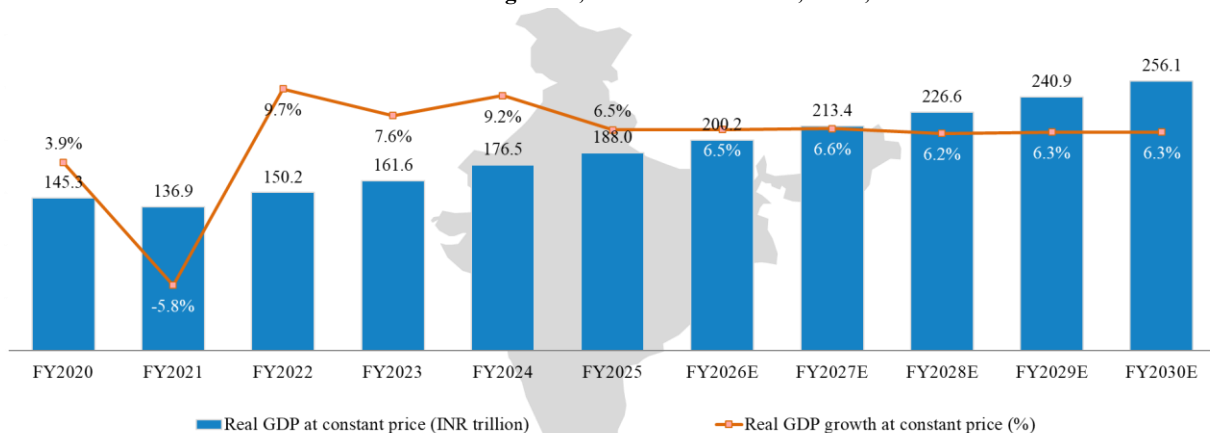
Source: IMF July 2025 forecast, Frost & Sullivan analysis

1.2 Review of the Indian Economy

1.2.1 Review and outlook of Real GDP growth in India

The Union Budget FY2026 outlines a total expenditure of INR 50.65 lakh crore with a capital outlay of INR 11.21 lakh crore (3.1% of GDP) and a fiscal deficit target of 4.4% of GDP. The Budget identifies four engines of growth: Agriculture, MSMEs, Investment, and Exports. Key macroeconomic announcements include enhanced support for the manufacturing sector through PLI schemes, infrastructure investments under PM Gati Shakti, and targeted incentives for MSMEs such as credit facilitation and compliance simplification. Additional allocations toward energy efficiency programs and appliance market development are also expected to drive demand for components used in cooling and refrigeration systems. A National Manufacturing Mission and measures for the toy, leather, and food processing sectors aim to boost “Make in India.”

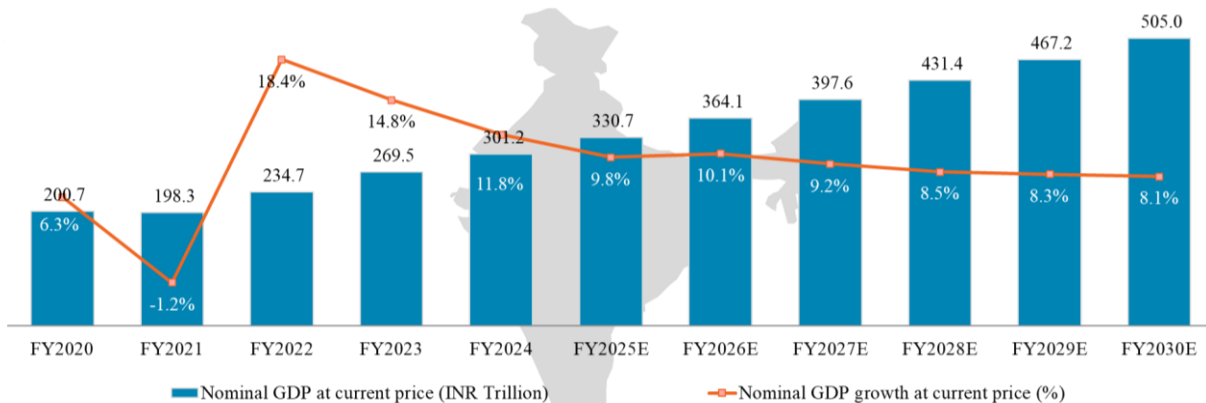
On the investment front, focus areas include education, skilling, healthcare, and infrastructure, with INR 1.5 lakh crore set aside for 50-year interest-free loans to states. Key initiatives include an INR 20,000 crore Nuclear Energy Mission, an INR 25,000 crore Maritime Development Fund, and an Urban Challenge Fund. Innovation receives a boost with an investment of INR 20,000 crore for R&D and the launch of Deep Tech and Geospatial missions. Export promotion and regulatory reforms, such as 100% FDI in insurance, a Grameen Credit Score, and the Jan Vishwas Bill 2.0, round out the government’s roadmap for inclusive, innovation-led, and employment-intensive growth.

Exhibit 1.3: Annual Real GDP and growth, value in INR trillion, India, FY2020 - FY2030E

Source: MoSPI (Annual Estimates of GDP at constant price, 2011-12 series), IMF, ADB, S&P, Frost & Sullivan Analysis

The Reserve Bank of India (RBI) projects India's real GDP growth at 6.5% for FY2025 and FY2026E, reflecting sustained momentum despite global uncertainties. For FY2025, the forecast was trimmed by 20 basis points due to heightened global volatility, though domestic drivers remain strong — a favourable monsoon, recovering manufacturing, resilient services, and rising investment backed by government infrastructure spending and healthy corporate and bank balance sheets. External risks such as trade disruptions and geopolitical tensions may weigh on merchandise exports. For FY2026E, the RBI maintains its 6.5% estimate, citing an “evenly balanced” outlook supported by firm consumption, continued public capital expenditure, and initiatives like the PLI scheme and National Manufacturing Mission.

Exhibit 1.4: India - Nominal GDP and nominal GDP growth (annual % change), value in INR trillion, growth in %, FY2020-FY2030E

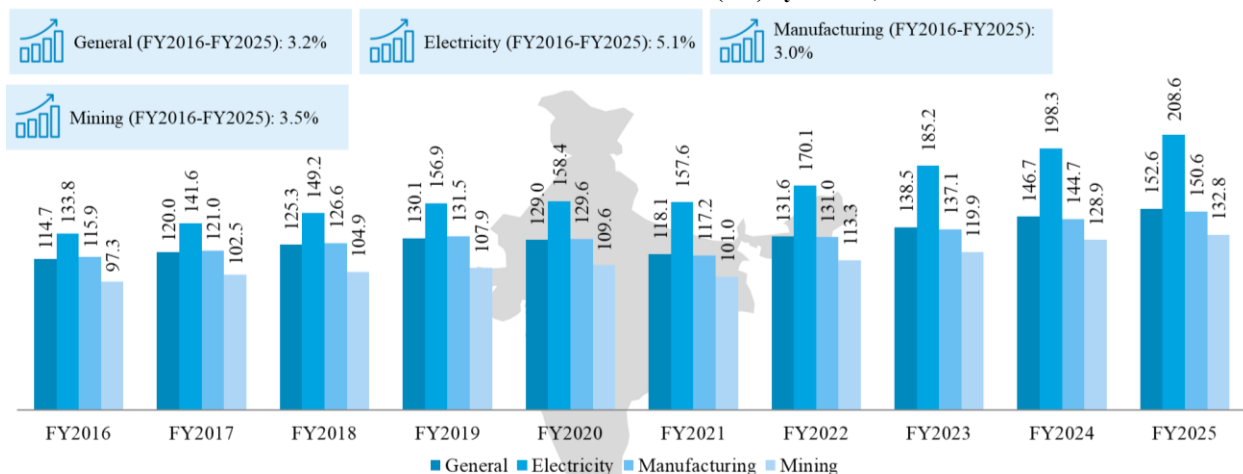


Source: MoSPI (Annual Estimates of GDP at current prices), Worldometer; Frost & Sullivan Analysis

1.2.2 Index of Industrial Production (IIP)

India's Index of Industrial Production (IIP) witnessed healthy growth across all major sectors in FY2025. The manufacturing sector, which contributes ~77% to the IIP index, rose from 137.1 in FY2023 to 150.6 in FY2025, showing consistent recovery and resilience. This was supported by broad-based expansion in industries like motor vehicles, electrical equipment, pharmaceuticals, and food processing. The electricity index in the same period grew robustly from 185.2 to 208.6, indicating higher power demand from industrial and residential users. The mining index also improved from 119.9 to 132.8, reflecting strong mineral production, especially coal and lignite.

Exhibit 1.5: India - Index of Industrial Production (IIP) by sectors, FY2018 - FY2025



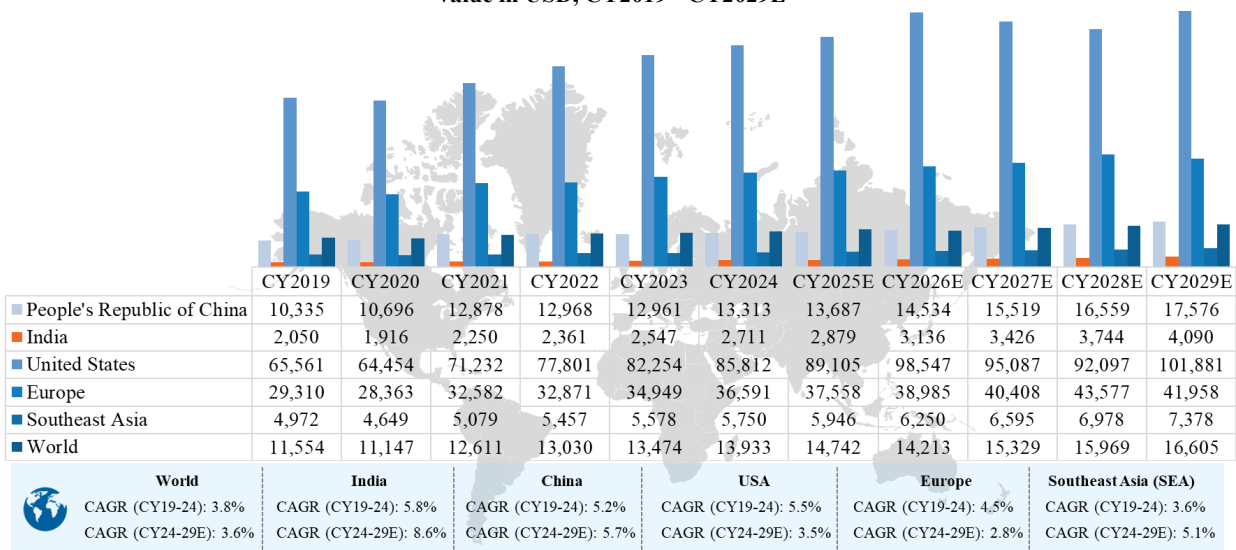
Source: MoSPI (Annual Estimates of GDP at constant price, 2011-12 series); RBI (Reserve Bank of India); Frost & Sullivan Analysis

The overall growth in FY2025 was supported by the government's strong push to boost manufacturing through PLI schemes, increased spending on infrastructure, and a steady rise in demand within the country. Although there were some ups and downs during the year due to changes in the previous year's base and global events, industrial activity remained strong throughout FY2025. This shows that India's industry is continuing to grow steadily, especially compared to the slowdown seen during the pandemic years.

1.2.3 Per capita income

India's per capita income is estimated to reach USD 2,878.5 in CY2025, up from USD 2,546.8 in CY2023, reflecting a steady upward trajectory as the economy continues to expand and formalise. While this growth is encouraging, India remains a lower-middle-income country, with its income level still expected to be over five times lower than the global average of USD 14,741.6 in CY2025.

Exhibit 1.6: India vs. Global – Per capita income of India vs leading economies (USA, China, Europe and Southeast Asia), value in USD, CY2019 - CY2029E



Source: IMF; Frost & Sullivan Analysis

India's per capita GDP is projected to increase from approximately USD 2,711 in CY2024 to around USD 4,090 by CY2029, reflecting a growth of over 50% over the five-year period. This steady rise in income, supported by formal job creation, industrial productivity gains, and wider access to healthcare and education, is expected to boost discretionary spending. The resulting consumption uptick is likely to drive long-term demand for consumer appliances, automotive components, and other manufactured goods.

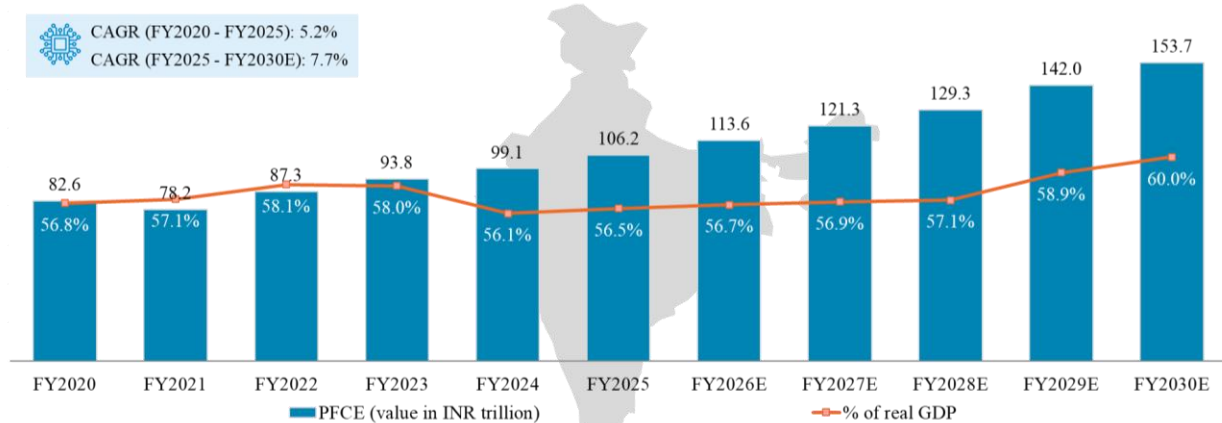
Importantly, India's demographic advantage—along with ongoing digital and infrastructure reforms—is expected to add nearly 400 million middle- and high-income earners by FY2031, fueling consumption and economic diversification.

Globally, high-income economies like the United States (USD 89,105.2) and Europe (USD 37,557.9) continue to maintain strong per capita incomes in CY2025, while China's per capita income is projected at USD 13,687.3, narrowing the gap with developed nations. Southeast Asia, with an average income of USD 5,946.3, is also witnessing robust catch-up growth, particularly in countries like Vietnam, Indonesia, and the Philippines. India's relative performance places it in the early stages of this transition—its CY2024–29 CAGR of 8.6% in per capita income is among the fastest globally, signaling strong upside potential. However, this also highlights the urgency to address disparities in income distribution, skills, and urban–rural infrastructure to ensure that India's growth story is both inclusive and sustainable.

1.2.4 Private Final Consumption Expenditure (PFCE)

Private Final Consumption Expenditure (PFCE) in India has shown a steady upward trend in value terms, increasing from INR 82.6 trillion in FY2020 to INR 106.2 trillion in FY2025, and is projected to reach INR 153.7 trillion by FY2030. Despite temporary disruptions in FY2021 due to the pandemic, consumption rebounded from FY2022 onward, reflecting improving economic sentiment and income growth. In FY2025, PFCE recorded a strong 7.2% year-on-year growth over FY2024 (INR 99.1 trillion), driven by a recovery in discretionary spending, improved rural demand, and a pickup in services and durable goods consumption. However, PFCE as a percentage of real GDP remained largely stable between 56% and 58% over the past several years, indicating that while consumption continues to grow in absolute terms, its share in the overall economy has not expanded significantly. The ratio dipped slightly in FY2024 to 56.1%, but is projected to gradually rise to 60.0% by FY2030E, suggesting a modest shift towards consumption-led growth in the coming years. This trend underscores the growing importance of domestic consumption as a key driver of India's economic expansion.

Exhibit 1.7: India – Private Final Consumption Expenditure as % of real GDP, value in INR trillion, contribution in %, FY2020-FY2030E

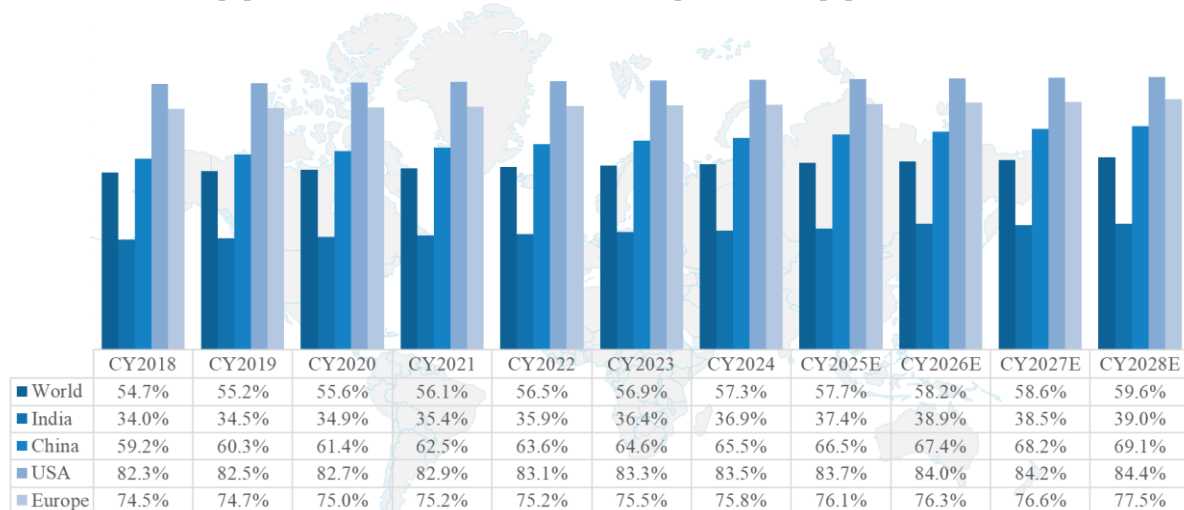


Source: MoSPI; Frost & Sullivan Analysis

1.2.5 Urbanization – India vs. leading global economies

As of CY2024, 57.3% of the global population lived in urban areas, and this trend is expected to continue, with the urban population set to more than double by CY2050, according to the World Bank. Higher

Exhibit 1.8: Urban population in India vs USA, China and Europe, % of total population, CY2018 - CY2028E



Source: United Nations - Data portal population division; Frost & Sullivan Analysis

urbanisation typically drives per capita income and economic growth. India, with 36.9% urbanisation, lags behind key economies such as the USA (83.5%), Europe (75.8%), and China (65.5%).

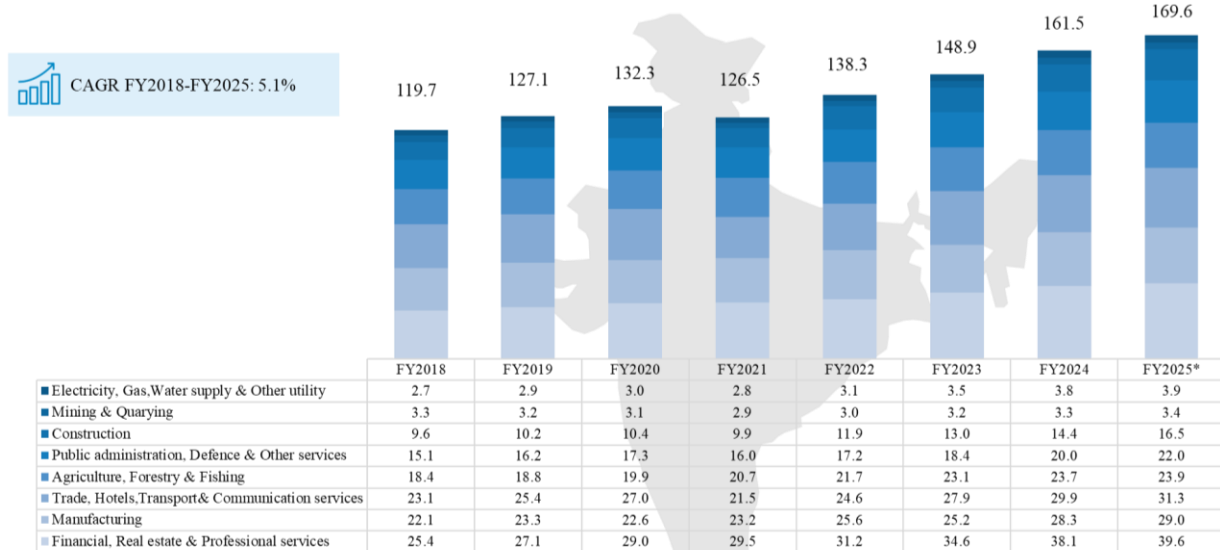
1.2.6 Sectoral share of Gross Value Added (GVA)

India's Gross Value Added (GVA) data for FY2025 indicates a diverse economic performance across sectors. The manufacturing sector experienced moderate growth, reflecting ongoing challenges in global demand and domestic production costs. The agriculture sector showed resilience, supported by favorable monsoon conditions and increased food grain production. Services, particularly financial, real estate, and professional services, continued their robust expansion, driven by strong domestic demand and digital transformation. Construction and public administration sectors also contributed positively, benefiting from increased government spending and infrastructure development initiatives.

Despite these sectoral strengths, the overall GVA growth of 5.0% in FY2025 represents a slowdown from the previous year's 8.5%, reflecting global economic uncertainties and domestic challenges. Private consumption remained a key growth driver, bolstered by rural demand and easing inflation. However, concerns persist regarding the sustainability of investment-led growth, with limited private sector participation and global trade uncertainties posing risks.

India's manufacturing sector has steadily expanded its economic contribution over the last several years, and the data reflects a clear shift towards higher value-added, capital-intensive industries. For example, machinery and equipment showed a robust rise from INR 5.3 trillion in FY2018 to INR 7.5 trillion in FY2024, growing at a CAGR of ~6.0%, reflecting growing investments in automation, industrial modernisation, and infrastructure development. This growth signals that Indian manufacturers are increasingly focusing on improving productivity and technology adoption rather than just volume growth.

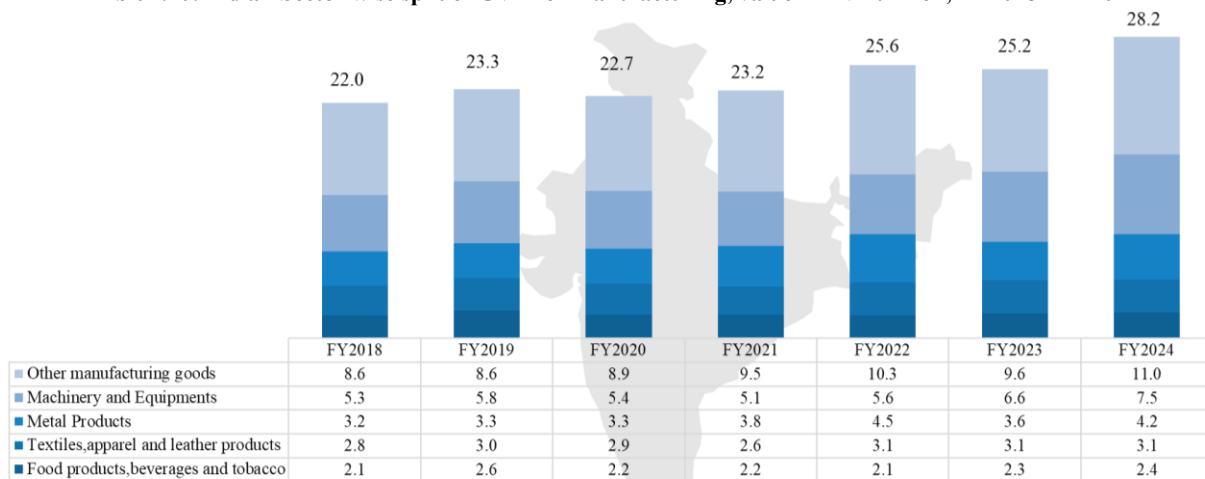
Exhibit 1.9: India - Gross value added (GVA) at basic price by economic activity, INR trillion, FY2018 - FY2025*



* Second Advance Estimates

Source: National Statistical Office; Frost & Sullivan Analysis

Similarly, metal products and other manufacturing goods have seen strong gains, driven by both domestic infrastructure demand and export opportunities. The surge in metal products from INR 3.2 trillion in FY2018 to INR 4.2 trillion in FY2024 can be linked to the government's push on construction, automobile, and defense sectors, which rely heavily on metal inputs. Meanwhile, the relatively modest growth in food products and textiles—traditional labour-intensive sectors—indicates a gradual transition of the economy from lower-value manufacturing towards more sophisticated industries.

Exhibit 1.10: India - Sector wise split of GVA for manufacturing, value in INR trillion, FY2018 - FY2024

Source: National Statistical Office; Frost & Sullivan Analysis

Underlying these sector trends are policy measures like the Production Linked Incentive (PLI) schemes, which are specifically designed to boost competitive, export-oriented manufacturing and attract global supply chains. Along with increased capital expenditure and infrastructure upgrades, these initiatives have encouraged businesses to invest in higher technology and scale up operations. This shift not only enhances India's global manufacturing competitiveness but also supports more sustainable, higher-quality job creation.

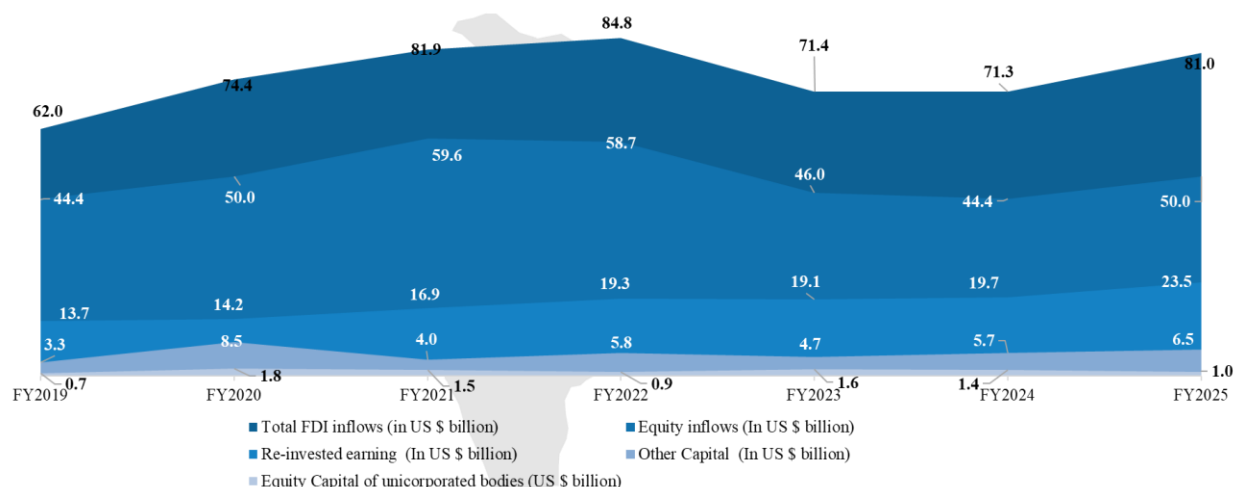
1.2.7 Government Infrastructure Push, Ease of Doing Business, and PLI Support for Manufacturing

Over the past few years, the Indian government has made significant strides in transforming the country's infrastructure and business ecosystem, aiming to position India as a global manufacturing hub. This transformation is being driven by three interconnected pillars: large-scale infrastructure investment, ease of doing business reforms, and targeted incentives under the Production Linked Incentive (PLI) schemes.

Infrastructure Investment: Infrastructure development has been the cornerstone of India's economic growth agenda. The government launched the National Infrastructure Pipeline (NIP) in 2019, targeting investments worth ₹111 lakh crore (USD ~1.5 trillion) over FY2020–FY2025, with key focus areas including energy, roads, railways, and urban infrastructure. Further, the PM Gati Shakti National Master Plan launched in FY2022 aims to bring synergy across departments by integrating 16 infrastructure-related ministries. Gati Shakti targets a USD ~1.2 trillion investment outlay to improve connectivity and logistics across the country. In particular, the Dedicated Freight Corridors (DFC) for railways, expansion of national highways, modernization of ports, and large-scale renewable energy installations have been key initiatives under this umbrella.

Improvement in Ease of Doing Business: India has made remarkable progress in improving the ease of doing business through streamlined approval processes, digitalization, and compliance reforms. Although the World Bank discontinued the Doing Business report after 2020, India had already climbed to 63rd rank in 2019 from 142nd in 2014. These reforms have translated into greater investor confidence and increased FDI inflows. Foreign Direct Investment (FDI) in India has witnessed robust growth over the last several years, supported by structural reforms, proactive government policies such as Make in India, and consistent improvements in India's Ease of Doing Business rankings. Between FY2019 and FY2025, the country attracted a cumulative USD 526.8 billion in total FDI inflows, underscoring its position as a key investment destination among emerging economies.

Exhibit 1.11: FDI inflow in India, in USD billion, FY2019 – FY2025



Source: DPIIT, Frost & Sullivan Analysis

India recorded its highest-ever FDI inflow of USD 84.8 billion in FY2022, driven by strong investor confidence in sectors like digital infrastructure, renewable energy, and advanced manufacturing. While FDI moderated slightly to USD 71.4 billion in FY2023 and remained nearly flat at USD 71.3 billion in FY2024, these levels were still broadly in line with the six-year average of ~USD 75 billion per annum. Notably, India has managed to sustain this momentum despite regulatory tightening around FDI from certain geographies, including China.

In FY2025, total FDI inflows rebounded to USD 81.0 billion, reflecting renewed investor interest amid improving macroeconomic stability and strong domestic consumption trends. The rebound was led by a pickup in equity inflows (USD 50.0 billion) and a significant increase in reinvested earnings (USD 23.5 billion) — a sign of long-term investor commitment to the Indian market.

Even in a globally high-interest-rate environment, India's FDI performance has outpaced that of many of its peer developing economies. This resilience is largely attributed to the structural demand strength of the Indian economy, ongoing government initiatives to reduce compliance burden, and strategic focus on high-growth sectors such as semiconductors, electric vehicles, green hydrogen, and electronics manufacturing.

Supportive Policy Measures and PLI Scheme: A central pillar of India's manufacturing strategy is the Production Linked Incentive (PLI) scheme, launched in 2020 with an initial outlay of ₹1.97 lakh crore (USD ~24 billion) across 14 sectors. These include electronics, pharmaceuticals, automobiles, advanced chemistry cell batteries, and textiles. The scheme aims to boost domestic production, attract investment, encourage import substitution, and support job creation.

As of FY2024, PLI has led to actual investments of over ₹1.46 lakh crore, generated ₹14 lakh crore in output, and created 1.15 million jobs. Notably, over ₹5.31 lakh crore worth of goods were exported under PLI-enabled units. However, there remain executional gaps: as of FY2024-end, subsidy disbursements accounted for less than 10% of the total approved outlay, highlighting the need for improved monitoring and faster fund flows. Sectors such as telecom, white goods, and textiles have outperformed, while others—like solar PV modules—are yet to fully scale.

2. MARKET ASSESSMENT OF SENSOR SOLUTIONS (INDIA AND GLOBAL)

2.1 Key Products Overview

Industrial sensors play a critical role across a broad spectrum of industries by enabling real-time monitoring, control, and optimization of operations. With the rapid advancement of industrial automation, stricter regulatory compliance, and a growing emphasis on predictive maintenance and safety, the global demand for intelligent sensing technologies is increasing significantly.

Sensors refer to a class of industrial devices that detect, measure, and transmit information about physical or chemical conditions such as temperature, pressure, flow, or proximity. Temperature sensors are among the most utilized, playing critical roles in assuring thermal stability, equipment safety, and process efficiency.

Temperature Sensors

Temperature sensors are devices that collect information or data about temperature from certain sources and transform it into intelligible formats for an observer or other devices. Temperature sensors are vital not only for traditional sectors like chemicals, oil & gas, and power generation, but also for fast-evolving domains such as EV battery management, food safety, renewable energy systems, and semiconductor manufacturing. Their ability to provide accurate and timely thermal data is crucial for digitalization, energy optimization, and smart factory transformation.

The key product categories within temperature sensors include:

- **Contact Sensors** – Contact Sensors include **Thermocouples, Resistance Temperature Detector (RTDs), Thermistors, Fiber Optic Temperature Sensors, Gauges, etc.** A contact temperature sensor works by physically touching the surface or medium whose temperature is being measured. It senses temperature using the heat transferred from the item to the sensor element. These sensors are widely used in industries like metals, chemicals, power generation, food processing, aerospace, and automotive.
- **Non-Contact Sensors** – Non-contact sensors include **Infrared (IR) Sensors - Pyrometers and Fixed Industrial Thermal Imagers.** A non-contact temperature sensor works by detecting the thermal radiation (infrared energy) emitted by an object without making physical contact. These sensors calculate temperature based on the intensity of radiation, making them ideal for moving, hot, or hazardous surfaces. They are widely used in glass manufacturing, steel mills, electronics, battery and semiconductor applications, where traditional contact methods are impractical or unsafe.
- In some applications, both contact and non-contact temperature sensors can be used effectively. The choice often depends on factors like customer preference, budget, required accuracy, and sensor lifespan, among others.

Temperature Sensors – Other Allied Products

- **Sensor Protection** - Sensor protection components include **thermowells and protective tubes.** Sensor protection is intended to protect temperature sensors from extreme conditions such as high pressure, corrosive substances, abrasion, and mechanical damage. These protective components increase sensor life, reduce maintenance frequency, and ensure operator safety. Sensor protection is vital in industries such as oil and gas, petrochemicals, pharmaceuticals, and power production, where sensors are subjected to harsh processing conditions.

- **Temperature Calibrators** - Temperature calibrators are used to evaluate and adjust temperature sensors and transmitters by providing a constant, known temperature reference. Calibration enables consistent performance, regulatory compliance, and traceability. They are crucial in industries like pharmaceuticals, food and beverage, aerospace, and power generation, where precise temperature control is required for product quality and process integrity.
- **Data loggers** - These instruments record temperature data over time, allowing for continuous monitoring, traceability, and historical study of thermal conditions, including *in-situ* industrial processes. Data loggers are frequently employed in industries that require precise and dependable temperature tracking, including pharmaceuticals, automotive, cold chain logistics, food processing, environmental monitoring, and cleanroom operations.
- **Temperature Transmitters** – They convert signals from sensors like RTDs or thermocouples into standard outputs (e.g., 4–20 mA) for accurate, long-distance transmission. It ensures signal stability, noise reduction, and compatibility with control systems. Used widely in process industries, power plants, and pharma for precise temperature monitoring. It is also applied in HVAC, water treatment, and testing labs for automation and control.

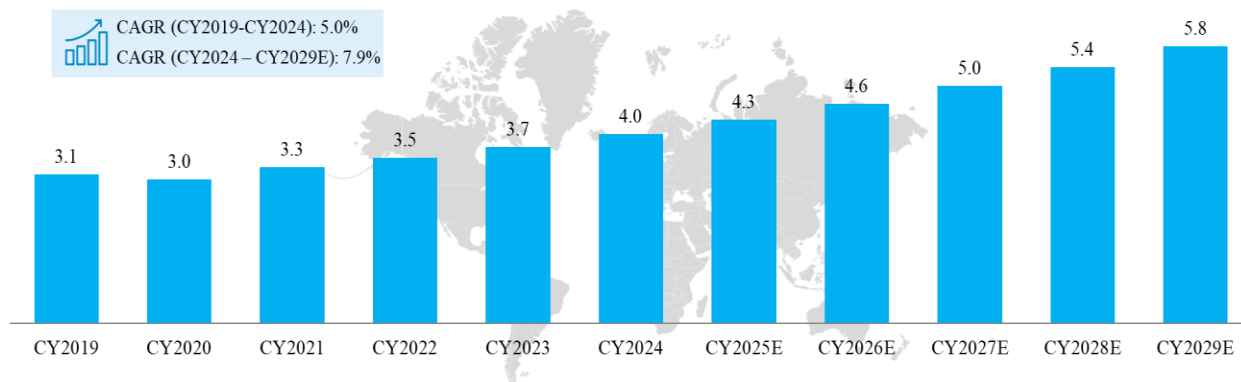
Exhibit 2.1: Mapping Grid: Categories vs Tempsens Products

CATEGORY	MAPPED TEMPESENS PRODUCTS
Temperature (Contact) Sensors	- Thermocouple - Resistance Temperature Detector (RTD) - Temperature Gauges
Temperature (Non-Contact) Sensors	- Infrared Pyrometers - Fixed Industrial Thermal Imagers
Sensor Protection	- Thermowells - Protection Tubes
Calibration & Validation Tool	- Temperature Calibrators
Data Acquisition	- Data Loggers
Other Allied Products	- Heat Flux Detectors

2.2 Temperature Sensor and Allied Solutions: Global Market Overview

The global temperature sensors and allied products market has shown strong and steady growth over the past several years, fueled by rapid industrial automation, increased focus on process accuracy, stricter regulatory compliance, and rising adoption of smart factory systems.

The market is also witnessing strong traction from industries transitioning toward energy efficiency and emissions compliance, where accurate thermal measurement is key to optimizing process performance and reducing waste. Advances in sensor miniaturization, wireless connectivity, and digital calibration are making temperature sensing more accessible and versatile across a wide range of applications, from high-speed semiconductor production lines to remote offshore oil rigs.

Exhibit 2.2: Global market size for Temperature Sensors and Allied Products (Value in USD Bn), CY2019 – CY2029E

From CY2019 to CY2024, the global market expanded at a CAGR of 5.0%, growing from approximately USD 3.1 billion in CY2019 to an estimated USD 4.0 billion in CY2024. Despite short-term disruptions during the COVID-19 pandemic in CY2020, demand remained resilient, particularly in essential and energy-intensive sectors such as oil & gas, chemicals, metals, power generation, glass manufacturing, etc. These industries relied heavily on precise thermal monitoring and control to ensure process integrity, safety compliance, and operational continuity, even during supply chain and workforce challenges.

Recovery in CY2021 and CY2022 was driven by renewed manufacturing activity, a surge in demand for data-driven instrumentation, and expanding adoption of non-contact sensing, real-time data logging, and wireless sensor networks across both developed and emerging markets.

The market is forecast to grow from USD 4.0 billion in CY2024 to USD 5.8 billion in CY2029, translating to an approximate CAGR of 7.9%. Growth will be driven by:

- **Stricter Safety & Compliance Norms**

Industries such as pharmaceuticals, food & beverage, and chemicals face tighter temperature monitoring mandates for quality assurance and regulatory compliance (e.g., FDA, ISO, HACCP). This is driving demand for high-accuracy sensors, loggers, and calibration tools.

- **EV & Clean Energy Ecosystem Growth**

The rapid growth of electric vehicles, lithium-ion battery production, and renewable energy systems has created a need for advanced temperature sensing. RTDs and infrared sensors - Pyrometers are now critical for battery thermal management, inverters, and electrolyzers.

- **Semiconductor & Electronics Manufacturing**

The semiconductor boom is driving demand for ultra-precise temperature control during wafer fabrication, lithography, and assembly. Non-contact infrared sensors and micro RTDs are being used to maintain tight thermal tolerances.

- **Infrastructure Upgrades & Retrofitting**

Aging facilities across Europe, North America, and parts of Asia are modernizing outdated analog systems. Industrial players are retrofitting with smart temperature sensors and transmitters that integrate with PLCs and SCADA systems for energy-efficient operations.

In the global temperature sensor market, non-contact sensors are also growing faster than contact sensors, though contact sensors still hold the majority share. Contact Sensors are expected to grow at a CAGR of around 6–7% through CY2029. On the other hand, non-contact sensors, including infrared sensors,

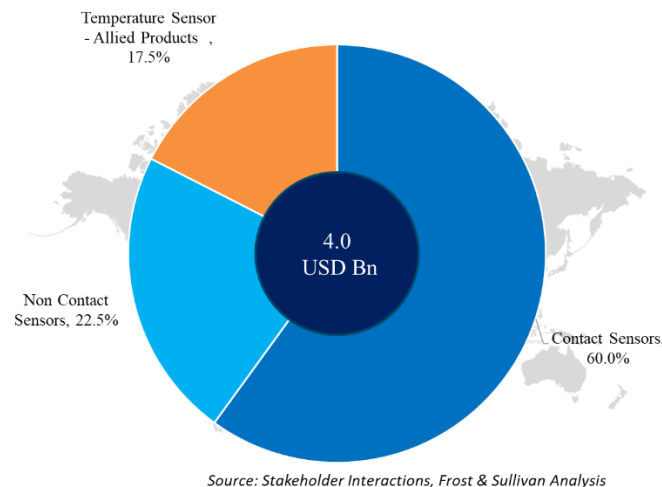
pyrometers, and fixed thermal imagers, represent about 22.5% of the market and are projected to grow at a faster CAGR of 9–11% over the same period.

Several factors are driving this higher growth in non-contact sensors. Firstly, industries like semiconductors, EVs, glass manufacturing, and aerospace increasingly demand precise, non-intrusive thermal monitoring where traditional contact sensors fall short. Secondly, predictive maintenance strategies, especially in Europe and North America, are pushing the adoption of thermal imagers and IR sensors for electrical audits, motor diagnostics, and process safety. Lastly, as hygiene standards, automation levels, and remote monitoring requirements rise globally, non-contact technologies are gaining favor due to their ability to provide real-time, contactless, and scalable thermal insights. With falling costs, enhanced accuracy, and increasing digital compatibility, non-contact sensors are positioned as the fastest-growing segment in the global temperature sensing landscape.

2.2.1 Temperature Sensor and Allied Solutions: Product-Wise Segmentation (Global)

The global Temperature sensor and Allied products market comprises three core product categories - Contact Sensors, Non-Contact Sensors, and allied temperature sensor solutions such as Sensor Protection, Temperature Calibrators, Heat Flux Detectors, and Data Loggers, each serving distinct roles across manufacturing, process industries, and energy infrastructure. Contact Sensors, which account for the largest share of the market (60.0% in CY2024), are widely used in various sectors, including chemicals, Steel, cement, non-ferrous metals, and glass. The demand for non-contact sensors is expected to increase due to the growing adoption of IoT, the need for reduced downtime, and the lower operational costs over the device's lifetime compared to contact temperature sensors.

Exhibit 2.3: Product-Wise Contribution to Global Temperature Sensor and Allied Solutions Market CY2024



Non-contact sensors, including infrared sensors, pyrometers, and Fixed Industrial thermal imagers, account for 22.5% of the market. They are witnessing increasing adoption in EV battery lines, semiconductors, glass, and switchyards where direct contact is impractical.

Sensor protection components, such as thermowell and protection tubes, underline the need to extend sensor life and ensure performance in harsh industrial environments like oil & gas and chemical plants. Temperature calibrators support growing quality and compliance needs in regulated industries like pharmaceuticals, food processing, and advanced materials, where measurement accuracy is critical. With an increasing global focus on traceability, audits, and digital monitoring, both data loggers and calibrators are expected to see strong future growth.

2.2.2 Temperature Sensors and Allied Products: Market Segmentation by Countries/ Region (Global)

The global temperature sensors and allied products market, encompassing contact and non-contact sensors, sensor protection devices, temperature calibrators, and data loggers, is geographically diverse, shaped by regional variations in industrial intensity, regulatory mandates, and digital adoption levels. Below is a detailed regional breakdown:

A. North America (Key markets include the United States and Canada)

Market Drivers:

- Growing focus on predictive maintenance and asset health monitoring is increasing the use of integrated temperature sensors in rotating equipment and thermal systems.
- Reshoring advanced manufacturing and semiconductor fabs is boosting demand for ultra-precise thermal monitoring in clean rooms and high-tech environments.
- Federal incentives for energy efficiency upgrades (e.g., U.S. DOE's Better Plants Program) are driving retrofitting of legacy temperature sensing infrastructure in power and process industries.

Key Trends:

- Growth in demand for thermistors in HVAC and medical equipment applications.
- Increasing use of RTDs and thermocouples in EV batteries, food processing, and semiconductors.
- Retrofit demand for replacing legacy gauges with smart, digital contact sensors.
- Strong preference for RTDs in regulated sectors for their high precision and traceability

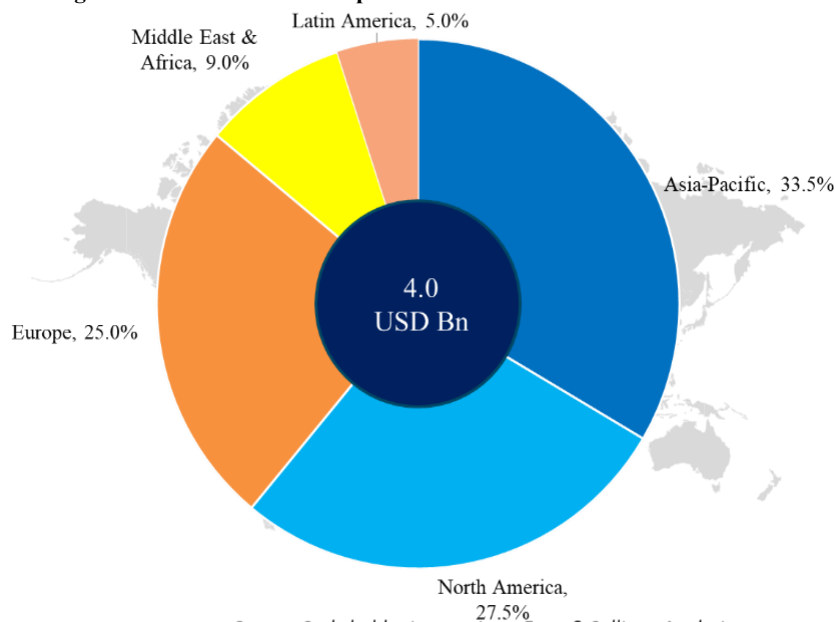
B. Europe (Key Markets: Germany, France, Italy, UK, Netherlands)

Market Drivers:

- EU Green Deal and industrial decarbonization goals are accelerating the adoption of high-precision thermal monitoring systems for energy-intensive sectors.
- Stricter compliance with EN/ISO calibration traceability and audit readiness is pushing industries to upgrade to digitally certified temperature measurement solutions.
- Rapid growth in pharmaceuticals, biologics, and cleanroom manufacturing is driving demand for validated high-accuracy temperature sensors and data loggers.

Key Trends:

- Retrofit programs in Germany and France are driving large-scale deployment of digitally calibrated thermocouples in heavy industries.
- Calibration traceability and CE compliance are accelerating RTD adoption with digital transmitters and thermowells.
- Growth in non-contact sensors for high-temperature environments like steel and glass.

Exhibit 2.4: Regional Share of Global Temperature Sensors and Allied Solutions Market CY2024

Source: Stakeholder Interactions, Frost & Sullivan Analysis

C. Asia-Pacific (Key markets: China, India, Japan, South Korea)

Market Drivers:

- Explosive growth in manufacturing hubs for metals, chemicals, semiconductors, and electronics is driving large-scale deployment of precision temperature sensors for process control.
- The rapid expansion of EV, battery, and solar module ecosystems is creating high-volume demand for compact, high-response temperature sensors for thermal safety and process accuracy.

Key Trends:

- Surge in miniaturized RTDs for electronics, EV battery packs, and PCB assembly lines, especially in China, Japan, and South Korea.
- India is becoming a hub for thermocouple and thermowell manufacturing, with players like Tempens scaling to meet export and domestic demand.
- Surge in IR sensors and micro RTDs in semiconductor fabs and battery pack lines.

D. Middle East & Africa (Key Markets: UAE, Saudi Arabia, South Africa)

Market Drivers:

- Large-scale automation and digitalization across oil, gas, and refining assets are driving demand for rugged, high-precision temperature sensors in harsh environments.
- Petrochemical and metal industries require robust thermal monitoring solutions to ensure operational safety, process stability, and compliance in high-temperature zones.
- Government-led localization programs like Saudi Arabia's Vision 2030 are boosting domestic manufacturing and sourcing of industrial instrumentation, including temperature sensing components.
- Massive greenfield/brownfield green energy projects

Key Trends:

- Demand for explosion-proof thermocouples and armored RTDs in oil & gas, refineries, and petrochemicals.
- Use of heat-resistant thermowells paired with contact sensors in furnace and flare stack monitoring systems.
- Growing interest in remote-calibrated RTDs and rugged sensors for desert and offshore plant conditions.

E. Latin America (Key Markets: Brazil, Mexico, Chile)

Market Drivers:

- Rising food and beverage exports are driving demand for traceable, calibrated temperature sensors to meet international safety and quality standards.
- Growth in automotive and aerospace component manufacturing is fueling the adoption of precision thermal sensors for R&D, testing, and production line monitoring.
- Government-backed industrial modernization programs are incentivizing the replacement of legacy thermal instrumentation in the energy, mining, and chemical sectors.

Key Trends:

- Increasing use of contact sensors in food & beverage, driven by traceability and HACCP compliance, especially in Brazil.
- RTDs and thermocouples are being integrated into automation systems in Mexico's automotive and industrial clusters.
- Public investment in process optimization is driving upgrades to digitally integrated RTDs and sensor protection assemblies in the metal and mining sectors.

2.2.3 Temperature Sensor and Allied Solutions: End User Application Area (Global)

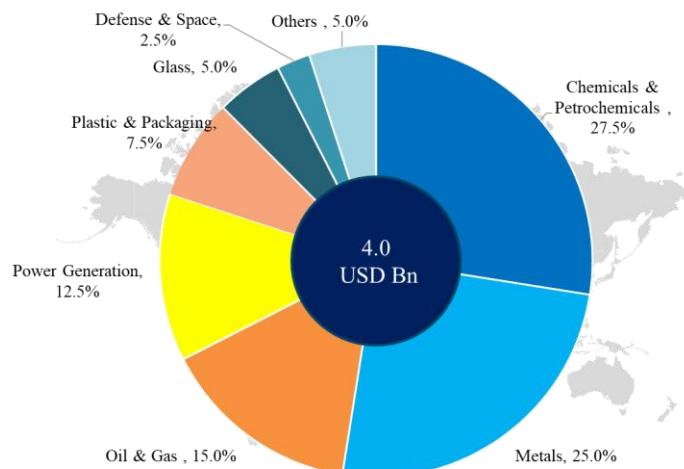
The global temperature sensors and allied products market, valued at USD 4.0 billion in CY2024, is deeply integrated into the operational framework of a wide range of industries, where precise thermal monitoring, safety, and compliance are essential.

The chemicals & petrochemicals sector leads with a 27.5% share, using RTDs and thermocouples in reactors and pipelines for process control and regulatory compliance. Plants across the U.S. Gulf Coast, the Middle East, and China rely on validated temperature sensors for real-time thermal mapping, often integrated with DCS and PLC systems.

The metals industry accounts for 25.0% of global demand and relies heavily on high-temperature sensors and protective assemblies in furnaces and rolling operations. Infrared sensors and thermal imaging are also applied for non-invasive monitoring of molten metal and forging lines. Germany, South Korea, India, and China are major markets.

Oil & Gas accounts for 15.0% of global demand. Temperature sensors are critical for pipeline monitoring, tank gauging, and refining operations. Demand is strong in Saudi Arabia, the U.S., UAE, and Canada, particularly for field-deployable, corrosion-resistant solutions.

The power generation segment accounts for 12.5% of global demand and uses RTDs and thermocouples to optimize boiler and turbine performance. RTDs and thermocouples help maintain system efficiency and enable predictive maintenance.

Exhibit 2.5: End-user application Global Temperature Sensors and Allied Solutions Market CY2024

Source: Stakeholder Interactions, Frost & Sullivan Analysis

Plastic & packaging accounts for 7.5% of global demand and employs contact sensors for precise temperature control in extrusion and molding processes. Contact sensors (RTDs and thermocouples) are extensively used in extruders, injection molding machines, and thermoformers to maintain temperature precision during processing.

Glass manufacturing accounts for 5.0% of global demand and uses thermocouples and IR sensors, Pyrometers for melting and annealing operations. Glass production demands high-temperature monitoring for melting, annealing, and tempering. High-temperature precious metal thermocouples with protection tubes and IR sensors are deployed in glass furnaces and float lines.

The defense & space sector accounts for 2.5% of global demand, and it is essential in missile systems, thermal imaging devices, avionics, and propulsion systems. Aerospace-grade RTDs and precision calibrators are used in engine testing and environmental chambers. This is a high-growth, small share, and high-margin segment in the overall Temperature Sensors and Allied Solutions market.

The remaining 5.0% classified as "others" covers critical, high-value applications in pharmaceuticals, EV battery systems, semiconductors, food processing, and cleanrooms. In these sectors, data loggers, calibrators, and traceable sensors are essential tools.

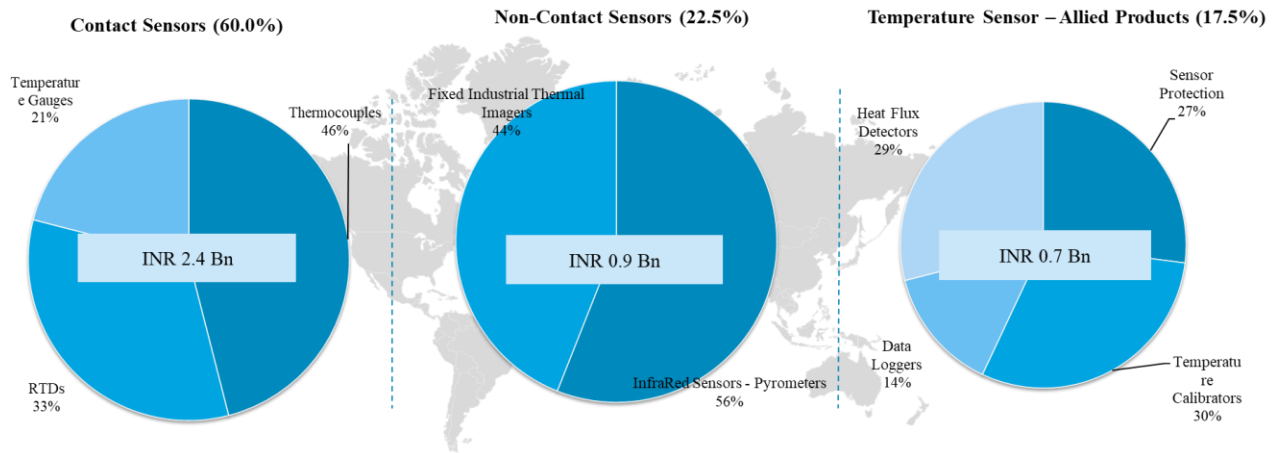
2.2.4 Global Sub-Segmentation for Individual Products – Contact, Non-Contact Sensors and Sensor Protection

Thermocouples lead in rugged, high-temperature settings like steel mills and refineries, while highly accurate RTDs dominate power plants, pharma, and food processing, particularly in Europe, the U.S., and South Korea. Compact, fast-responding thermistors are widespread in electronics, HVAC, and medical applications across the Asia-Pacific, and heat-flux detectors are rapidly gaining ground in North America and Europe to support energy-efficiency and sustainability initiatives.

Infrared and thermal imagers are rapidly expanding due to their non-contact, real-time temperature mapping capabilities, widely adopted in North America and Europe for electrical safety and energy-audit applications, and experiencing rapid growth in the Asia-Pacific's automotive, semiconductor, and pharma sectors. Within this evolving landscape, TempSens stands out as India's largest player (in terms of revenue) in contact temperature sensors, as of March 31, 2025, uniquely differentiated by its deep backward

integration in manufacturing. This capability not only ensures a smooth supply chain, faster turnaround, quality control across thermocouples and RTDs, but also positions the company as one of the Indian manufacturer with end-to-end operational integration in this domain. Sensor protection components, which account for about a quarter of the global market, continue to be in high demand in EMEA's chemical and power plants, as well as North America's oil and gas facilities.

Exhibit 2.6: Sub-Segment Market Share, Contact, Non-Contact Sensors, Sensor Protection, Global, CY2024



Source: Stakeholder Discussions, Frost & Sullivan Analysis

2.2.5 Temperature Sensors: Sub-Segmentation Key End User Application Area (Global)

Advances in technology, quality compliance requirements, and smart manufacturing adoption are reshaping the global temperature sensor market. From process industries to precision electronics, temperature sensing is foundational to safety, efficiency, and product quality.

Thermocouples dominate harsh-environmental applications like steel mills and petrochemical refineries due to their ruggedness and wide temperature range. RTDs, valued for precision and stability, are widely adopted in pharmaceuticals, power generation, and food processing.

Infrared sensors are preferred in semiconductors, food, and metal processing, while thermal imagers are increasingly deployed for predictive maintenance and high-resolution thermal analysis in defence and infrastructure monitoring. Adoption is strong in the U.S., Europe, and East Asia, where automation and advanced diagnostics are becoming critical to operation.

Exhibit 2.7: Global Temperature Sensors and Allied Solutions Market — Sub-Segmentation with Applications, CY2024

CATEGORY	SUB-SEGMENT	% SHARE WITHIN CATEGORY	KEY INDIA END-USE APPLICATIONS
Contact Sensors (60.0%)	Thermocouples	46.0%	Steel manufacturing, petrochemical refineries, automotive assembly lines, boilers, and industrial furnaces
	RTD	33.0%	Power plants, pharmaceutical processing, food and beverage lines, HVAC systems, cleanrooms, and semiconductors.
	Temperature Gauges	21.0%	General industrial machinery, HVAC systems, water treatment, utility monitoring, shipbuilding and marine equipment

Non-Contact Sensors (22.5%)	Infrared Sensors Pyrometers	56.0%	Semiconductor fabs, food processing lines, glass and steel plants, plastic molding, and industrial safety systems
	Fixed Industrial Thermal Imagers	44.0%	Predictive maintenance (electrical panels, motors, furnaces), surveillance, , R&D labs, quality control in electronics, process control – power, cement, oil and gas
Temperature Sensor Allied Products (17.5%)	Sensor Protection - Thermowells/ Protection Tubes	27.0%	Chemical plants, power boilers, oil & gas pipelines, pharma reactors
	Temperature Calibrators	30.0%	Utilities, heavy machinery, mechanical workshops, and boiler systems
	Heat Flux Detectors	29.0%	Solar panel testing, aerospace R&D, building energy audits, material science labs
	Data Loggers	14.0%	Cold Chain, Power Utilities, Process control – Cement, Steel

Sensor protection hardware, like thermowell and protection tubes, plays a vital role in safeguarding sensors in corrosive, high-pressure, or abrasive environments. Common in oil & gas, power, and chemicals sectors, these components enable sensor longevity and consistent performance. Europe and North America are key markets due to stringent safety and process compliance standards.

2.2.6 Temperature Sensors and Applied Solution: Key Growth Drivers, Trends, Investment Trends (Global)

A. Growth Drivers

Smart Manufacturing & Industry 4.0

Increasing automation across industries is driving demand for precise, real-time temperature monitoring integrated with PLCs, SCADA, and IoT systems. Siemens integrates RTDs and thermocouples into its SIMATIC automation systems for temperature control in continuous process industries.

Electrification of Transport & Energy Transition

EVs, battery systems, fuel cells, and renewables (e.g., solar, hydrogen) require thermal management solutions, boosting sensor demand in energy and mobility sectors. LG Energy Solution uses flexible temperature sensors in battery cell manufacturing to detect overheating risks early.

Stringent Quality & Safety Regulations

Regulatory compliance (FDA, ISO 17025, GMP) in pharma, food, and aerospace is pushing the adoption of high-accuracy sensors, calibration devices, and data loggers. NASA uses high-accuracy thermocouples and IR sensors on spacecraft and testing platforms.

Precision temperature control for Emerging segments

In Semiconductor and Electronics Manufacturing, Precision temperature control is vital for wafer processing, PCB soldering, and chip fabrication. TSMC and Samsung use heat-flux sensors and thermocouples in semiconductor fabs to maintain tight process control during deposition and etching. Intel employs real-time IR imaging systems to detect hot spots during chip burn-in testing.

Global Cold Chain Expansion

Growth in biologics, fresh food exports, and vaccine distribution has intensified the need for calibrated sensors and real-time data loggers for thermal compliance. Cold storage warehouses use wireless temperature loggers to monitor perishable goods across the supply chain.

B. Trends

Advanced Sensor Protection Systems

Thermowells and protection tubes are being redesigned with coated alloys, ceramic liners, and modular threads to support higher pressures, corrosive fluids, and faster sensor replacement. Design reduces vibration-induced failures in high-velocity steam lines.

Digital Twin Compatibility

Temperature sensor data, especially from RTDs, thermocouples, and thermal imagers, is now directly fed into digital twins for process simulation, asset health modeling, and thermal design optimization. GE Digital's Digital Twin of Wind Turbines incorporates RTD and thermocouple data from the nacelle and gearbox regions for real-time predictive analytics.

Growth of Infrared and Non-Contact Sensors

Non-contact sensors such as infrared thermometers and thermal imagers are expanding rapidly in use cases where contamination risk, speed, or inaccessibility are factors. Infrared pyrometers are deployed in glass and metal manufacturing for continuous temperature monitoring of moving or high-temperature objects.

Edge-based Temperature Sensing

Contact sensors like RTDs and thermocouples are now integrated with edge computing modules to enable local processing, anomaly detection, and predictive alerts without relying on centralized systems. It combines contact temperature sensors with edge analytics to detect sensor drift and optimize recalibration cycles.

C. Investment Trends

Asia-Pacific is seeing large-scale investments in sensor production capacity, especially for thermistors and RTDs catering to EVs, electronics, and industrial automation. North America is focusing on R&D and smart sensor integration, targeting edge computing and digital twin applications. Europe is expanding in medical, cleanroom, and process automation-grade sensors, with an emphasis on compliance and traceability. Investment is also flowing into sensor protection (thermowell, housings) and wireless data logging systems, enabling broader deployment in hazardous and remote applications. These investments span geographies from North America and Europe to Asia Pacific and reflect a robust confidence in the long-term demand for Temperature Sensors and allied Products.

The table below highlights some of the most significant investments made between late 2024 and early 2025

Exhibit 2.7: Recent Global Investments in Temperature Sensors

COMPANY	COUNTRY	INVESTMENT(\$Mn)	PURPOSE	DATE
Omega Engineering	USA / UK	60.0	Modernization of calibration and sensor protection (thermowell) systems	Jan 2025

2.3 Temperature Sensor and Allied Solutions: India Market Overview

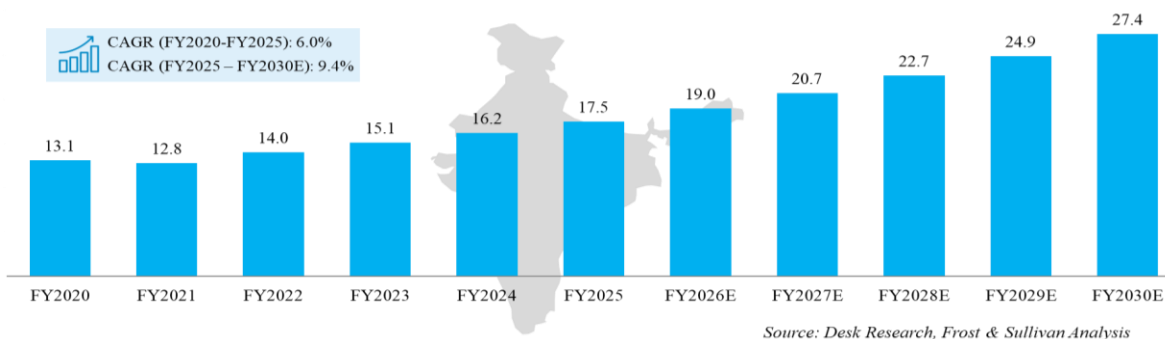
India's temperature sensors and allied products market was valued at approximately INR 17.5 billion in FY2025 and is projected to reach INR 27.4 billion by FY2030E, growing at a CAGR of 9.4%. Tempsons is the largest manufacturer of contact and non-contact temperature (in terms of revenue) sensors in India as

of March 31, 2025. Tempsons is also the only manufacturer of fibre optic temperature sensors and thermal profiling systems in India as of March 31, 2025. Tempsons' manufacturing capabilities are backward integrated for contact temperature sensors, making it one of the few companies in India with this capability in FY25. This deep backward integration in manufacturing puts Tempsons in a uniquely differentiated position. This capability ensures a smooth supply chain, faster turnaround, and quality control across thermocouples and RTDs.

Tempsons has its backward integration facility for Thermocouples, located at Udaipur. India's Sensor protection components, which account for about a quarter of the global market, continue to be in high demand in EMEA's chemical and power plants, as well as North America's oil and gas facilities.

The rising emphasis on precision monitoring, energy efficiency, and automation across both traditional and new-age industries underpins this growth.

Exhibit 2.8: India market size for Temperature Sensors and Allied solutions (Value in INR Bn), FY2020 – FY2030E



While core sectors such as steel, power generation, chemicals, and oil & gas continue to anchor demand, significant traction is now coming from electric vehicles (EVs), pharmaceuticals, food processing, semiconductors, and smart infrastructure projects. These sectors demand real-time thermal profiling, high accuracy, and rapid-response solutions. The product mix is evolving rapidly from conventional thermocouples and RTDs to advanced infrared sensors and other advanced technologies.

Demand for thermowells, protection tubes, transmitters, and temperature and pressure gauges is also expected to grow in tandem, especially from sectors emphasizing hygienic design. As India continues its journey toward smart manufacturing and sustainability, temperature sensing and monitoring systems will be pivotal in quality assurance, energy optimization, and equipment uptime, making this segment a critical enabler of industrial transformation.

In the Indian temperature sensor market, non-contact sensors are growing significantly faster than contact sensors. While contact sensors such as thermocouples, RTDs, and gauges continue to dominate with a 69.7% market share, they are expected to grow at a steady CAGR of 8–9% from FY2025 to FY2030. In contrast, non-contact sensors, which currently hold an 11.4% share, are projected to grow at a much faster CAGR of 12–14% over the same period. This acceleration is driven by the increasing adoption of smart manufacturing across sectors like EVs, semiconductors, glass, and cleanrooms, where real-time, hygienic, and contactless thermal monitoring is essential. Non-contact technologies such as infrared pyrometers and thermal imagers are being favored for their speed, precision, and ability to support predictive maintenance in modern industrial setups.

2.3.1 Temperature Sensors and Allied Solutions: Product-Wise Segmentation (India)

The market is broadly segmented into three key product categories - contact sensors, non-contact sensors, and Temperature sensors allied products (sensor protection components, calibration systems, Heat Flux

Detector, and data loggers), each catering to specific industrial needs. Contact sensors, including thermocouples, RTDs, and Temperature Gauges, dominate the landscape with a 69.7% share, widely used in core sectors like steel, power, chemicals, pharma, and food processing.

Non-contact sensors, including infrared sensors, pyrometers, and Fixed Industrial thermal imagers, account for 11.4% of the market. They are witnessing increasing adoption in EV battery lines, semiconductors, glass, and cleanroom environments where direct contact is impractical. These sensors are now being combined with AI and analytics to detect anomalies and enable predictive maintenance.

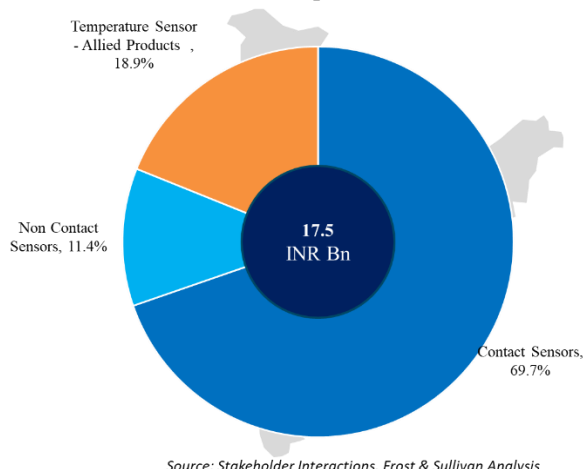
Sensor protection components, including thermowells and protection tubes, make up another 6.9% of the market. These are crucial in ensuring sensor longevity, hygiene, and safety in harsh or corrosive environments like chemical plants, pharmaceuticals, and wastewater treatment facilities.

Temperature calibration systems, though a smaller segment (4.6%), are vital in regulated industries like aerospace, pharmaceuticals, and defense, and also in general sectors like Steel, Cement, etc. Institutions and quality labs increasingly rely on automated and portable calibration solutions to maintain measurement accuracy.

Heat flux detectors, with a 4.6% market share, are crucial for measuring thermal energy transfer in applications like fire testing, combustion analysis, and insulation performance. Demand is rising in sectors such as aerospace, defense, and automotive, driven by the need for high-precision, fast-response, and integrated thermal measurement systems.

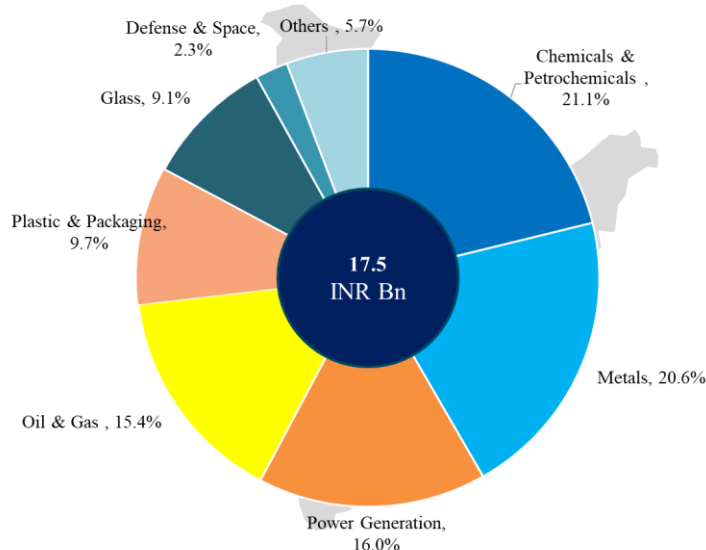
Finally, temperature data loggers and traceability tools account for approximately 2.9% of the market. They are indispensable in cold chain logistics, vaccine storage, and export-oriented sectors where real-time monitoring and regulatory compliance are critical.

Exhibit 2.9: Product-Wise Contribution to India Temperature Sensors and Allied Solutions Market FY2025



2.3.2 Temperature Sensors: End User Application Area (India)

India's temperature sensors and allied products market in CY2024 shows a diverse demand landscape led by process-intensive and precision-driven sectors. Chemicals & Petrochemicals hold the largest share at 21.1%, driven by the need for corrosion-resistant and ATEX-compliant sensors in reactors and pipelines. The metals sector, contributing 20.6%, relies heavily on rugged thermocouples and thermowells to withstand high temperatures in furnaces and rolling mills. Power Generation, with a 16.0% share, demands accurate and SCADA-integrated sensors for monitoring boilers and turbines, with a growing shift toward remote calibration. Oil & Gas accounts for 15.4%, where explosion-proof and wireless sensors are deployed in refineries and pipelines to enable real-time diagnostics and ensure safety compliance.

Exhibit 2.10: End-user application India Temperature Sensors and Allied Solutions Market FY2025

Source: Stakeholder Interactions, Frost & Sullivan Analysis

Plastic & Packaging (9.7%) utilizes compact RTDs and thermistors in extrusion and sealing lines to support automation and thermal precision. In the glass industry (9.1%), infrared and high-temperature sensors are used in forming and annealing processes, where durability and accuracy are key. The Defense & Space segment, though small at 2.3%, requires high-precision, traceable sensors for aerospace and missile applications. The remaining 5.7% spans sectors like pharmaceuticals, food processing, semiconductors, and EVs, where the demand is rapidly rising for smart sensors, temperature loggers, and compliance-ready thermal monitoring solutions.

2.3.3 Temperature Sensors: Sub-Segmentation for individual product (India)

India's temperature sensor and allied products market is a well-structured and steadily evolving segment, with a total estimated market size of INR 17.5 billion in FY25. Tempsens is the largest player in India, holding around 10.0% market share in the Temperature sensor segment in FY25.

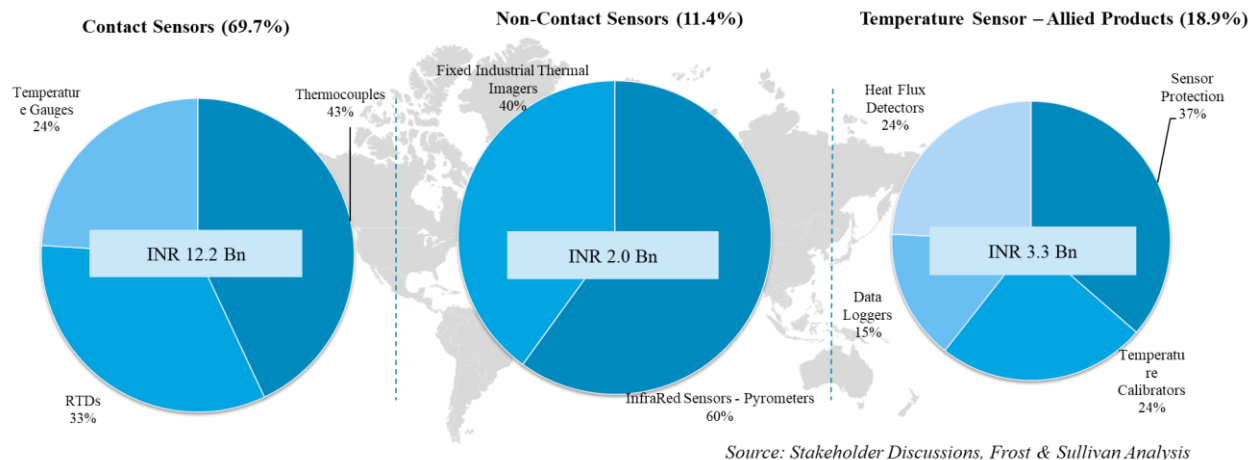
Contact sensors, which account for nearly 69.7% of the total market, form the core of India's temperature sensing landscape. Thermocouples (43.0%) continue to be the go-to solution in rugged, high-temperature environments such as steel mills, petrochemical plants, and cement factories. RTDs (33.0%) remain popular in applications requiring high accuracy and stability, such as pharmaceutical manufacturing, power plants, and food processing lines.

The non-contact sensor segment, valued at INR 2.0 billion, is becoming increasingly vital in India's industrial modernization journey. Infrared Sensors - Pyrometers, which make up 60% of this category, are widely adopted across sectors for non-invasive, hygienic, and real-time thermal monitoring, particularly useful in food safety, electronics testing, and predictive maintenance. Fixed Industrial Thermal imagers, constituting the remaining 40%, are seeing accelerated uptake in smart factories, data centers, utilities, and even EV battery systems. As Indian industries move toward smarter, contactless, and IoT-enabled environments, this segment is expected to grow at double-digit rates over the next few years.

Tempsens is the only Indian manufacturer of Non-contact temperature sensors in the market as on March 31, 2025. It holds ~18% of the Non-contact temperature sensor market share in FY2025. There are currently no other domestic manufacturers in this segment, making the country largely dependent on imports. By

indigenising Non-contact temperature sensor development, Tempsens has reduced reliance on foreign suppliers and established a strong leadership position. Its solutions are widely adopted across steel, glass, power, EV, and semiconductor industries. In FY2025, it is the only manufacturer of pyrometers and online thermal imagers in India.

Exhibit 2.11: Sub-Segment Market Share, Contact, Non-Contact Sensors, Sensor Protection, India, CY2024



Equally important is the temperature sensor–allied products market, which contributes INR 3.3 billion to the ecosystem. This category includes sensor protection systems, thermowells, protection tubes, temperature calibrators, Heat Flux Detectors, and data loggers, each playing a critical role in ensuring operational safety, sensor durability, and compliance with industry standards.

Thermowells are indispensable in refineries, chemical plants, and HVAC systems where analog and mechanical backups still provide reliable redundancy. Sensor protection tubes are especially important in corrosive or abrasive environments, preventing frequent sensor failures and reducing lifecycle costs.

Temperature Calibrators (INR 0.8 billion) and data loggers (INR 0.5 billion) serve high-growth verticals like pharmaceuticals, food logistics, and cleanroom environments, where traceability, accuracy, and auditability are non-negotiable.

Heat flux detectors, while representing a smaller 4.9% share, are gaining traction in advanced research, battery testing, and energy efficiency audits. This segment showcases a balance between legacy industrial reliability and emerging high-precision applications.

2.3.4 Temperature Sensors: Sub-Segmentation Key End User Application Area (India)

India's temperature sensor market is led by contact sensors used in core industries, while non-contact sensors are growing in EVs and smart manufacturing. Sensor protection and calibration tools are increasingly critical for compliance in sectors like pharma and energy. The market is shifting toward smarter, more reliable, and traceable solutions across traditional and emerging applications.

Exhibit 2.12: India Temperature Sensors and Allied Products Market – Sub-Segmentation with Applications, FY2025

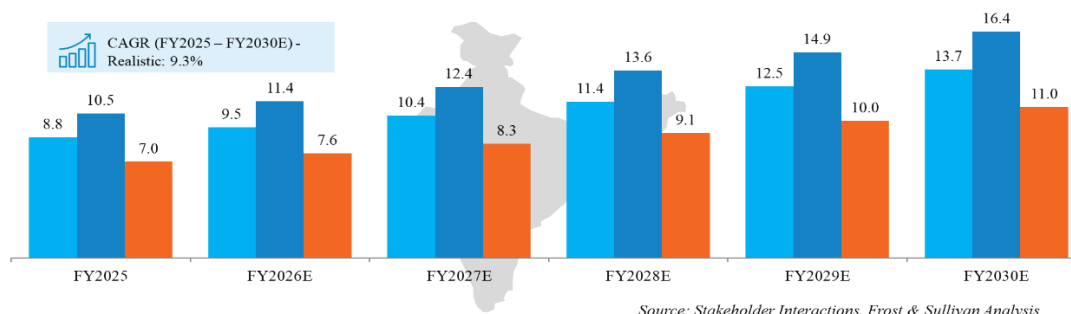
CATEGORY	SUB-SEGMENT	% SHARE WITHIN CATEGORY	KEY INDIA END-USE APPLICATIONS
Contact Sensors (69.7%)	Thermocouples	43.0%	Steel plants, glass manufacturing, cement kilns, furnaces, and petrochemicals

	RTD	33.0%	Pharmaceuticals, food & beverage, power generation, HVAC, cleanroom monitoring
	Temperature Gauges	24.0%	Chemical, Pharmaceuticals, Oil and Gas, HVAC
Non-Contact Sensors (11.4%)	Infrared Sensors Pyrometers	60.0%	EV battery lines, steel mills, packaging lines, electronics assembly, and flame detection
	Fixed Industrial Thermal Imagers	40.0%	Predictive maintenance, electrical audits, defence, aerospace components, and smart grid monitoring
Temperature Sensor Allied Products (18.9%)	Sensor Protection - Thermowells/ Protection Tubes	36.0%	Chemical plants, power boilers, oil & gas pipelines, pharma reactors
	Temperature Calibrators	25.0%	Utilities, heavy machinery, mechanical workshops, and boiler systems
	Heat Flux Detectors	24.0%	Research laboratories, Aerospace testing, Fire Safety, Automotive R&D
	Data Loggers	15.0%	Automotive, Glass, Cold Chain, Power Utilities, Process control – Cement, Steel

2.3.5 Temperature Sensor Solutions: Replacement Market (India)

The replacement market for temperature sensor solutions in India forms a vital part of the industry, contributing approximately 35% to 45% of the total market value. This demand is driven by regular wear, regulatory compliance, and the operational intensity of sectors such as steel, chemicals, power, pharmaceuticals, and food processing. Contact sensors like thermocouples, RTDs, and temperature gauges dominate the replacement space, accounting for 40–50% of the volume due to frequent exposure to high temperatures, corrosion, and vibration. These typically require replacement every 12-24 months, with rising adoption of digital, plug-and-play options that reduce downtime and simplify retrofits.

Exhibit 2.13: India Temperature Sensors and Allied Products Solutions Replacement Market Opportunity (Realistic, Optimistic & Pessimistic scenarios): FY2025 to FY2030E, INR Bn



Non-contact sensors, including infrared sensors, Pyrometers, and Fixed Industrial thermal imagers, contribute 10-15% of the replacement market. Though their replacement frequency is typically lower, every 2–5 years, they carry a higher unit cost and are essential in precision-driven sectors like EVs,

semiconductors, and glass manufacturing. Replacement is triggered by calibration drift or degradation in high-heat or hazardous environments.

Sensor protection components, such as thermowells and protection tubes, account for approximately 15–20% of the replacement demand. These are typically replaced every 2–4 years, depending on their exposure to corrosive media, high pressure, or thermal fatigue. There's increasing demand for sector-specific, hygienic-grade, or high-alloy materials that enhance longevity and reliability in critical process environments.

Temperature calibrators and data loggers, although lower in replacement volume (5–10%), are high-value tools essential for compliance in regulated industries. These are usually replaced or upgraded every 4–6 years, while annual revalidation or recalibration is standard practice in sectors like pharmaceuticals, aerospace, and power. The market is steadily shifting toward multifunctional, portable, and digitally connected calibration solutions that streamline quality control processes. To ensure traceable accuracy and compliance, Tempens operates one accredited temperature-sensor calibration laboratory one in India (NABL) and its Joint Venture, PT Tempens Asia Jaya operates one accredited temperature-sensor calibration laboratory in Indonesia (KAN).

The replacement market for temperature sensor solutions in India is expected to grow at a CAGR of 8.5% during FY2025–FY2030E, driven by its recurring nature and lower dependence on capital expenditure cycles. The growing adoption of plug-and-play, modular, and IoT-enabled sensors is accelerating replacement frequency, especially in sectors focused on uptime and efficiency. Regulatory industries follow strict validation schedules, typically replacing contact sensors every 12–24 months and non-contact sensors every 2–5 years. Additionally, high-growth sectors like EVs, battery manufacturing, and semiconductors, where large-scale installations began between 2021 and 2023, are now entering their first wave of systematic replacements, further supporting market momentum.

Tempens demonstrates its capabilities through a diverse mix of Project/OEM engagements and a steadily recurring replacement business. The Project/OEM segment represents a high-barrier, approval-driven market, where winning large, competitive orders for instrumentation in greenfield or brownfield setups underscores the company's technical credibility and customer trust. In contrast, the replacement segment provides a stable, recurring revenue stream, less dependent on capital expenditure cycles and strongly linked to process uptime, regulatory compliance, and lifecycle management.

Tempens' technical expertise extends to advanced conductor solutions, positioning them among the very few specialist manufacturers in India. As of March, 31, 2025, only a few companies operate in this niche segment.

2.3.6 Temperature Sensors and Allied Products: Exports (India)

India has emerged as a significant global exporter of temperature sensors and related products, serving diverse industries including automotive, healthcare, industrial automation, and oil & gas. With annual exports valued at INR3.8 billion, the sector is experiencing steady 8-10% growth, fueled by rising global demand for IoT-enabled and industrial automation solutions. The export portfolio encompasses three main categories: contact sensors (70% share), non-contact sensors (25%), and protection devices (5%).

Contact sensors dominate exports, particularly thermocouples shipped to the USA, Germany, and UAE for industrial applications, along with RTDs (PT100/PT1000) supplied to European pharmaceutical and food processing markets, and thermistors exported to China, South Korea, and Singapore for electronics and medical uses. The fast-growing non-contact segment includes infrared sensors for Germany, the USA, and

Japan's industrial sectors. Critical protection components like thermowells find buyers in Saudi Arabia and Russia's energy sectors, while advanced transmitters serve Germany and China's automation industries.

Tempsens has established itself as one of India's largest exporters of temperature sensors and allied solutions, with export sales contributing nearly 26.7% of revenues from operations in FY2025. By consistently outperforming domestic peers in international markets, the company has built a strong global footprint and positioned itself as a trusted supplier to industries worldwide.

The market is evolving with emerging trends such as smart IoT sensors for Western markets, compact medical sensors for Germany and Japan, and specialized aerospace-grade sensors for France and the USA.

India's Temperature Sensors & Allied Products Market – From Import Dependence to Local Manufacturing Leadership

India's temperature sensor market is undergoing a strategic transformation from being largely import-driven to increasingly embracing localized manufacturing. Indian players like Tempsens have gained a market leading position. It has around 10.0% market share in temperature sensors and allied products in FY25. While global brands like WIKA and Endress+Hauser have traditionally dominated the space, Indian players such as Tempsens Radix and Pyroelectric are now making significant inroads. The high-end import segment remains relevant, especially in precision-critical sectors like pharma, power, and aerospace. However, rising price sensitivity, growing demand for faster delivery, and strong policy support under Make-in-India are shifting the market in favor of domestic manufacturers. Over the past 5–7 years, the market share of global brands has dropped from 75% in FY2018 to 60% in FY2025, while organized Indian players have risen from 15% to 30%, driven by cost competitiveness, customization, and digital capabilities. The unorganized sector, although stable at 10%, remains limited by the depth of technology. This evolving composition signals a clear shift toward value-added, export-ready sensor systems rooted in India's growing manufacturing maturity.

Tempsens benefits from low import dependency, backward integration, localized supply chain, R&D and Technology and cost-competitive manufacturing, making it more agile in both domestic and export markets. Other key global players, despite their brand equity, are constrained by high overheads and import-led cost structures, effectively making them an assembly player in India. Indian players are no longer low-cost alternatives; they are emerging as full-stack sensor solution providers with growing R&D and digital capabilities. Global brands must localise beyond assembly or risk losing ground, especially in price-sensitive and mid-segment B2B markets.

Tempsens physical presence in strategic international markets is strengthened through its joint ventures and subsidiaries - PT Tempsens Asia Jaya, Indonesia; Tempsens Gulf, UAE and Tempsens Korea, South Korea. With a strong physical presence in key regions, the joint venture in Indonesia, PT Tempsens Asia Jaya, stands as one of the market leaders (in terms of revenue) in temperature sensors as of March 31, 2025.

Competitive landscape in India: Temperature Sensors and allied Products

The Indian temperature sensor landscape is bifurcated: domestic firms lead in traditional contact sensors with localised production, while multinationals dominate high-precision and smart sensing. With EV growth and industrial automation, competition is set to intensify as domestic players upgrade to IoT-enabled offerings and MNCs expand under "Make in India." End-use industries are the key driver. The metals sector, targeting ~300 MTPA steel capacity by 2030, is fueling demand for advanced furnace and rolling mill monitoring. Thermal power investments are projected to double to ₹2.3 lakh crore by 2027–28, with private players contributing nearly a third. The glass industry is scaling capacity for construction and solar panels, requiring robust high-temperature monitoring. Meanwhile, capital goods are expected to grow at

~8–10% CAGR, with automation and robotics accelerating adoption of smart temperature control. Together, these expansions position temperature sensors as mission-critical enablers of efficiency, safety, and compliance in India's industrial growth.

Tempsens Instruments is a leading Indian manufacturer of temperature sensors, with a strong foothold in contact-based sensing solutions such as thermocouples, RTDs, and thermowells. The company caters primarily to traditional industries like Power Generation, Aluminium, Railways, Petrochemicals, Steel, Glass, Cement, O&G, Chemicals, Plastics and Nuclear power etc. It is also focusing on high-growth or emerging segments like Pharma, Food, Aerospace, Semiconductor, Defense, Renewables, Battery Storage, where reliable and rugged temperature monitoring is critical. Tempsens is recognized for its robust customization capabilities, fast turnaround, and broad sensor assemblies, making it a preferred partner for OEMs and end-users seeking localized and cost-effective solutions.

Tempsens holds key global certifications ATEX, IECEx, ECAS, and PESO, giving it a strong competitive edge and credibility on the international stage.

Tempsens has successfully obtained registrations and product certifications by meeting stringent criteria, creating significant entry barriers for prospective competitors. These hurdles stem from the specialized, mission-critical nature of engineered products and the demanding approval processes tied to both project-based and replacement supply. Qualifying as a supplier typically requires extended evaluation cycles, including exhaustive testing and comprehensive field trials, before customers approve new vendors for high-stakes applications.

The process of qualifying with a major Indian PSU in the engineering and electrical equipment industry highlights these high barriers, particularly in the thermal engineering sector. Such rigorous standards not only safeguard reliability but also reinforce Tempsens' position as a trusted partner for critical projects.

Exhibit 2.14: Temperature Sensors and Allied Products – Key Local Competitors in India

COMPANY	KEY OFFERINGS	END-USER SEGMENTS SERVED
Tempsens Instruments	Thermocouples, RTDs, thermowell, protection tubes, Infrared sensors, temperature calibrators, data loggers	Steel, Cement, Chemicals, Oil & gas, pharma, Defense, Renewables, Battery Storage, Glass, Food, Nuclear Power, Plastics, Semiconductors, Aerospace
Precision Mass Products	NABL-certified RTDs, TCs, sanitary thermowell, SS fittings, temperature transmitters, data loggers	Oil and Gas, Power Generation, Pharmaceuticals, steel,
Radix Electrosystems	RTDs, thermocouples, digital indicators, IR pyrometers, SS enclosures, wireless data loggers	Pharma, steel, food & beverage, discrete manufacturing, factory automation
Pyro Electric Instruments	General thermocouples, screw-in sensors, basic thermowell, analog loggers (low-end)	Petrochemical, Steel, Power, SMEs, and basic industries

In the domestic market, Tempsens faces competition from players like Pyro Electric, Precision Mass Products, and Radix Electrosystems. These companies offer overlapping product lines, including RTDs, thermocouples, transmitters, and enclosures, and often compete on technology. Local competitors are particularly active in sectors such as power generation, pharmaceuticals, and process industries, where sensor calibration, traceability, and documentation are critical.

Tempsons has emerged as the leading domestic player by combining technology focus, manufacturing strength, and international reach. They offer one of the most extensive portfolios of bespoke thermal engineering solutions in India and globally.

Exhibit 2.15: Temperature Sensors and Allied Products – Key Global Competitors in India

COMPANY	KEY OFFERINGS	END-USER SEGMENTS SERVED
Endress+Hauser (Germany)	High-precision RTDs, thermocouples, modular hygienic thermowell, fiber-optic sensors, automated calibrators, industrial loggers	Pharmaceuticals, food & beverage, chemicals, energy, water
WIKA Instruments (Germany)	Industrial RTDs, thermocouples, armored thermowell, high-pressure protection tubes, precision calibrators, multi-input data loggers	Oil & gas, steel, power, refineries, heavy process industries
OMEGA Engineering (USA)	Thermocouples, RTDs, flanged thermowell, lab-grade calibrators, IoT-enabled data loggers	R&D labs, OEMs, test systems, and engineering institutions
Honeywell (USA)	Smart RTDs, explosion-proof enclosures, digital loggers	Chemicals, refining, utilities, building systems, automation

On the global front, Tempsons competes with multinational giants like Endress+Hauser, Honeywell, WIKA, and OMEGA Engineering. These firms dominate the high-end and digital sensor space, supplying precision wireless systems and smart calibration tools to advanced sectors like aerospace, semiconductors, and EV manufacturing. While global players lead in technological innovation and automation integration, Tempsons is also steadily strengthening its position through localized manufacturing, advanced technologies (Thermal Imager, developing slot RTD), competitive pricing, and a growing presence in digital and export-ready sensor solutions.

Tempsons is now competing head-to-head with global giants by focusing on automation and developing critical engineered products for extreme conditions. The company holds multiple patents and is backed by a 59-member R&D team of engineers and researchers.

The industry is characterized by high entry barriers, driven by the critical nature of the products the key players manufacture, and the stringent approval and registration processes required for both project-based and replacement supply. These approvals often involve extensive technical evaluations, compliance audits, and long qualification cycles, making it difficult for new entrants to establish credibility or gain access to large-scale industrial projects.

Reducing Import Dependence through Localised Innovation

The sensor segment in India is seeing a clear move towards indigenisation and reduction of import dependency. Leading players are working closely with government and industrial partners in steel, power, defence, and other process-intensive sectors to develop and manufacture advanced sensors and furnace cameras domestically. This shift strengthens process safety and supports the operational requirements of high-temperature environments, while reducing reliance on imported technologies.

Tempsons has been actively engaged in indigenization initiatives with leading government companies in sectors such as steel, power, and defense. Defence indigenization policies are pushing local manufacturing of critical systems.

By developing and locally manufacturing advanced thermal monitoring solutions, including furnace cameras and sensor systems, the company has positioned itself as a strategic partner in reducing import

dependency, enhancing process safety, and meeting the stringent operational requirements of high-temperature and process-intensive industries.

2.3.7 Temperature Sensors and Applied Solution: Key Growth Drivers, Trends, and Challenges (India)

A. Key Growth Drivers – India (Temperature Sensors and Applied Solutions)

Industrial Automation and Process Control Modernization: India's rapid shift toward Industry 4.0, especially in sectors like chemicals, steel, and power, is driving increased integration of temperature sensors within control systems. Real-time monitoring, predictive maintenance, and SCADA integration are becoming essential, pushing demand for advanced contact and non-contact sensors.

Compliance and Quality Assurance in Regulated Sectors: Sectors like pharmaceuticals and food processing require strict temperature control to meet regulatory standards (e.g., WHO-GMP, FSSAI, and USFDA). This is accelerating the adoption of traceable RTDs, thermocouples, data loggers, and calibration systems across the value chain -from manufacturing to cold chain logistics.

Energy Efficiency and Sustainability Mandates: Government-led programs such as the PAT scheme and India Cooling Action Plan are promoting the use of energy-efficient sensors in HVAC, boilers, and industrial processes. Accurate sensing helps reduce energy wastage, improve process yields, and meet emission compliance norms.

Electrification and Clean Energy Projects: The expansion of solar power, electric vehicle (EV) manufacturing, and battery storage facilities is creating new demand for high-precision thermal monitoring systems. IR sensors, fiber-optic sensors, and digital loggers are essential in EV battery lines, solar panel manufacturing, and thermal energy storage setups.

Rising Industrial Capex Across Core Sectors: India's sustained capital expenditure boom in chemicals, oil & gas, metals, power, glass, and semiconductors is sharply boosting demand for precision temperature measurement. Large-scale greenfield and brownfield projects ranging from refinery upgrades to semiconductor fabs require embedded sensing for process safety, yield optimization, and environmental compliance. As industrial plants scale up with higher automation intensity, temperature sensors are increasingly positioned as mission-critical components in capex-driven modernization cycles.

B. Key Trends – India (Temperature Sensors and Applied Solutions)

Shift Toward Smart and Connected Sensing Platforms: IoT-enabled temperature sensors integrated with SCADA, PLCs, and cloud systems are gaining traction for real-time monitoring and predictive maintenance, especially in critical sectors like oil & gas, pharma, and F&B.

Growing Demand for Non-Contact and High-Precision Sensing: Automation-led sectors such as EVs, semiconductors, and glass manufacturing are driving demand for infrared and fiber-optic sensors that offer accurate, contactless temperature monitoring.

“As of March 31, 2025, Tempsens is the only manufacturer of fibre optic temperature sensors and thermal profiling systems in India.

Localization and Capacity Expansion by Indian Sensor Manufacturers: Domestic players like Tempsens and Radix are expanding production of thermocouples, RTDs, and assemblies to reduce import reliance and meet industrial demand.

Emphasis on Sensor Protection and Modular Integration: Industries are investing in thermowells, enclosures, and hygienic fittings, with a rising preference for modular sensor kits that enable faster deployment and easier calibration.

Increased Adoption in Smart Infrastructure and Mobility Sectors: Fast-response sensors like thermistors and RTDs are increasingly used in HVAC, EVs, and smart buildings for real-time thermal management and efficiency.

C. Regulatory Framework & Policies

Technology Innovation & Government Schemes

Government programs like Digital India, Smart Manufacturing, and the PLI Scheme for White Goods promote the use of digital, IoT-enabled temperature sensors in appliances and industrial systems. The FAME II and EV policies indirectly boost demand for sensors in EV battery management and motor control systems.

Standards and Compliance

Temperature sensors in India follow BIS and IEC standards (e.g., IS 60584 for thermocouples, and IS 60751 for RTDs). Regulated sectors such as pharmaceuticals and food processing must ensure calibration traceability (NABL) and compliance with GMP, USFDA, and FSSAI for validated temperature monitoring and logging systems.

Environmental & Safety Regulations

Temperature sensors are increasingly required under BEE energy efficiency programs, the Factories Act, and the Pollution Control Board norms to monitor and maintain safe thermal limits in industrial operations. This drives the adoption of certified sensors and loggers for safety and emission control in sectors like steel, cement, and chemicals.

Incentives & Grants

Schemes like MSME Technology Upgradation (CLCSS) and state industrial policies offer subsidies for upgrading to smart temperature sensing systems. National programs under DST, BIS, and NPL also support calibration infrastructure, helping industries and sensor manufacturers enhance quality and compliance.

D. Threats and Challenges

Threats

Competitive Intensity

The market is highly fragmented with global giants and strong local players. International players dominate high-precision and smart sensing, while Indian firms leverage cost, customization, and localization. This dual pressure compresses margins and accelerates commoditization.

Import Dependence on Critical Tech

Despite localization, India still depends on imports for high-end non-contact sensors, fiber optic sensing, and advanced calibrators. This creates vulnerability to forex volatility, supply chain shocks, and technology embargoes.

Technology Disruption Risk

New-generation solutions, MEMS-based, wireless, fiber optic, and digital twin-compatible sensors, pose a threat to traditional thermocouples and RTDs. Players relying only on conventional products risk losing relevance.

Commoditization of Legacy Products

Thermocouples and basic RTDs, widely used in India's metals, power, and chemical industries, face commoditization from low-cost suppliers. Customers increasingly view them as interchangeable parts, limiting pricing power.

Regulatory and Compliance Pressures

Stricter norms (FDA, GMP, FSSAI, ISO, BIS, NABL, IEC) increase certification costs, extend project approval timelines, and create risks of disqualification if compliance is not met.

Challenges

Balancing Localization with Precision

While Make-in-India and import substitution create opportunities, local players struggle to meet global standards of calibration traceability, long-term accuracy, and rugged design, especially in regulated sectors like pharma, aerospace, and semiconductors.

Calibration Infrastructure & Costs

Maintaining NABL/IEC-compliant calibration labs is capital-intensive. Frequent revalidation cycles in pharma and aerospace make it harder for smaller firms to compete, while multinationals leverage advanced automated labs

Slow Adoption Among SMEs

Many Indian SMEs still rely on cheap, uncertified, or imported grey-market sensors. Convincing them to adopt premium, traceable solutions remains difficult, slowing market maturity.

Integration with Digital/IIoT Platforms

End-users increasingly demand IoT-enabled, SCADA/PLC-integrated sensors with predictive analytics. Indian firms lag global competitors in digital twin compatibility, wireless connectivity, and AI-driven diagnostics

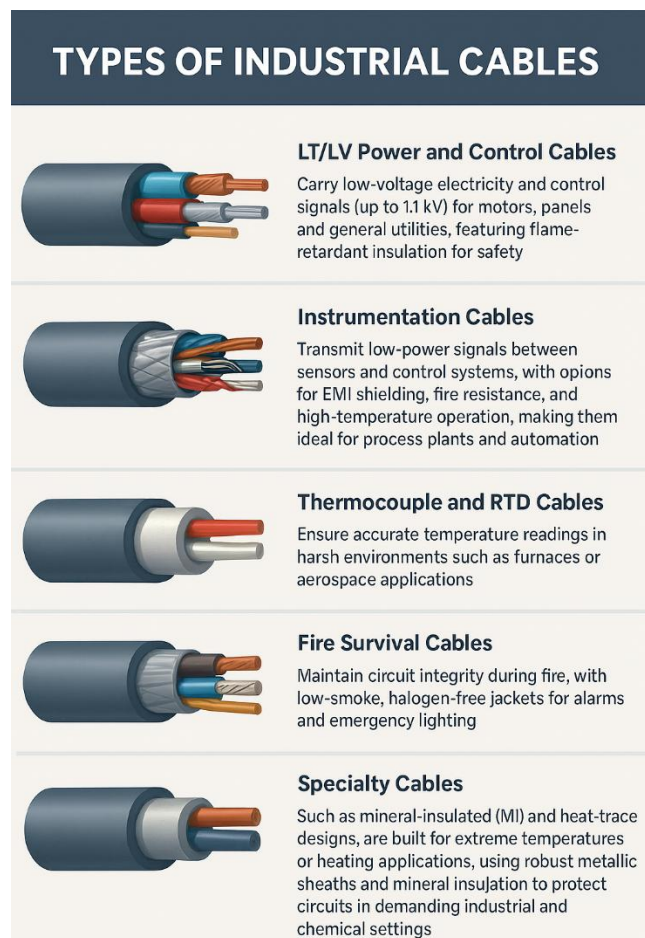
2.3.8 CAPEX Analysis

SECTOR	KEY INVESTMENTS / TRENDS
Chemicals & Petrochemicals	Multi-year capex cycle; IOCL ₹61k cr Paradip petrochem complex; BPCL ₹48k+ cr Bina cracker; specialty chem demand from agro, fluorochemicals, custom synthesis; PLI schemes + PCPIR revamp supporting China+1 diversification.
Oil & Gas	BPCL ₹95k cr Andhra refinery-petchem complex + 1.2 MMTPA ethylene cracker at Bina; IOCL ₹61k cr Paradip expansion; Reliance, HPCL modernising for higher petchem yield; CGD networks near full India coverage driving pipeline/distribution capex.
Metals & Mining	Steel capacity target 300 MTPA by 2030 (JSW 50 MTPA, AM/NS Hazira 15 MTPA Phase-1); aluminium expansions (Vedanta, Hindalco) in alumina + downstream; Critical Mineral Mission fast-tracking exploration/processing of lithium, REE, cobalt.
Power & Renewables	Record RE addition 29.5 GW in FY25 (total ~220 GW); 500 GW non-fossil target by 2030; ~32 GW thermal under construction; large-scale transmission upgrades incl. HVDC, Green Energy Corridors; hybrid/round-the-clock RE projects gaining traction.

Semiconductors & Electronics	Tata-Powerchip ₹91k cr fab at Dholera; Micron ATMP at Sanand; Tata + CG Power–Renesas in ATMP/OSAT; billions in PLI/state incentives; ecosystem build-out for cleanrooms, high-precision equipment, process control & supply chain localisation.
Data Centres & Digital Infra	Capacity is expected to grow from ~1.8 GW (2025) to 4.5 GW+ (2030), requiring \$20–25B. Hyperscalers (AWS, Microsoft, Google) are announcing multi-billion-dollar builds, while domestic players (AdaniConneX, Yotta, Hiranandani) are scaling. Additionally, Digital India and AI/cloud adoption are boosting demand.
Glass	Float/flat glass expansions (Saint-Gobain 7th line, Gold Plus, Asahi); solar glass investments driven by PV module surge; container glass capacity up for beverages/pharma; energy-intensive sector adopting thermal monitoring & automation for efficiency.
Plastics & Polymers	New crackers with a capacity of millions of tonnes; BPCL Bina and IOCL Paradip expansions; GAIL's Usar PDH-PP (500 KTA) project, which strengthens polypropylene supply; and downstream polymer projects that cut imports and meet the growth of packaging, auto & consumer goods.
EVs & Batteries	Tata Agratas 20 GWh gigafactory in Sanand; Exide, Ola, and Amara Raja's multi-GWh facilities in South India; auto OEMs adding EV lines; investments in battery packs, motors, and charging infrastructure; backed by FAME + PLI; fastest-growing industrial capex vertical.
Food Processing & Cold Chain	Govt. schemes (PMKSY, PLISFPI) driving 1,600+ projects (400 cold chains); expansion in frozen storage, reefer logistics; private players scaling dairy, seafood, meat, packaged food plants; exports + organized retail fuelling long-term growth.
Pharma & Medical Devices	Bulk drug parks (AP, Gujarat, HP) with ₹1k cr each in central support; PLI boosting API & KSM independence from China; medical device clusters scaling; investments in sterile facilities, compliance infra, labs & cleanrooms to meet global standards.
Aerospace & Defence	Defence capex ~₹1.8 lakh cr FY26; Tata-Airbus C295 assembly line Vadodara (deliveries 2026); HAL, BEL, L&T expanding UAVs, radars, avionics; strong push on indigenization; global OEMs (Safran, Boeing, GE) ramping MRO & manufacturing presence.

3. MARKET ASSESSMENT OF SPECIALISED CABLES (INDIA AND GLOBAL)

3.1 Specialised Cables: Product Overview



Industrial cables are the lifelines of any plant or manufacturing facility, designed to withstand the harsh conditions of their environment. Unlike standard commercial cables, they are engineered for durability, reliability, and specific functions—from transmitting high power to carrying sensitive data signals. This classification organizes them by their primary function, highlighting the unique features that make each type essential for ensuring safety, efficiency, and operational integrity in industrial settings.

Industrial cables can be grouped into five broad types. LT/LV power and control cables carry low-voltage electricity and control signals (up to 1.1 kV) for motors, panels, and general utilities, featuring flame-retardant insulation for safety. Instrumentation cables transmit low-power signals between sensors and control systems, with options for EMI shielding, fire resistance, and high-temperature operation, making them ideal for processing plants and automation. Thermocouple and RTD cables, a subset of instrumentation, ensure accurate temperature readings in harsh environments such as furnaces or aerospace applications. Fire survival cables

maintain circuit integrity during fire, with low-smoking, halogen-free jackets for alarms and emergency lighting. Finally, specialty cables, such as mineral-insulated (MI) and heat-trace designs, are built for extreme temperatures or heating applications, using robust metallic sheaths and mineral insulation to protect circuits in demanding industrial and chemical settings.

Tempsens portfolio extends into advanced conductor solutions, where they are among the very few manufacturers of these specialist conductor products in India, operating in this field as of March 2025.

3.2 Importance of Specialised Cables in Industrial Applications

Specialised low-voltage (LV) cables — including control, instrumentation, and select industrial power cables — are designed to transmit signals, data, and control instructions in addition to electrical power. They are engineered for safe, reliable, and intelligent operation of industrial facilities, supporting automation, monitoring, and other critical functions across core industries.

Their importance stems from the following roles:

- **Enabling Automation and Process Control:** Control and instrumentation cables form the neural network of industrial automation systems, transmitting precise signals between field devices and

control rooms. They support high accuracy and low interference, ensuring that machinery responds predictably to inputs.

- **Ensuring Operational Safety and Uptime:** In industries such as oil & gas, steel, chemicals, and power, equipment failure can lead to catastrophic outcomes. These cables are engineered with high fire resistance, shielding, and thermal tolerance to operate safely in demanding environments.
- **Supporting Critical Monitoring Functions:** Thermocouple and RTD cables are essential for temperature sensing, enabling operators to monitor and regulate thermal profiles in real time. They are vital for both quality assurance and equipment longevity.
- **Customisation for OEM and Harsh Conditions:** Many of these cables are custom-built for specific machines or conditions, such as high-temperature zones, corrosive atmospheres, or tight bending radii. This degree of customisation makes them integral to specialised industrial applications.

Building on this foundation, Tempsens is among the very few companies in the world with a backwards-integrated manufacturing facility for thermocouples, cables, and electrical heaters, located at Udaipur, India as of March 2025. Tempsens' backwards-integrated manufacturing capabilities further differentiate them, making them one of the few companies in India with this degree of operational integration. Also, Tempsens is one of the very few manufacturers in India to hold the ASME U-Stamp certification for pressure vessels as of March 2025.

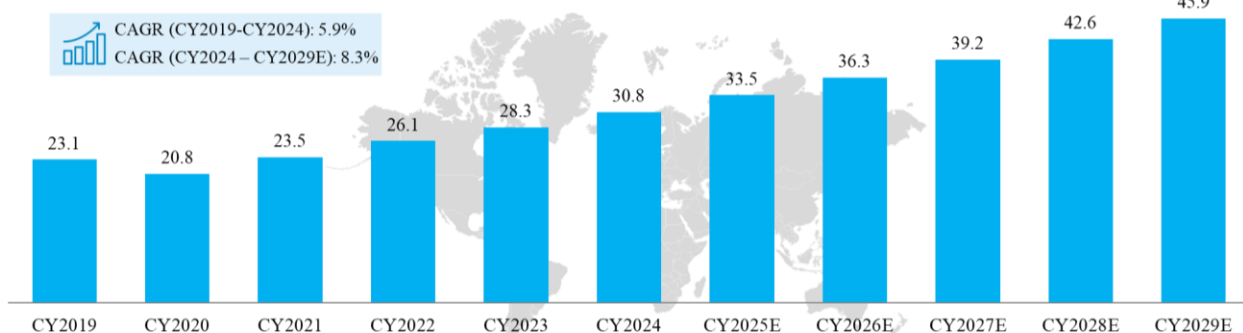
3.3 Specialised Cables: Global Market Overview

The global market for speciality and industrial cables has grown steadily over the past decade, rising from USD 23.1 billion in CY2019 to an estimated USD 30.8 billion in CY2024, despite a temporary dip in 2020 due to the pandemic. Growth has been driven by infrastructure expansion, industry modernisation, and stronger safety and automation requirements.

Key demand boosters include increased industrial automation, the shift to renewable energy, and stricter safety norms requiring heat- and fire-resistant cables. Manufacturing diversification beyond China — notably into India and Vietnam — is also fuelling new installations.

Looking ahead, the market is projected to grow at a CAGR of ~8.3% (CY2024–CY2029E), reaching about USD 45.9 billion. Expansion in data centres, EVs, and semiconductor fabs will complement demand from traditional industries such as steel, cement, and chemicals, while modernisation of existing plants and utilities will support continued uptake of advanced cabling solutions.

Exhibit 3.1: Global market size for Specialised Cables (Value in USD Bn), CY2019 – CY2029E

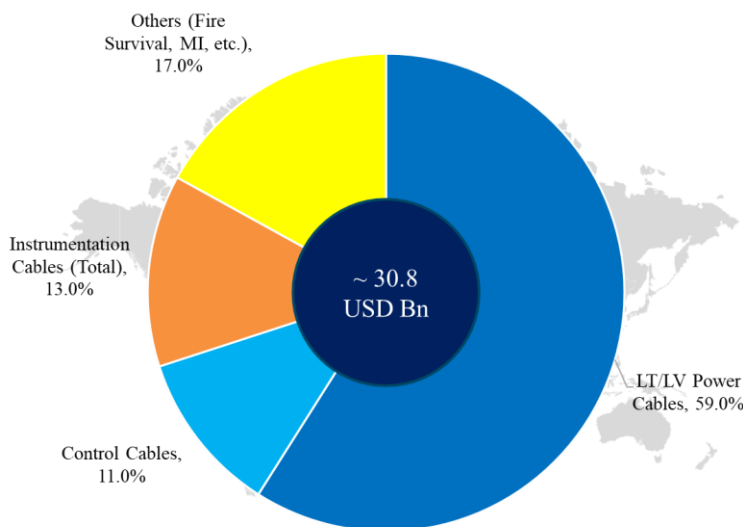


Source: Stakeholder interactions, Frost & Sullivan Analysis

3.3.1 Specialised Cables: Product-Wise Segmentation (Global)

The global specialised cables market is expanding as industries automate, upgrade infrastructure, and adopt stricter safety standards. LT/LV power cables lead the market with about 59% share, supplying electricity to plants, utilities, and construction sites. Instrumentation cables (around 13%) support accurate signal transfer in automation and process control, while control cables (11%) link machines to control systems in smart factories. The remaining 17% includes speciality cables such as fire-survival, high-temperature, and mineral-insulated types, which are essential for harsh or high-risk environments like refineries, steel plants, metros, and defence projects. Growing focus on safety, efficiency, and modernisation is driving demand in both mature and emerging economies.

Exhibit 3.2: Product-Wise Contribution to Global Specialised Cables Market CY2024



Source: Stakeholder Interactions, Frost & Sullivan Analysis

3.3.2 Specialised Cables: Market Segmentation by Countries/ Region (Global)

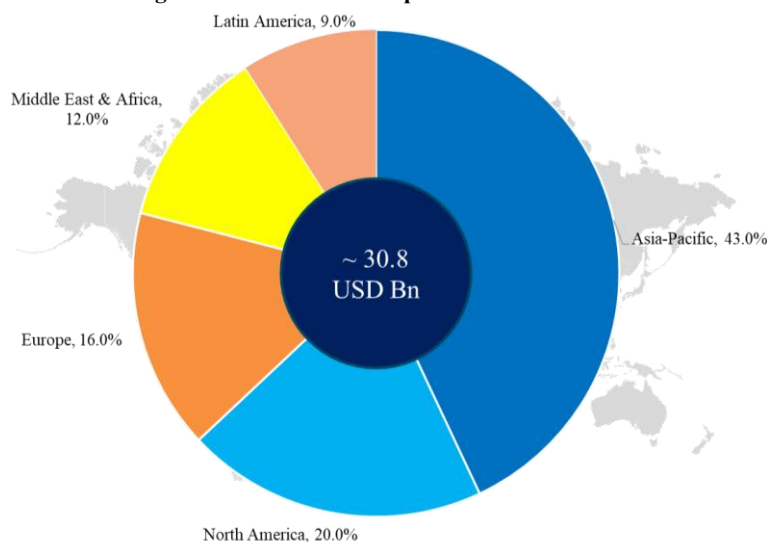
Asia-Pacific (43%) holds the dominant share in the global specialised cables market, supported by large-scale industrialisation and infrastructure expansion across emerging economies like China, India, Vietnam, and Indonesia. The region's rapid growth in manufacturing, power generation, oil & gas, and renewables has created strong demand for LT/LV power and signal cables for plant-level power and control applications. Instrumentation and fire survival cables also witness increasing adoption in sectors such as steel, cement, pharmaceuticals, and process industries, where operational safety and reliability are key. Additionally, the region benefits from government-led capex in industrial corridors, metro rail, and smart cities, all of which require technically specified cabling. Domestic cable manufacturers in China and India are increasingly producing high-specification cables at scale, helping meet demand at competitive prices.

North America (20%) remains a high-value market for specialised cables, driven by a mature base of process industries, a strong focus on workplace safety, and high uptake of automation and digitalisation in industrial operations. The oil & gas, aerospace, defense, and chemicals sectors are key consumers of MI cables, fire survival cables, and thermocouple cables, given their exposure to extreme temperatures and operational criticality. Stricter regulations around flame retardancy, low-smoke characteristics, and signal integrity further propel demand for high-performance, specialised cable solutions. Retrofit and upgradation of ageing infrastructure — particularly in utilities and refineries — add to replacement demand in this region.

Europe (16%) is a technically mature market with well-established standards around safety, emissions, and material sustainability. The demand for specialised cables is driven by precision-driven industries such as automotive, manufacturing, and renewables, where fire survival, instrumentation, and thermocouple cables are extensively used. Fire resistance, halogen-free construction, and low-smoke emission are often mandatory, in line with EU directives and EN standards. Industrial automation, factory digitalisation (Industry 4.0), and offshore wind installations are among the key growth drivers. While volume growth is relatively moderate, the region remains significant in value terms due to its preference for technologically superior and compliant cable systems.

Middle East & Africa (12%) represents a structurally important market, particularly for high-temperature and mechanically robust cables used in oil & gas, petrochemical, power, and desalination industries. Harsh ambient conditions, combined with the need for operational continuity and fire safety, create strong demand for fire survival, MI, and heat-resistant cables. Instrumentation and RTD cables are also witnessing uptake in utility-scale infrastructure projects and industrial control systems. In addition to the GCC, countries in North and East Africa are increasingly investing in power and industrial capacity, which supports demand growth in this region.

Exhibit 3.3: Regional Share of Global Specialised Cables Market CY2024



Source: Stakeholder Interactions, Frost & Sullivan Analysis

Latin America (9%) is a growing market, anchored by developments in mining, power, cement, and industrial automation, particularly in Brazil, Chile, Mexico, and Peru. The increasing regulatory push for workplace safety and control reliability is gradually driving demand for specialised cables — particularly thermocouple, LT signal, and instrumentation variants. Industrial corridors and modernisation of manufacturing setups are supporting wider deployment of signal and control cabling, especially in automation-centric facilities. While the market is smaller in size, it is steadily expanding in line with industrial and infrastructural investment flows.

3.3.3 Specialised Cables: End User Application Area (Global)

Specialised cables play a critical role in ensuring power and signal integrity across a range of industries, particularly where performance, safety, and reliability are non-negotiable. The application of these cables varies widely across sectors based on operational intensity, environmental conditions, and safety standards.

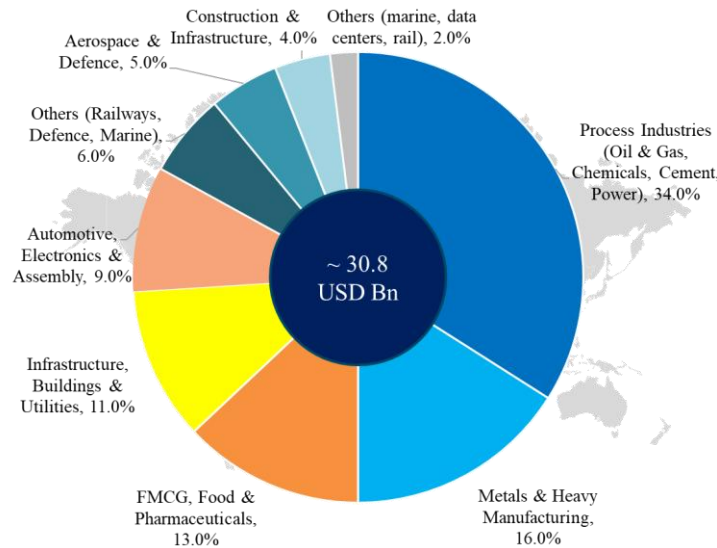
Process Industries (Oil & Gas, Chemicals, Cement, Power) – ~34.0% share: These industries drive the highest demand for specialised cables, particularly LT/LV power cables, instrumentation cables, and

thermocouple cables. Their operations involve high-temperature zones, explosive atmospheres, and complex automation setups, necessitating durability, interference-resistant, and fire-safe cabling.

Metals & Heavy Manufacturing – ~16.0% share: Steel, non-ferrous metals, and other heavy industries require high-temperature cables, MI/MIMS cables, and robust power transmission solutions. The harsh operating environments and continuous processes demand cables that offer both thermal and mechanical resilience.

FMCG, Food & Pharma – ~13.0% share: These sectors prioritise precision and hygiene. RTD and instrumentation cables are widely used for regulated temperature and process control, while fire survival cables support safety compliance in automated packaging and processing zones.

Exhibit 3.4: End-user application Global Specialised Cables Market CY2024



Source: Stakeholder Interactions, Frost & Sullivan Analysis

Infrastructure, Buildings & Utilities – ~11.0% share: While this segment typically uses standard cables, demand for fire survival and Low Smoke Zero Halogen (LSZH) cables is rising in hospitals, airports, metros, and data centers. These applications emphasize uninterrupted power and signal continuity during fire or hazard situations.

Automotive, Electronics & Assembly – ~9.0% share: In this segment, signal cables and instrumentation cables play a growing role with increased automation, robotics, and data-based process controls. Cable design must also factor in compact space and flexibility requirements.

Others (Marine, data centre, rail etc.) – ~2.0% share: These niche but critical segments demand ruggedised cables, often with special standards (e.g., fire survival, halogen-free, marine-grade). Applications are highly customised and sensitive to safety and durability needs.

3.3.4 Cables: Sub-Segmentation Key Application Area (Global)

Exhibit 3.5: Global Cable Market — Sub-Segmentation with Applications, CY2024

MAIN PRODUCT SEGMENT	SUBSEGMENTS	KEY APPLICATIONS
LT/LV Power Cables (up to 1.1kV)	- Single-core - Multi-core - Armoured / Unarmoured	Transmission of low-voltage power from source to equipment in industrial, commercial, and infrastructure settings

	- Copper / Aluminium conductor	
LT/LV Signal Cables (up to 1.1kV)	- Shielded / Unshielded - Twisted pair / Multi-pair - PE / PVC / XLPE insulation	Transmission of low-voltage signal data to/from control and monitoring equipment
Instrumentation Cables	- Shielded twisted pair / Multi-pair - Fire Survival Cables - High Temperature Cables	Signal transmission in harsh environments and manufacturing from field instruments to control/monitoring units; minimize interference
RTD Cables <i>(subset of Instrumentation)</i>	- Single pair / Multi-pair - Shielded - PVC / PTFE / XLPE insulated	Used in temperature sensors (RTDs), connects sensor to control/readout devices; high signal fidelity
Thermocouple Cables <i>(subset of Instrumentation)</i>	- Thermocouple Cable (same material as thermocouple) - Extension Cable (similar material) - Compensating Cable (dissimilar but calibrated material)	Measures and transmits temperature signals from sensors to instruments
Fire Survival Cables <i>(subset of Instrumentation)</i>	- Mica taped - XLPE / LSZH / Ceramic insulation - Copper conductor	Critical infrastructure where circuit integrity must be preserved under fire; low smoke/toxic emissions
High Temperature Cables <i>(subset of Instrumentation)</i>	- Fibre glass insulated - Alumina / Ceramic yarn insulated - Rated up to 1200°C	Foundries, furnaces, and industrial areas with high ambient temperature
Mineral Insulated Metal Sheathed (MI/MIMS)	- MICC (Mineral Insulated Copper Cable) - Heating cable (NiCr) - Thermocouple cable (Nickel alloys) - Heating Cables	High-temp applications needing mechanical, electrical, and chemical stability; used for heating, power, and sensing

3.3.5 Cables: Key Growth Drivers, Trends, Investment Trends (Global)

D. Key Growth Drivers For Niche Industrial Cable

Global Industrial Automation Surge: Across Europe, the US, and East Asia, increasing automation in sectors such as automotive, pharmaceuticals, and electronics is driving global demand for instrumentation and signal cables that support clean and accurate data transmission.

Stringent International Safety Standards: Growing emphasis on fire performance standards (e.g., EN 50200, IEC 60331) in Europe and North America is pushing adoption of fire-survival and high-temperature cables globally, particularly in public transport, data centers, and nuclear facilities.

Energy Infrastructure Modernisation: Energy transition across Europe and the US is driving upgrades in grid infrastructure and process industries—supporting greater usage of thermocouple and RTD cables for precise monitoring and control.

Extreme Environment Applications on the Rise: Global growth in space, defense, and offshore oil & gas sectors is spurring demand for MI/MIMS cables due to their unmatched performance in high-temperature, vibration, and radiation-exposed environments.

E. Trends

Shift Toward Application-Specific Cable Design: Globally, there is a growing shift from generic, catalogue-based cables toward highly customised, application-specific solutions. End-users and OEMs are demanding cables engineered for precise use-cases — whether it's resistance to specific chemicals, ability to withstand constant flexing, or tight tolerance on signal accuracy. This has led to increased collaboration between cable manufacturers and process consultants during project design stages.

Increased Adoption of High-Temperature and Fire-Survivable Cables: Driven by safety regulations and performance needs in sectors such as steel, cement, oil & gas, and transport infrastructure, there is a clear trend toward using high-temperature cables with PTFE, ceramic, and fiberglass insulation. Fire-survivable and halogen-free cables — especially mineral insulated (MI) types — are gaining traction for mission-critical environments globally.

Cable Harnesses: Large industrial OEMs and EPCs increasingly prefer cable harnesses — factory-fabricated assemblies that integrate multiple cables, sensors, and connectors into a single plug-and-play unit — over buying individual cable drums. These assemblies improve installation speed, reduce errors, and simplify procurement. The cable harness market is especially strong in export-oriented OEM hubs across defence, automotive, Europe, North America, and East Asia.

Miniaturization and Sensor Integration Driving Cable Innovation: The rapid proliferation of field-level sensors, edge instrumentation, and IoT devices in global manufacturing has driven demand for compact, flexible, and EMI-shielded cables. Tempsens holds a distinctive advantage in this space, being one of the few cable manufacturers that also produce thermocouples as of March 2025. This vertical integration enables tighter quality control, improved compatibility, and offers cross-selling opportunities that many competitors cannot match. As a result, Tempsens is uniquely positioned to deliver innovative cable solutions tailored for sensor integration and precise signal fidelity, addressing the evolving needs of industrial IoT and automation applications.

Sustainability and Circularity Becoming a Design Priority: Sustainability goals are influencing cable choices globally. End-users are seeking recyclable insulation materials, halogen-free compounds, and extended lifecycle performance. European markets, in particular, are demanding environmental declarations (like RoHS/REACH compliance, EPDs) and engaging in cable reuse/recycling practices — a trend now extending to North America and parts of APAC.

F. Investment Trends

The global specialised cables market has witnessed significant investments from leading industry players between 2022 and 2025, driven primarily by growing demand in industrial automation, energy, and safety-critical applications. The table highlights focused capital deployment across key cable segments including

Thermocouple, RTD, High Temperature, Instrumentation Signal, and Mineral Insulated Metal Sheath (MI) cables.

Notable trends include expansion of manufacturing capacities, increased R&D efforts for enhanced durability and smart functionalities, and establishment of new facilities, particularly in Europe and North America. Investments by companies such as Prysmian, Nexans, TKF Group, and Southwire underscore the strategic importance of heat-resistant and fireproof cables, while collaborations and modernization initiatives by Siemens and ABB reflect a push toward precision sensing and process control applications.

Looking ahead, rising industrial digitalisation and stringent safety regulations are expected to sustain strong investment momentum, with production capacity and innovation focused on supporting smart factories and electrification.

Exhibit 3.6: Global Investment Trends in Specialised Cables Market (CY2022– CY2025E)

CALENDAR YEAR	COMPANY	INVESTMENT TYPE	REGION	CABLE PRODUCT	INVESTMENT (USD MILLION)
2022	Prysmian Group	Plant Expansion & R&D	Europe, USA	High Temperature Cables, Instrumentation Signal Cables	120
2023	Nexans	Product Innovation & Capacity Expansion	Europe	Instrumentation Signal Cables	85
2023	TKF Group	Manufacturing Facility Setup	Europe	Mineral Insulated Metal Sheath (MI) Cables	70
2023	General Cable	Capacity Upgrade	North America	Thermocouple Cables	50
2024	Southwire	R&D and Production Expansion	USA	High Temperature Cables, Mineral Insulated (MI) Cables	95
2024	Siemens	Innovation & Strategic Partnership	-	RTD Cables	60
2024	TE Wire & Cable	Facility Modernization & Automation	Asia, Europe	Thermocouple Cables, Instrumentation Signal Cables	75
2025E	Leoni AG	Expansion & Digitalization	-	Instrumentation Signal Cables, High Temperature Cables	110

3.4 Specialized Cables: India Market Overview

India's specialised cables market is steadily expanding, driven by a combination of industrial growth, infrastructure expansion, digital transformation, and regulatory emphasis on safety and energy efficiency. Rapid industrialisation, especially in sectors like steel, cement, chemicals, oil & gas, automotive and

pharmaceuticals, is creating sustained demand for high-performance, application-specific cables. In addition, ongoing investments in railways, metro projects, smart cities, and renewable energy are expanding the addressable market for fire-survival, control, and instrumentation cables.

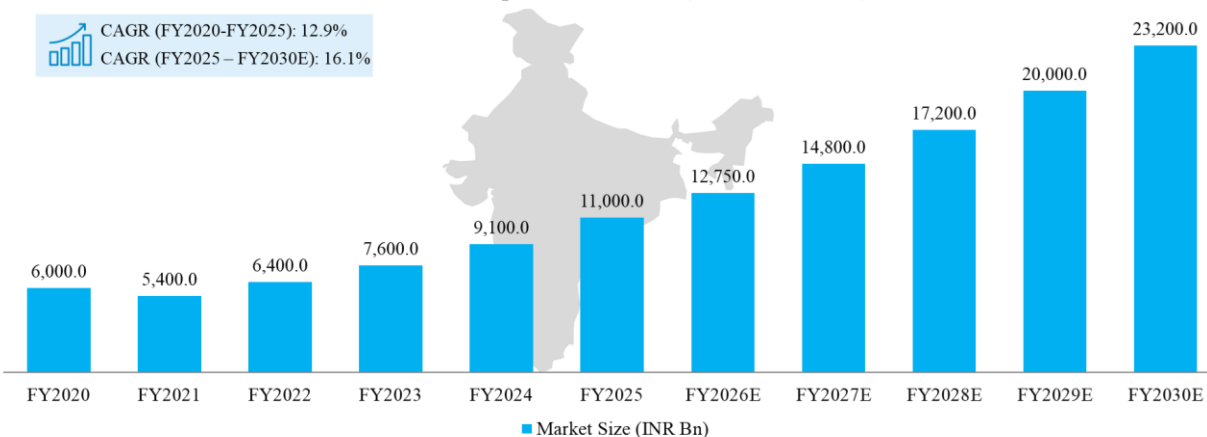
Low Tension (LT)/Low Voltage (LV) Power Cables, which account for the largest share of the market in India, are widely used for power transmission (up to 1.1 kV) across various industrial sectors. The demand is underpinned by industrial capex recovery and government initiatives like ‘Make in India’ and ‘Power for All’. While the segment is fairly mature, the volume is large and continues to grow with increased electrification and industrial activity.

Instrumentation Cables, including thermocouple and RTD variants, are seeing growing adoption across process industries such as oil & gas, chemicals, and pharma, which rely heavily on automation, control systems, and real-time monitoring. India’s push toward indigenisation in sectors like chemicals, bulk drugs, and refining is accelerating demand in this segment. These cables ensure precision in signal transmission and are vital for safety-critical applications.

Control Cables are being increasingly deployed in industrial automation projects and machine manufacturing, particularly in sectors like automotive, cement, and FMCG. As Indian industry embraces automation, smart factory concepts, and industrial IoT, the need for control cables to interface PLCs, motors, and sensors is growing. Medium-sized OEMs and equipment manufacturers are also driving volume demand, although consolidation in this segment remains limited.

The remaining speciality cables segment, comprising fire survival, high-temperature, hybrid, and mineral-insulated (MI) cables, is gaining relevance in India’s infrastructure and industrial backbone. For instance, fire survival and LSZH (Low Smoke Zero Halogen) cables are increasingly mandated in public infrastructure—metros, airports, tunnels, and healthcare facilities—where fire safety is critical. MI cables, though niche, are finding application in sectors like nuclear energy, defence establishments, and mission-critical facilities where system failure cannot be tolerated.

Exhibit 3.7: India market size for Specialised Cables (Value in INR Bn), FY2020 – FY2030E



Source: Stakeholder interactions. Frost & Sullivan Analysis

Tempsens is among the very few companies in India engaged in the manufacturing of MI-cable-based linear thermal detectors, a highly specialised product with limited global players as of March 2025. This combination of integration and specialisation reinforces the company’s position in mission-critical applications. Moreover, Tempsens’ combined expertise in both sensor and cable manufacturing offers significant cross-selling potential, allowing the company to provide integrated solutions that enhance customer value and deepen client relationships across industries.

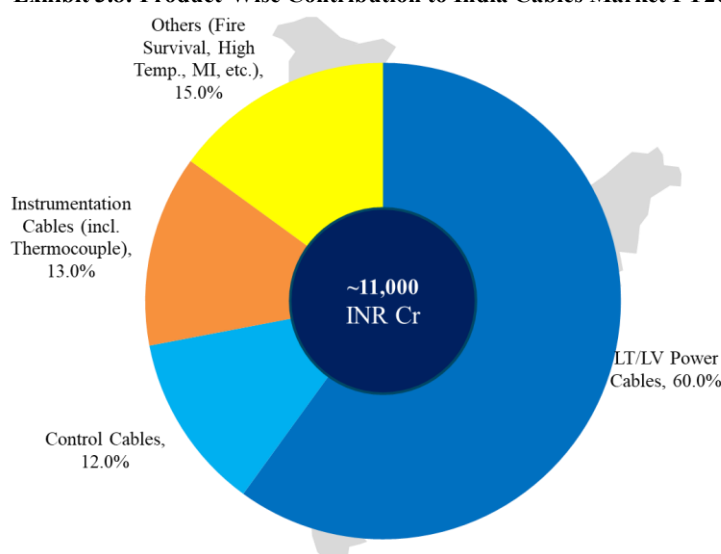
3.4.1 Specialised Cables: Product-Wise Segmentation (India)

India's specialised cables market is witnessing steady growth, driven by sustained capex across industrial, infrastructure, and renewable segments. The product mix in India diverges moderately from global trends, reflecting unique demand drivers such as widespread low-voltage electrification, cost-conscious automation adoption, and increasing fire safety compliance in public infrastructure.

LT/LV Power Cables – ~60% share: This is the largest segment in the specialised cable space, due to high volume usage in industrial plants, data centres, solar installations, metro rail, and manufacturing clusters. These cables (typically rated up to 1.1kV) are used for power transmission from source to equipment in both industrial and infrastructure settings. Given India's scale of ongoing electrification (e.g., Smart Cities, PLI-linked manufacturing plants, EV infra), demand remains resilient. Clients have observed that LV power cables form the core backbone for most industrial projects in India.

Control Cables – ~10% share: Control cables are primarily used for regulating and controlling the functioning of machinery and HVAC systems. In India, their demand is linked to brownfield automation and mid-scale capital expansion across sectors like cement, metals, food processing, and pharma. While automation levels are improving, the share remains slightly lower than global standards due to the slower pace of digital retrofits in legacy factories.

Exhibit 3.8: Product-Wise Contribution to India Cables Market FY2025



Source: Stakeholder Interactions, Frost & Sullivan Analysis

Instrumentation Cables (Incl. Thermocouple, RTD) – ~15% share: Instrumentation cables are used for data transmission from control equipment to measurement units, with thermocouple and RTD cables catering to temperature-sensitive operations. These find application in process-intensive industries such as oil & gas, power generation, and steel. However, the share is lower than global levels due to relatively limited instrumentation sophistication and a more cost-driven procurement approach in many Indian industrial setups.

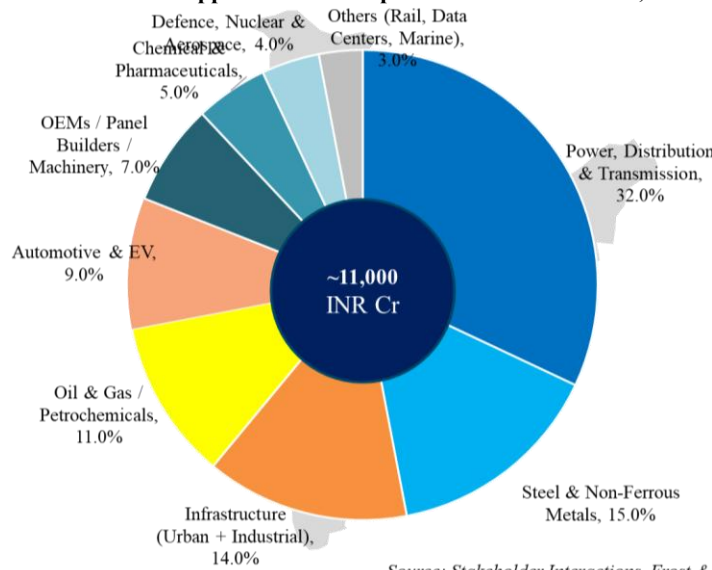
Others (Fire Survival, MI, High-Temp., etc.) – ~15% share: This segment includes high-temperature cables, fire survival cables, and mineral-insulated (MI) variants. Their usage is rising in India, backed by stricter compliance under the National Building Code (NBC), increased safety norms for tunnels and metros, and growing application in critical infrastructure (e.g., refineries, thermal plants, airports, defence). Export potential for MI and fire-survival cables is also rising, especially toward the Middle East and Europe.

3.4.2 Cables: End User Application Area (India)

India's specialised LV cable market is uniquely defined by its industrial diversity and infrastructure-led economic development. Unlike global peers where automation or energy transition dominate demand, India's market is more evenly distributed, rooted in power infrastructure, core industries like steel and metals, and emerging sectors such as EV and renewables. The demand is further shaped by strong government-led initiatives in manufacturing, electrification, and process modernisation.

Exhibit 3.9: India's Specialised LV Cable Market – Application-wise Demand

APPLICATION AREA	SHARE OF DEMAND (%)	KEY DRIVERS / USAGE
Power, Distribution & Transmission	30–33	Backbone of demand – LV power & control cables in substations, switchyards, transformer yards; signal & instrumentation cables in control rooms. Growth from RDSS, DISCOM reforms, industrial electrification, and renewable integration.
Steel & Non-Ferrous Metals	16–18	High-temperature, MI, and fire-survival cables for furnaces, rolling mills, electro-refining. Driven by PLI schemes, capacity expansion, and exports.
Infrastructure (Urban + Industrial)	12–14	Fire-retardant, control, and LSZH cables for metros, airports, smart cities, data centres, warehouses. Demand from HVAC, elevators, fire-safety, and automation systems.
Oil & Gas / Petrochemicals	10–11	Fire-survival, instrumentation, and thermocouple cables for refineries, LNG terminals, and chemical complexes. Growth along India's refining hubs.
Automotive & EV	8–10	EMI-shielded, flexible, heat-resistant cables for EV batteries, robotic welding, BMS, and automation in ICE & EV plants.
OEMs & Panel Builders	6–7	Hybrid and custom cables for HVAC, packaging, clean rooms, lab automation, and machine tools.
Chemicals & Pharmaceuticals	5–6	Flame-retardant, low-smoke, moisture-resistant signal and instrumentation cables for regulated, clean environments (API plants, formulations).
Defence, Nuclear & Aerospace	~3	Highly specialised radiation-resistant, high-temp, lightweight cables for reactors, missiles, aircraft, and military vehicles; driven by DRDO/BARC-certified programs.
Others (Textiles, Data Centers, Rail, Labs, Marine)	3–4	Fragmented demand: heat-resistant cables for textiles/paper, LSZH & low-interference for data centres, signal/fire-survival for rail and ports. Growth from data localisation, rail upgrades, port modernisation.

Exhibit 3.10: End-user application India Specialised Cables Market, in INR Cr, FY2025

Defence, Nuclear & Aerospace – Niche but Highly Specialised (~3%): Though small in volume, these sectors demand extremely high-quality cables — radiation-resistant, high-temperature, and lightweight — for critical applications. These cables are used in reactors, military-grade vehicles, missiles, and aircraft. The ecosystem is R&D-intensive and often works with selected certified vendors under DRDO or BARC programs.

Others (Textiles, Data Centers, Rail, Labs, Marine) – Fragmented Long-Tail (3–4%): These segments comprise a fragmented but growing base of demand. For instance, textile and paper mills use heat-resistant cables, data centers require LSZH and low-interference cables, and rail systems need signal and fire-survival types. Growth in data localization, suburban rail, and port modernization is expanding this long tail.

3.4.3 Specialised Cables: Sub-Segmentation Key End User Application Area (India)

India's specialised cable market is evolving rapidly in response to the country's growing industrial, infrastructure, and technological needs. With ambitious national programs such as Smart Cities Mission, Make in India, and the rapid electrification of transport and industry, the demand for niche cable types has grown significantly. From automation in manufacturing plants to thermal sensing in steel furnaces, each sub-segment of specialised cables serves a critical Players in the market often undergo multi-year qualification processes to meet the procurement norms of PSUs and large EPC players.

End users typically require extended qualification periods, in-depth testing, and comprehensive field trials before approving new suppliers for mission-critical applications. The process of qualifying as a supplier for a major Indian PSU in the engineering and electrical equipment industry further demonstrates the high entry barriers in the thermal engineering sector, especially for mission-critical products.

Exhibit 3.11: India Specialised Cables Market – Sub-Segmentation with Applications, FY2025

MAIN CATEGORY	SUB-CLASSIFICATION	REMARKS / TYPICAL INDIA-SPECIFIC USE-CASES
Thermocouple Cables	a. Thermocouple Cable	Primarily used in industries where measurement accuracy is critical, such as nuclear power and aerospace. They are also employed in sectors like glass and steel manufacturing, and

		power plants, often in legacy automation systems within energy-intensive industries.
	b. Extension Cable	Extension cables are common across all industries, serving as essential components in various control and instrumentation systems. While cost considerations remain important, accuracy and reliability continue to be key requirements.
	c. Compensating Cable	Widely used in process industries (sugar, textiles, basic chemicals) with moderate precision needs.
RTD Cables	a. Standard RTD Cable	Growing use in food, pharma, HVAC, automotive lines. OEMs also demand these in factory builds.
	b. Shielded / Armoured RTD Cable	Found in refineries, paint booths, and emission-prone zones; usage rises with automation upgrades.
High-Temperature Cables	a. Fiberglass Insulated Cable	Fiberglass insulated cables are primarily demanded in high ambient temperature environments such as glass manufacturing, aerospace, defence, and steel industries, where thermal resistance and durability are critical..
	b. PTFE Insulated Cable (Teflon)	Strong play in pharma clusters (Ahmedabad, Hyderabad, Baddi), food units, cleanrooms.
	c. Ceramic Fiber Insulated Cable	Used in metallurgical zones (Jharkhand, Chhattisgarh), thermal power station boilers, rare but critical.
Mineral Insulated (MI) Cables	a. MI Thermocouple Cable	MI cables are primarily used as thermocouples in industries such as steel, cement, glass, oil and gas, and by OEMs. They also find direct application in critical environments like tunnels (metro, mining), defence, and nuclear power setups, representing a premium, niche segment. This dual role reflects their versatility across industrial and infrastructure sectors.
	b. MI RTD Cable	Low-volume, high-importance segment for fire zones, oil rigs, chemical reactors.
	c. MI Power Cable (LV)	They are also used in metros, nuclear plants, and other critical infrastructure projects, but remain less common in the private sector.
LV Industrial Power & Control Cables	a. Specialized LV Power Cable (up to 1.1kV)	Bread-and-butter segment for industrial OEMs; growing use in EV manufacturing plants, textiles, packaging.
	b. Multi-core Control Cable	Driven by panel manufacturers in Bhiwandi, Manesar, and Chennai; India demand mostly in brownfield upgrades.
	c. Armoured / Enhanced Protection Cables	Used in mining, cement, sugar, and chemical clusters where rodents, abrasion, and chemicals are prevalent.
Customized / Specialty Cables for OEMs	a. Hybrid Cables (Power + Signal)	Early-stage but visible in robotics, automotive Tier-1 suppliers, CNC machine users.

	b. Special Sheathing (UV / Oil / Flame / Chemical Resistant)	Growing usage in solar farms, oil terminals, chemical clusters in Ankleshwar, Dahej, Vizag.
	c. OEM-Specific Builds (coiled, connectorized, bespoke insulation)	Used by export-focused OEMs, machine tool builders, and import substitution efforts in automation. Still a niche segment.

The Project/OEM segment is characterized by stringent qualification requirements and high entry barriers, with suppliers required to obtain approvals and compete for large orders in greenfield and brownfield installations. Tempsens have established a strong presence in this segment by meeting these stringent qualification standards and supplying to these approved projects.

3.4.4 Specialised Cables: Replacement Market (India)

The specialised cables market in India—comprising categories such as instrumentation, control, fire-survival, mineral-insulated (MI), and low-voltage signal cables—is poised for sustained growth, projected to expand from INR 11,000 crore (INR 110 billion) in FY2025 to INR 23,200 crore (INR 232 billion) by FY2030E. A significant share of this demand will emerge not just from new infrastructure development but also from the replacement of ageing and substandard cable installations, especially across power-intensive and safety-sensitive sectors.

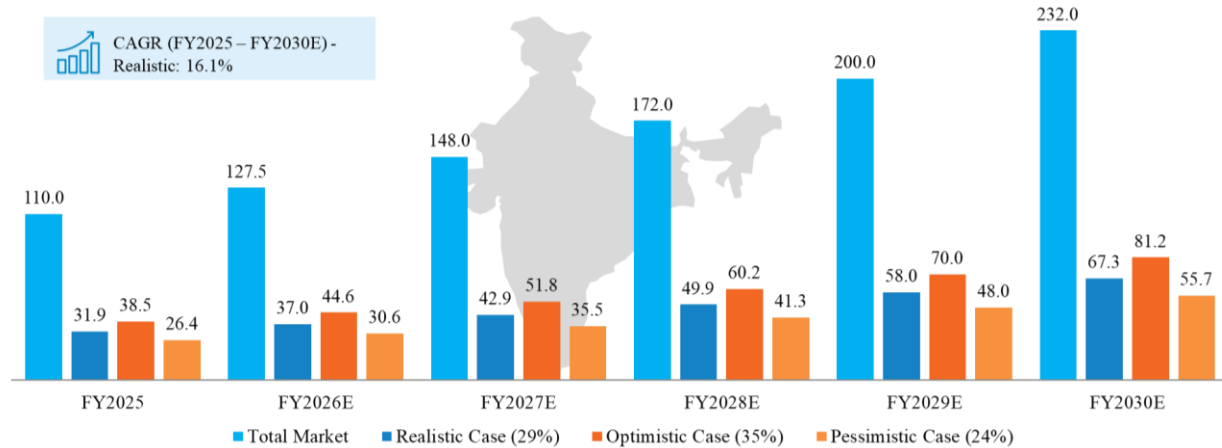
Rising Replacement Demand: Structural Drivers

India saw a surge in infrastructure and industrial development between 2005 and 2015, with large-scale cable installations across power generation and distribution, metro rail, airports, heavy industries, and commercial buildings. Much of this cable infrastructure is now approaching or has exceeded its rated service life of 15–20 years, particularly in harsh operating environments like steel, non-ferrous metals, chemicals, and oil and gas.

Moreover, several evolving drivers are accelerating cable replacement needs:

- **Upgraded safety norms** under the National Building Code (NBC), along with fire safety rules and state-level inspectorate mandates, are **rendering older non-compliant cables obsolete**.
- **Power, distribution, and transmission sectors**—the largest users of cables—are now phasing in new cable technologies for energy efficiency, reliability, and real-time diagnostics.
- **Industrial plants in metals, chemicals, and cement sectors** are actively retrofitted with fire-rated, flame-retardant, low-smoke halogen-free (FRLSH), and thermocouple/instrumentation cables to enhance system uptime and meet ESG mandates.
- **Urban transport, data centres, and healthcare infrastructure** are also replacing legacy cables to meet higher operational uptime and safety certifications.
- **EV charging and renewable integrations** are prompting utility-scale and commercial users to replace cables to support higher current capacities and frequent cycling.

Exhibit 3.12: India Specialised Cables Replacement Market Opportunity (Realistic, Optimistic & Pessimistic scenarios): FY2025 to FY2030E, INR Bn



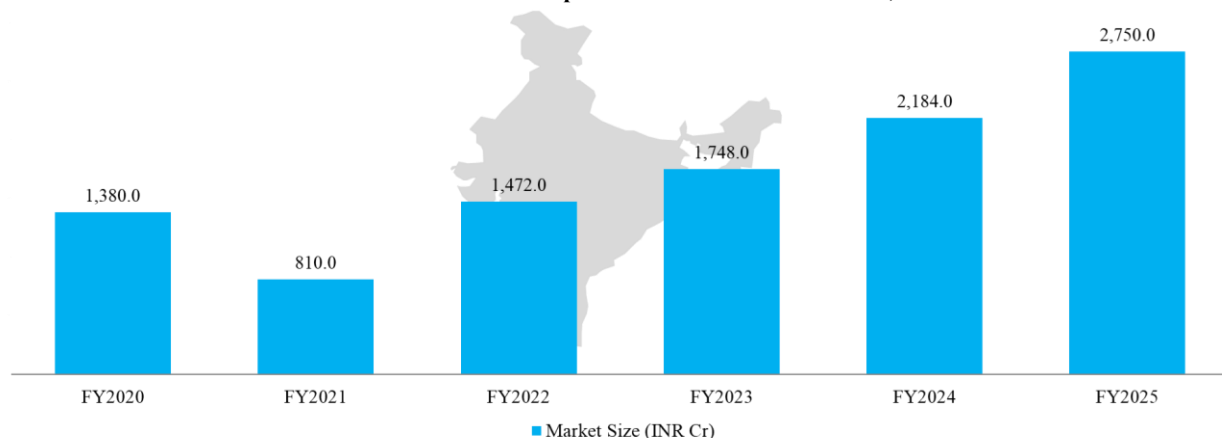
Source: Stakeholder Interactions, Frost & Sullivan Analysis

3.4.5 Specialised Cables: Exports (India)

India's cable export market has shown a strong recovery and impressive growth over the past several years. Starting from a market size of INR 1,380 crore in FY2020, the sector experienced a significant decline to INR 810 crore in FY2021, largely due to the global disruptions caused by the COVID-19 pandemic. However, the market bounced back quickly, reaching INR 1,472 crore in FY2022, and continued its upward trajectory with exports valued at INR 1,748 crore in FY2023. This growth trend is expected to accelerate further, with projections estimating the market to expand to INR 2,184 crore in FY2024 and INR 2,750 crore by FY2025.

This robust growth is driven by rising global infrastructure investments, particularly in power transmission, telecommunications, and renewable energy sectors, which are fueling demand for high-quality cables. India's competitive manufacturing ecosystem, supported by government initiatives like 'Make in India' and export incentives, has enhanced its appeal as a reliable and cost-effective supplier in the global market. Additionally, advancements in cable technology and growing supply chain diversification—where global buyers seek alternatives to traditional sources—are further strengthening India's position. Looking ahead, the Indian cable export market is well poised for sustained expansion, provided the industry continues to focus on quality enhancement, capacity building, and innovation to meet evolving global standards and demands.

Exhibit 3.13: India Cables Export Market FY2021 to FY2025, INR Cr



Source: Volza, Frost & Sullivan Analysis

3.4.6 Specialised Cables: Key Growth Drivers, Trends, Challenges, and Regulatory Framework and Policies (India)

A. Key Growth Drivers in India's Specialised Cable Market

- **Industrial Infrastructure Expansion** – New industrial parks, SEZs, and logistics hubs under PLI and PM-Gati Shakti are driving demand for LT/LV power and control cables in modern factories and warehouses.
- **Process Automation** – Wider adoption of DCS, PLC, SCADA, and IoT in cement, steel, oil & gas, and pharma is boosting need for instrumentation cables (RTD, thermocouple, shielded signal lines).
- **Clean Energy Shift** – Rooftop and MW-scale solar plants require DC, LV power, and monitoring cables, with rising demand for metering and inverter-data lines.
- **Process Industry Projects** – Chemical, fertiliser, and pharma expansions need reliable thermocouple and RTD cables for safety, emissions, and temperature control.
- **Safety & Compliance** – Preference for FR, LS, and LSZH cables is increasing as inspections and standards (IS/IEC/BS) gain importance across industrial and commercial buildings.

Regulatory approvals and industry certifications become equally important differentiators. Obtaining registration and product certifications for Tempsens' portfolio involves strict criteria, resulting in high entry barriers for prospective competitors. These hurdles arise from the specialised and high-stakes nature of Tempsens' engineered products, as well as from the demanding approval processes associated with both project-based and replacement supply.

B. Emerging Trends in India's Specialised Cable Market

Organized but Fragmented B2B Industrial Segment: While the B2B industrial cable market (particularly for instrumentation cables like thermocouple, RTD, and MI cables) is largely catered to by organized players due to stringent technical specifications, the space remains fragmented with many mid-sized manufacturers competing for project-based orders. Clients from process industries, refineries, pharma, and infrastructure projects demand reliable supply and adherence to standards—but may still float tenders that attract multiple regional or mid-scale players, limiting market consolidation.

Customization Demands Driving Product Differentiation: Customers in instrumentation-heavy sectors (such as oil & gas, cement, or chemical industries) are increasingly demanding custom-engineered cables based on installation conditions—such as chemical resistance, temperature range, shielding for EMI protection, or fire-survival ratings. This trend has prompted Indian manufacturers to invest in application-engineering teams to develop tailored cable solutions rather than relying solely on standard catalogue offerings, with companies like Tempsens placing particular emphasis on such customisation to address diverse industrial requirements.

Increased Awareness and Adoption of Fire Survival and High-Temperature Cables: Regulatory push for fire safety in infrastructure projects (metro, tunnels, airports, commercial buildings) and heightened awareness post major fire incidents have led to growing demand for fire survival cables and high-temperature cables. As projects increasingly require adherence to national building codes and global safety norms, the adoption of these specialised cables has increased, even in Tier 2 and Tier 3 cities.

Rising Use of MI and High-Temperature Cables in Hazardous and Industrial Zones: Mineral Insulated (MI) cables are gaining traction for their robustness in high-temperature, corrosive, or explosion-prone environments. Indian industries like steel, glass, refineries, and power plants are increasingly

specifying MI cables or high-temp fiberglass-insulated cables to ensure minimal signal loss, longevity, and compliance with safety standards.

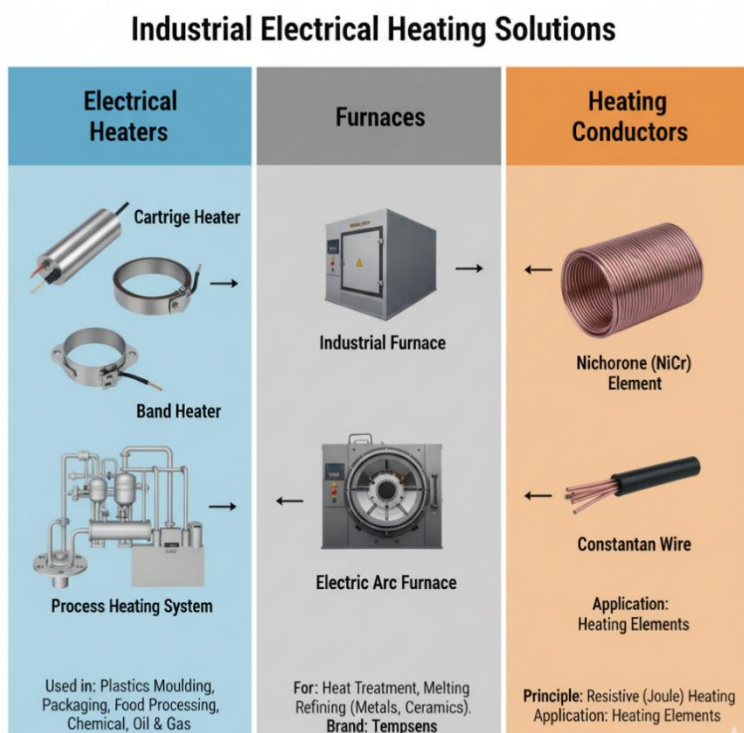
Gradual Shift to Direct Procurement by EPCs and OEMs: In project-driven segments, large EPCs and OEMs are increasingly bypassing traditional channel structures and procuring cables directly from reputed manufacturers to ensure quality compliance, project timelines, and post-installation support. This is gradually changing the procurement landscape in industrial and infrastructure segments.

C. Key Threats and Challenges

- **High Price Sensitivity:** Core sectors such as infrastructure, power, and industrial manufacturing remain extremely cost-conscious, often prioritising lower-priced cables over premium or certified options, which suppresses margins and discourages adoption of higher-quality products.
- **Fragmented and Unorganised Supply Base:** A large portion of the market, especially in Tier 2 and Tier 3 cities, is dominated by unorganised players. This creates challenges in enforcing quality standards, increases the prevalence of non-compliant products, and undermines market discipline.
- **Raw Material Volatility and Import Dependency:** Manufacturers face exposure to global price fluctuations of copper, aluminium, and specialty polymers, while also relying on imports for critical raw materials such as fluoropolymers and high-temperature insulation compounds. This creates cost instability and supply risks.
- **Rising Regulatory and Compliance Pressures:** Mandatory BIS certification and Quality Control Orders increase compliance costs, while counterfeit or falsely certified products remain widespread, eroding trust and creating uneven competition for compliant manufacturers..

4. MARKET ASSESSMENT OF HEATING SOLUTIONS (INDIA AND GLOBAL)

4.1 Key Products Overview



The Electrical heating solutions market plays a critical role across numerous industries by providing essential thermal energy for manufacturing, processing, and maintenance activities. With rising industrialisation, increasing automation, and a global push towards energy efficiency and sustainability, the demand for advanced heating technologies is steadily growing worldwide.

Electrical Heating solutions refer to a group of industrial equipment designed to generate, control, and maintain the heat required in various manufacturing and processing operations using electrical energy. These solutions are critical

components across many industries, including chemicals, metallurgy, and pharmaceuticals.

Heating solutions are vital not only for traditional sectors like metals, chemicals, and manufacturing but also for emerging applications in renewable energy, food processing, and advanced materials.

The key product categories within heating solutions include:

- **Electrical Heaters** convert electrical Energy into heat. Common types include cartridge heaters, band heaters, immersion heaters, tubular heaters, Process Heating System etc. They are widely used in plastics moulding, packaging, food processing, Chemical Petro Chemical, Oil and Gas and other manufacturing sectors.
- **Furnaces** are industrial thermal processing units used for heat treatment, melting, and refining in metals, ceramics, and chemical industries. They vary in size, fuel type, and sophistication, ranging from simple gas-fired models to advanced electric furnaces with precise temperature controls. Tempsons is a notable player manufacturing Electrical Furnaces.
- **Heating conductors:** Heating conductors are specialised electrical conductors designed to generate heat when an electric current passes through them, using the principle of resistive (Joule) heating. They are manufactured from materials with controlled electrical resistance, such as nichrome (nickel–chromium alloys) or constantan, and are embedded or configured in various forms depending on the application.

Product offerings of Tempsens

Exhibit 4.1: Mapping Grid: Categories vs Tempsens Products

CATEGORY	MAPPED TEMPESENS PRODUCTS
Heaters	- Cartridge Heaters - Tubular Heaters - Immersion Heaters - Band Heaters - Strip Heaters - Flexible Heaters (Silicone, Polyamide, PET) - Mica Heaters - Nozzle Heaters - Hot Runner Heaters - Air Heaters - High-Density Heaters, Process Heating System, Furnace Heaters
Furnaces	- Custom Laboratory and Process Electric Furnaces (used in metal treatment, ceramics, glass processing, etc.)
Heating Conductors	- Heating Elements such as NiCr (Nickel-Chromium) Wires, FeCrAl (Iron-Chromium-Aluminium) Wires

4.2 Application of heating equipments across industries

Heating equipment forms the backbone of industrial operations, enabling efficient, safe, and high-quality processes through precise thermal control. Electric heaters, furnaces, and conductors serve a wide spectrum of sectors — from refineries, petrochemicals, fertilizers, metals, and cement to emerging areas such as green hydrogen, battery storage, green ammonia, advanced chemicals, and nuclear power.

Their roles span pre-heating, distillation, cracking, and reforming in refining and petrochemicals; smelting, rolling, and heat treatment in metals; clinker formation and kilns in cement; and ammonia reforming and urea synthesis in fertilizers. The clean-energy transition is expanding opportunities into hydrogen production, thermal batteries, and chemical storage, making electric heating solutions indispensable across both traditional and future-focused industries.

A. Applications of heating equipment in a refinery

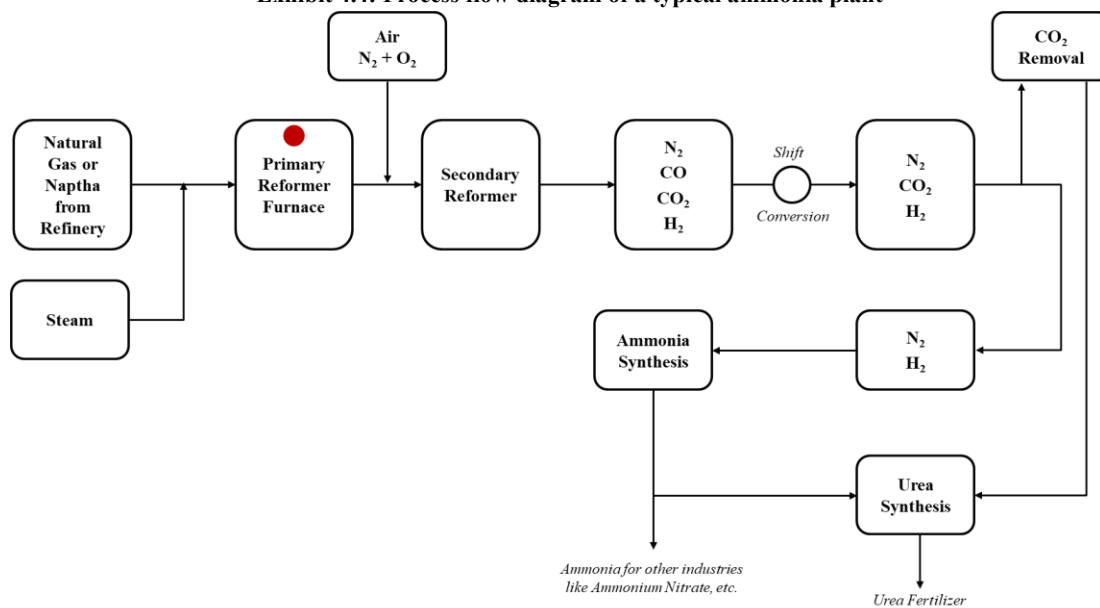
Process fired heaters and reformers are used in a typical refinery. Process fired heaters are the critical equipment in a refinery. Around 10 – 20 process fired heaters are used in any typical refinery. Of all the process fired heaters, four applications such as the crude distillation unit (CDU), vacuum distillation unit (VDU), delayed coker unit and catalytic reforming units are the most critical and the capex for these heaters is also high when compared with the other heater application areas in the refinery. Other applications for process fired heaters are hydrotreaters, hydrocrackers, fluid catalytic cracker (FCC), etc. Key processes where the process fired heaters are used in a refinery are:

- Crude Distillation Unit (CDU)
- Vacuum Distillation Unit (VDU)
- Fluid Catalytic Cracker Unit (FCCU)
- Hydrocracker Unit
- Visbreaker Unit
- Delayed Coker Unit
- Catalytic Reforming Unit
- Hydrotreating Unit, Bitumen Blowing Unit

C. Applications of heating equipment in a fertilizer (Urea) plant

Process fired heaters and reformers are used primarily in the ammonia plant of an integrated urea plant. Reformers are the most critical equipment in an ammonia plant. Reformers are used in ammonia production,

Exhibit 4.4: Process flow diagram of a typical ammonia plant



● This indicates the various units in an Ammonia and Urea plant where heating equipment are used.

Source: Frost & Sullivan research

which is later converted into urea. The process begins with a primary reformer to create hydrogen from a natural gas feedstock at temperatures over 1800°F. The hydrogen is then fed by a hydrogen transfer line into a secondary reforming vessel. In the secondary reformer, hydrogen in the presence of nitrogen reacts with a catalyst to form ammonia.

D. Applications of heating equipment in a Metals and Steel plant:

The metals and steel industry is one of the largest consumers of heating equipment globally. Electric heaters, furnaces, and conductors are critical in enabling processes such as ore reduction, steelmaking, casting, rolling, and finishing. Traditionally dominated by fossil-fuel-fired furnaces, the sector is now exploring partial electrification to reduce carbon emissions, improve energy efficiency, and meet ESG targets.

Key Applications of Heating Equipment:

1. Ironmaking & Steelmaking

- Blast Furnace / Direct Reduced Iron (DRI) → Preheating air and gases, electrode heating.
- Electric Arc Furnace (EAF) → High-intensity resistive heating for scrap melting, supported by heating conductors.
- Basic Oxygen Furnace (BOF) → Limited direct heating, but auxiliary heaters used for off-gas cleaning and slag conditioning.

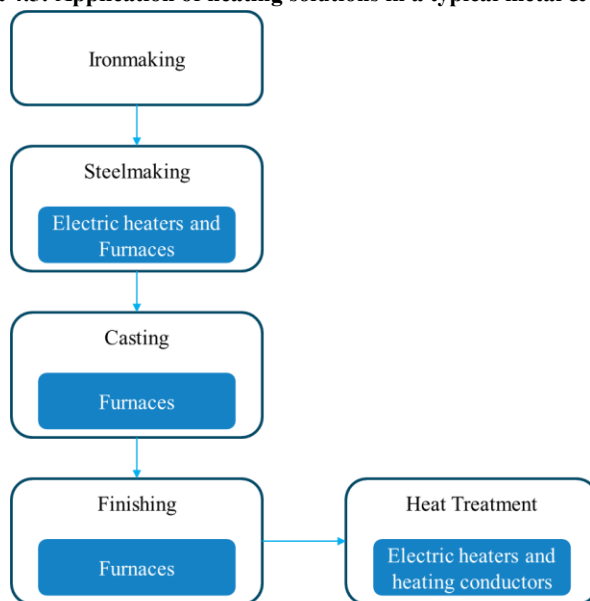
2. Casting

- Continuous Casting Machines → Electric immersion heaters used to maintain molten steel temperature in tundishes and ladles.

3. Rolling & Forming

- Reheating Furnaces → Furnaces (gas or electric) reheat steel slabs/billets before rolling.
- Induction Heaters / Tubular Heaters → Preheating for hot rolling, forging, and extrusion.

Exhibit 4.5: Application of heating solutions in a typical metal & steel plant



Source: Desk Research,, Frost & Sullivan Analysis

4. Heat Treatment & Finishing

- Annealing, Tempering, Quenching Furnaces → Electric furnaces provide precise temperature control.
- Surface Coating (Galvanizing/Colour Coating) → Cartridge and strip heaters used in drying/curing ovens.

5. Auxiliary Systems

- Hopper heaters, ladle heaters, and process heating systems to prevent solidification and ensure material flow.

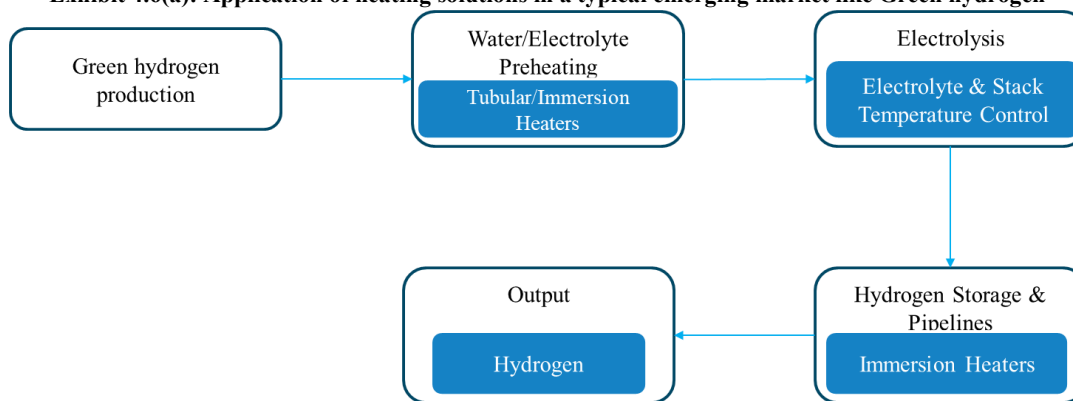
E. Applications of heating equipment in Emerging markets:

Emerging sectors are rapidly adopting advanced electric heating technologies to enable high-precision thermal processes, critical for clean energy, battery production, and next-generation materials. Heating equipment in these sectors is less about bulk energy and more about precision, consistency, and safety.

Key Applications of Heating Equipment:

1. Green Hydrogen Production

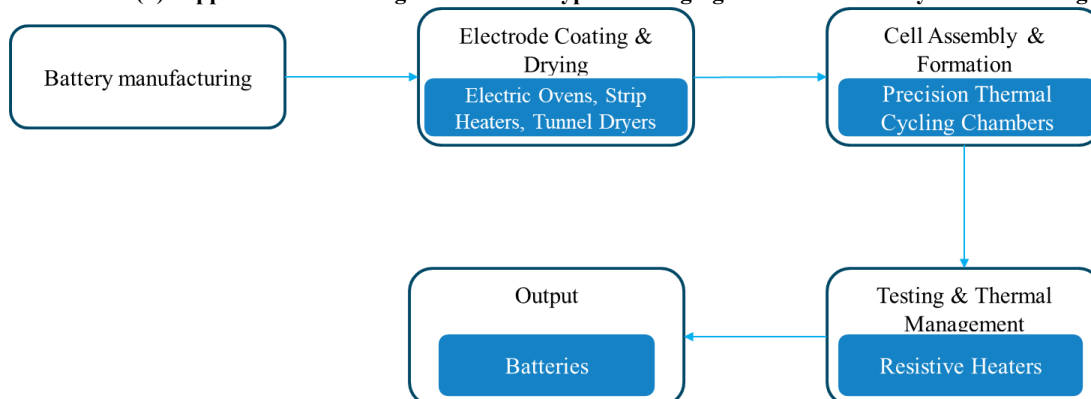
- **Electrolyzers & Water Splitting:** Some PEM and alkaline electrolyzers require controlled preheating of water or electrolytes to improve efficiency.
- **Electrolyte Temperature Control:** Tubular heaters, immersion heaters, and cartridge heaters maintain optimal operating temperature.
- **Hydrogen Storage:** Heating systems prevent condensation or freezing in pipelines and storage tanks.

Exhibit 4.6(a): Application of heating solutions in a typical emerging market like Green hydrogen

Source: Desk Research,, Frost & Sullivan Analysis

2. Battery Manufacturing

- **Electrode Coating & Drying:** Electric ovens, strip heaters, and tunnel dryers remove solvents from coated electrodes.
- **Cell Assembly & Formation:** Precise thermal cycling is required for activation, curing, and formation of battery cells.
- **Thermal Management Testing:** Chambers use resistive heaters for high-temperature testing and simulation of battery performance.

Exhibit 4.6(b): Application of heating solutions in a typical emerging market like battery manufacturing

Source: Desk Research,, Frost & Sullivan Analysis

3. Solar Module & PV Manufacturing

- **Lamination & Encapsulation:** Heating presses and ovens maintain controlled temperatures to cure EVA films and encapsulants.
- **Glass Tempering & Coating:** Tubular heaters and strip heaters control annealing and coating processes.

Exhibit 4.6(c): Application of heating solutions in a typical emerging market like Solar manufacturing

Source: Desk Research,, Frost & Sullivan Analysis

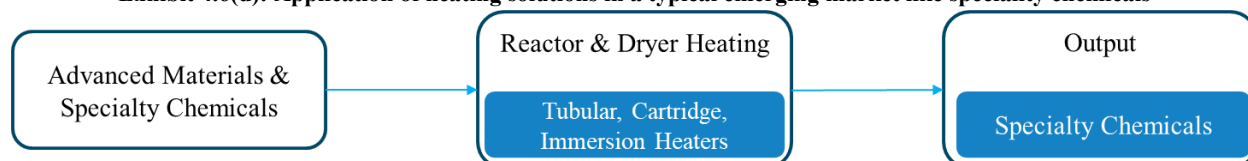
4. Hydrogen Fuel Cells & Electrolysers

- **Membrane & Catalyst Activation:** Controlled heating enhances catalyst activity and ionic conductivity.
- **Support Systems:** Pipeline tracing heaters, electrolyte preheaters, and safety heaters in storage and transport systems.

5. Advanced Materials & Specialty Chemicals

- **High-Precision Reactors:** Heaters maintain specific reaction temperatures in polymer synthesis, nanomaterials, or specialty chemical production.
- **Drying & Evaporation:** Immersion heaters, tubular heaters, and hot-oil systems ensure moisture removal without degrading materials.

Exhibit 4.6(d): Application of heating solutions in a typical emerging market like speciality chemicals

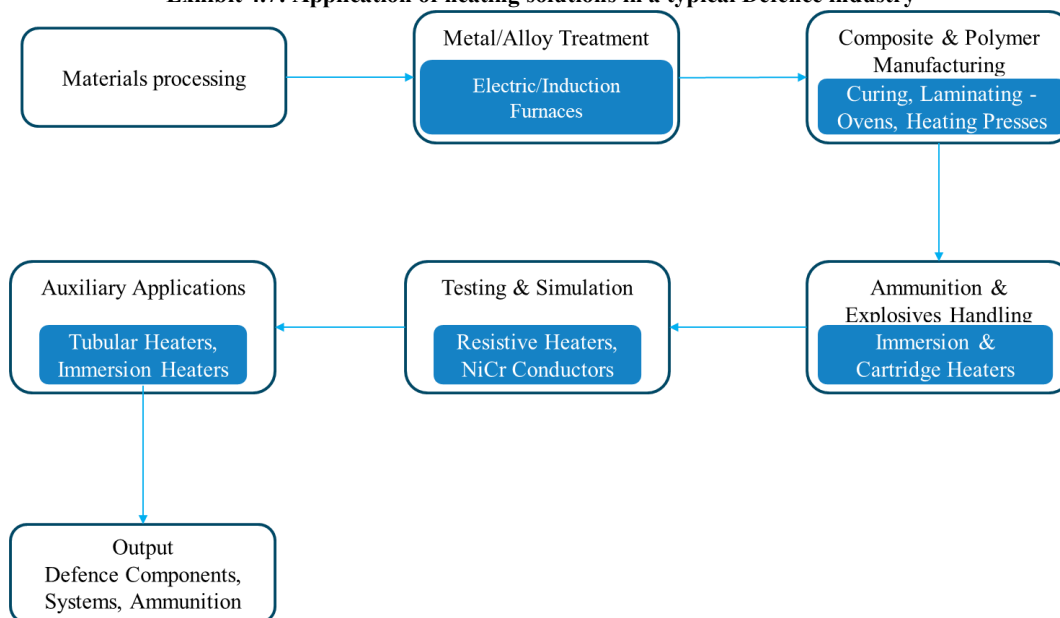


Source: Desk Research,, Frost & Sullivan Analysis

F. Applications for heating equipment in a Defence markets:

In the defence sector, heating equipment plays a critical role in materials processing, testing, and specialized manufacturing, where precision, reliability, and safety are paramount. Applications span from advanced materials production for armour and aerospace to thermal testing and ammunition preparation.

Exhibit 4.7: Application of heating solutions in a typical Defence industry



Source: Desk Research,, Frost & Sullivan Analysis

Key Applications for Heating Equipment:

1. Materials Processing

- **Metal & Alloy Treatment:** Annealing, tempering, and stress-relief of high-strength steels, titanium alloys, and aluminium components for defence applications.

- **Equipment Used:** Electric furnaces, induction heaters, strip heaters, tubular heaters.
2. **Composite & Polymer Manufacturing**
 - **Curing & Laminating:** High-performance composites for aircraft, missiles, and vehicles require controlled thermal curing.
 - **Heating Equipment:** Precision ovens, heating presses, and immersion heaters to maintain uniform temperatures.
 3. **Ammunition & Explosives Handling**
 - **Safe Thermal Conditioning:** Ensures materials are within safe temperature limits during storage, handling, and transport.
 - **Heating Solutions:** Immersion heaters, cartridge heaters, and conductive heating plates.
 4. **Testing & Simulation**
 - **Environmental & Thermal Chambers:** Simulate extreme conditions for components and systems.
 - **Heating Elements:** Resistive heaters, NiCr conductors, and tubular heaters provide accurate temperature profiles.
 5. **Auxiliary Applications**
 - **Support Systems:** De-icing, tank heating, and fluid line heating for fuel, lubricants, and hydraulic systems.
 - **Tempsens Relevance:** Sensors, cartridge heaters, and immersion heaters monitor and maintain operational temperatures safely.
1. **Forming & Molding**
 - **Glass Shaping:** Molten glass is directed to forming machines, including float glass lines, bottle molds, and fiber glass drawing lines.
 - **Heaters Used:** Forehearth heaters, tubular heaters, and radiant heaters maintain flow consistency and prevent solidification.
 2. **Annealing & Tempering**
 - **Stress Relief:** Glass is gradually cooled in annealing lehrs to prevent internal stresses and cracking.
 - **Heating Application:** Strip heaters and radiant heaters ensure uniform cooling and maintain controlled temperature gradients.
 3. **Coating & Finishing**
 - **Surface Treatment:** For coated or laminated glass, electric heaters maintain curing temperature and coating adhesion.
 - **Tempsens Relevance:** Precision heaters and sensors are critical in forming, annealing, and coating stages.

G. Applications of heating equipment in Power industry:

In the power sector, heating equipment is critical for both **generation and auxiliary processes**. While most of the core heat in thermal power plants comes from coal, gas, or nuclear fuel, electric heating is used

extensively for **startup, maintenance, efficiency improvement, and safety**. Increasing electrification and renewable integration are also opening new applications for precise thermal control.

Key Applications of Heating Equipment:

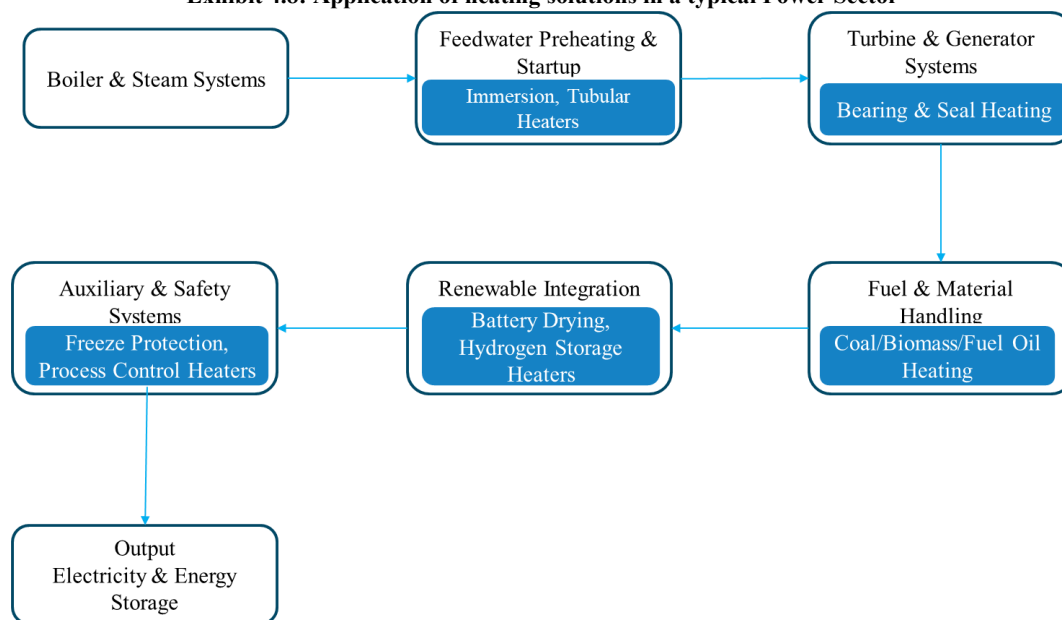
1. Boiler & Steam Systems

- **Auxiliary Heating:** Electric heaters preheat feedwater and maintain boiler drum temperature.
- **Startup Heating:** Immersion heaters and tubular heaters enable safe cold starts and prevent thermal stress.

2. Turbine & Generator Systems

- **Lubrication Oil Heating:** Cartridge and immersion heaters maintain turbine and generator oil viscosity for smooth operation.
- **Bearing & Seal Heating:** Prevent condensation and ensure efficient startup.

Exhibit 4.8: Application of heating solutions in a typical Power Sector



Source: Desk Research,, Frost & Sullivan Analysis

3. Fuel & Material Handling

- **Coal, Biomass, or Fuel Oil Heating:** Electric heaters prevent solidification or viscosity issues in fuel transport lines and storage tanks.
- **Pipeline Tracing:** NiCr or tubular conductors maintain consistent temperature along fuel lines.

4. Renewable Integration

- **Battery Storage & Solar PV:** Thermal management in energy storage systems, including battery drying and preheating.
- **Hydrogen Storage:** Electric heaters ensure safe storage and delivery.

5. Auxiliary & Safety Systems

- **De-icing & Freeze Protection:** Heating elements prevent freezing of water lines, flue gas ducts, and cooling systems in cold climates.

- **Process Control:** Immersion heaters, strip heaters, and tubular heaters are used for precise temperature management.

H. Applications of heating equipment in the Chemical industry:

The chemical industry is highly diverse and energy-intensive, with heating equipment playing a critical role in **reaction control, evaporation, distillation, and storage**. Precise temperature control is essential for product quality, safety, and energy efficiency. Electric heaters, furnaces, and conductors complement fossil-fuel-fired systems, especially in fine chemicals, specialty chemicals, and high-value intermediates.

Key Applications of Heating Equipment:

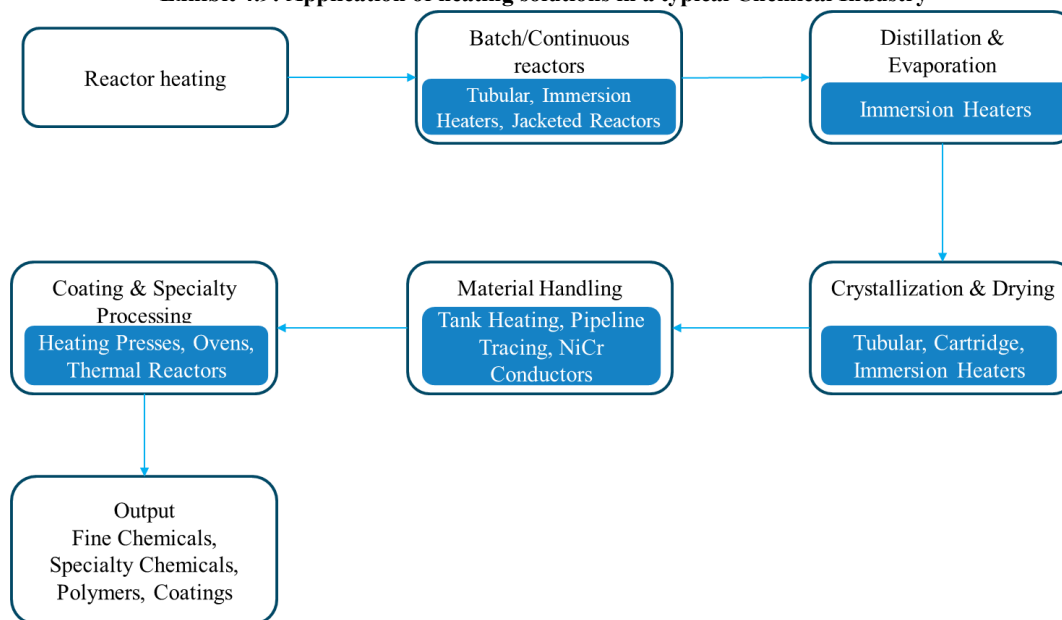
1. Reactor Heating

- **Exothermic & Endothermic Reactions:** Electric heaters maintain precise reaction temperatures in batch and continuous reactors.
- **Equipment Used:** Jacketed reactors with tubular heaters, immersion heaters, and NiCr conductors.

2. Distillation & Evaporation

- **Separation Processes:** Maintaining consistent heat in distillation columns and evaporators ensures product purity.
- **Heating Equipment:** Reboilers with tubular heaters, immersion heaters in solvent tanks, and hot-oil circulation systems.

Exhibit 4.9: Application of heating solutions in a typical Chemical Industry



Source: Desk Research,, Frost & Sullivan Analysis

3. Crystallisation & Drying

- **Solids Formation & Moisture Removal:** Controlled heating in crystallizers, dryers, and fluidized beds.

4. Storage & Material Handling

- **Tank Heating & Tracing:** Prevents solidification or viscosity issues in storage tanks, pipelines, and transport vessels.

- **Heating Equipment:** Immersion heaters, strip heaters, and NiCr conductors for uniform temperature maintenance.

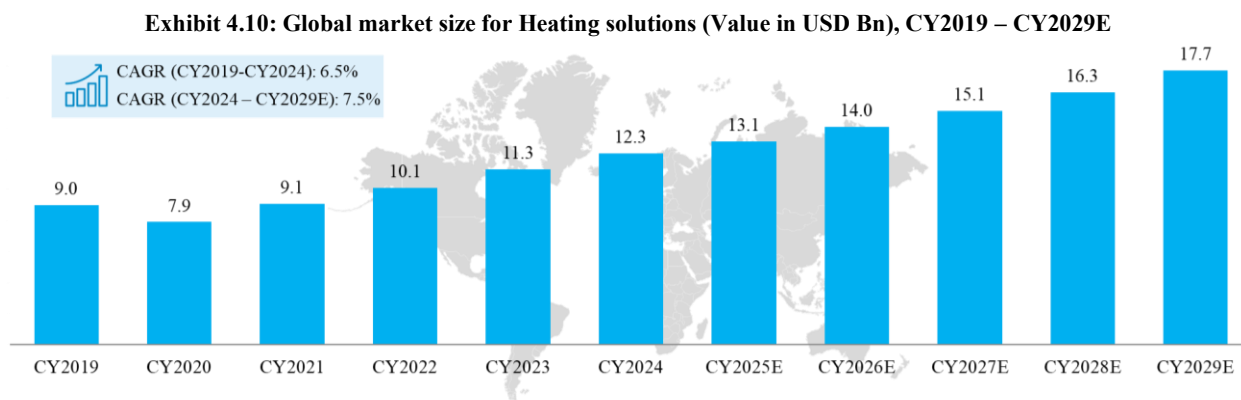
5. Coating & Specialty Processing

- **Polymerization & Coatings:** Precise thermal control in specialty coatings, adhesives, and polymer production.
- **Electric Heating Application:** Heating presses, ovens, and thermal reactors with embedded electric heaters.

4.3 Heating Solutions: Global Market Overview

The global industrial Electric heating solutions market has shown consistent and resilient growth over the past several years, driven by a combination of factors including industrial expansion, rising automation, increasing energy efficiency mandates, and the transition to cleaner, electrified heating systems.

From CY2019 to CY2024, the global market expanded at a moderate CAGR of 6.5%, increasing from USD 9.0 billion in CY2019 to an estimated USD 12.3 billion in CY2024. This period included disruptions caused by the COVID-19 pandemic in CY2020, which impacted industrial activity and capex cycles in sectors such as automotive, metals, and oil & gas.



Source: Desk Research, Expert interactions, Frost & Sullivan Analysis

However, recovery in CY2021 and CY2022 was swift, driven by resurgent demand in manufacturing, chemicals, and energy-intensive sectors, especially in Asia-Pacific and North America. The market is forecast to grow from USD 12.3 billion in CY2024 to USD 17.7 billion in CY2029E, translating to an approximate CAGR of 7.5%. Growth could be likely driven by:

- Continued demand for process heating in energy-intensive industries. The steel and glass industries rely heavily on high-temperature furnaces, particularly in countries like India, China, Germany, and Japan. As global infrastructure spending increases, these sectors are expanding capacity and modernising their heating systems. (These Segment used mainly Gas/Coal fired Furnaces and Heating system)
- Expansion of chemical processing units and speciality material plants. Global chemical majors like BASF, Clariant, and Reliance Industries are expanding their speciality chemical and advanced material units. Dow and SABIC are investing in low-carbon and green chemistry plants in Texas and the Netherlands, which use modular electric heating systems for reaction control.
- Increasing adoption of modular, skidded, and mobile heating systems. Skidded electric heating units are increasingly used in oil & gas, power generation, and on-site speciality manufacturing. Oil & gas

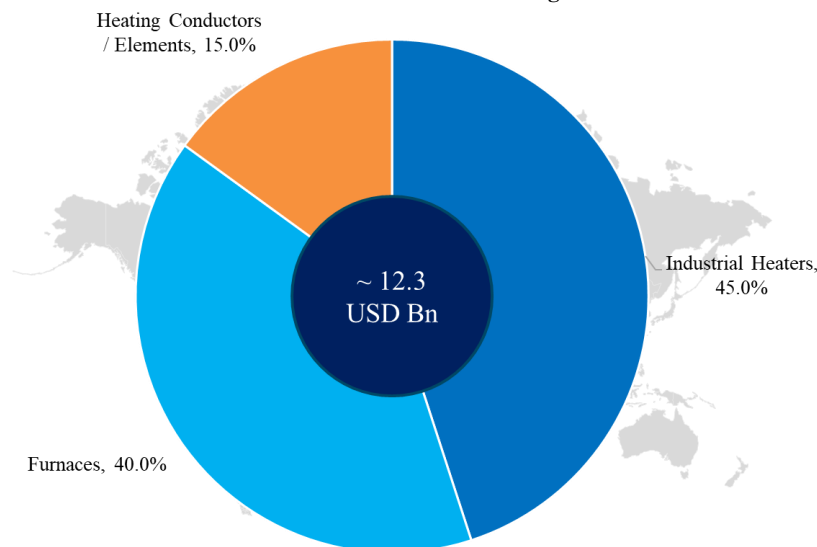
fields in the Middle East and North Dakota (U.S.) are deploying mobile heater skids for line and tank heating in harsh environments.

- Retrofit opportunities in ageing industrial facilities across Europe and the U.S. Many facilities in Germany, France, and the U.S. Midwest were built in the 1960s–1980s and are now under pressure to upgrade ageing heaters and furnaces to meet modern energy standards. The U.S. Department of Energy’s Better Plants Program is incentivising industrial players to replace old gas-fired systems with efficient electric resistance heaters or infrared heating units.

4.3.1 Heating Solutions: Product-Wise Segmentation (Global)

The global heating solutions market comprises three core product categories, such as industrial heaters, furnaces, and heating conductors or elements, each serving distinct roles across manufacturing, process industries, and energy infrastructure. Industrial heaters, which account for the largest share of the market (~45% in CY2024), are widely used in sectors like chemicals, pharmaceuticals, food processing, and semiconductors. The demand for electric heaters is surging due to the global shift toward decarbonization and electrified process heating. Notably, Tempsons has emerged as one of the leading players in electric heaters as of March 2025, particularly process heaters, further strengthening the industry’s transition toward sustainable heating technologies.

Exhibit 4.13: Product-Wise Contribution to Global Heating Solutions Market CY2024



Source: Stakeholder Interactions. Frost & Sullivan Analysis

Furnaces represent the second-largest segment (~40%), particularly vital to steel, glass, ceramics, and solar equipment manufacturing. Global demand is being driven by capacity expansions and clean energy transitions.

Heating conductors and elements (~15%) are integral components embedded in various systems, catering to high-performance applications in aerospace, electronics, and automotive industries. In addition, Tempsons’ technical expertise extends to advanced conductor solutions and are among the few manufacturers of these specialist conductor products in India, operating in this field as of March 31, 2025.

4.3.2 Heating Solutions: Market Segmentation by Countries/ Region (Global)

The global heating solutions market, comprising industrial heaters, furnaces, and associated thermal systems, is geographically diverse, with significant demand clusters emerging based on industrialisation levels, energy policies, and technology adoption. Below is a detailed regional breakdown:

F. North America (Key markets include the United States, Canada)

Market Drivers:

- Decarbonization of industrial heat (~30% of U.S. industrial energy use comes from process heating – U.S. DOE, 2024).
- Push for the electrification of heating systems in line with net-zero goals.
- Ongoing reshoring of manufacturing and semiconductor production.

Key Trends:

- Increasing adoption of electric heating.
- Integration of IoT-enabled thermal systems for predictive maintenance.
- Retrofits of existing gas-fired systems with electric alternatives.

Notable Activity:

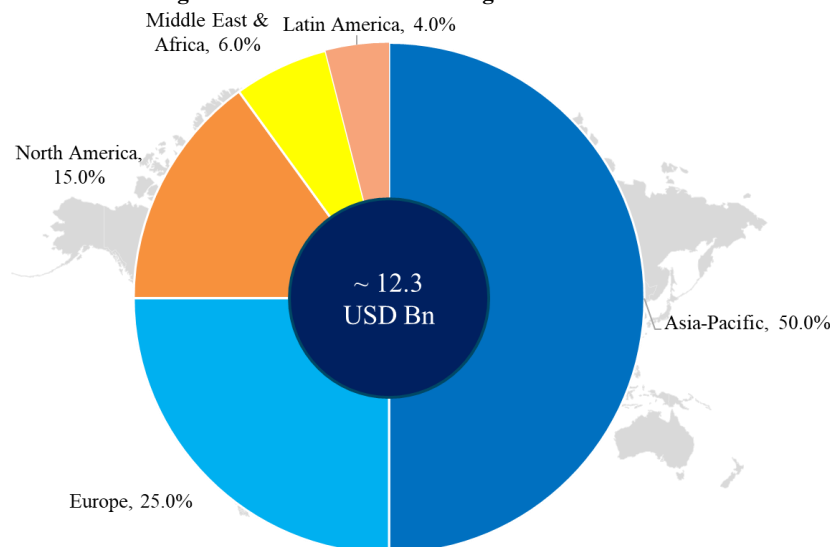
- In late 2024, Watlow Electric Manufacturing announced expansion of its advanced electric heater production in Missouri to support semiconductor fabs (Watlow, Nov 2024).
- The Canadian government's 2025 Clean Industry Program allocated CAD 250 million for the electrification of heating in the steel and chemical industries (Gov. of Canada, Jan 2025).

G. Europe (Key Markets: Germany, France, Italy, UK, Netherlands)

Market Drivers:

- Aggressive decarbonization mandates under the EU Green Deal.
- Ban on fossil-fuel-powered industrial heating in some segments starting in 2030.
- High energy efficiency standards and subsidies for clean heating tech.

Exhibit 4.14: Regional Share of Global Heating Solutions Market CY2024



Source: Stakeholder Interactions, Frost & Sullivan Analysis

Key Trends:

- Shift to electric resistance heating and hydrogen-compatible furnaces.

- Strong investment in automation and digital controls in heating systems.

Notable Activity:

- Elkem ASA (Norway) invested Euro 80 million in an electrified furnace facility to reduce CO₂ emissions by 40% (Elkem, Q4 2024).
- Germany's "Climate Neutral Industry Program" is incentivising heating system retrofits with Euro 4 billion in funding over five years (BMW, Jan 2025).

H. Asia-Pacific (Key markets: China, India, Japan, South Korea)**Market Drivers:**

- Rapid industrialisation and rising demand for process heating.
- Expansion of heavy industries (steel, glass, cement) and electronics.
- Focus on energy efficiency amid rising power costs.

Key Trends:

- High demand for custom-designed electric furnaces and immersion heaters.
- Increasing use of heating technologies in EV and battery production.

Notable Activity:

- China's 14th Five-Year Plan encourages local governments to transition industrial heating systems to electric or clean fuels.

I. Middle East & Africa (Key Markets: UAE, Saudi Arabia, South Africa)**Market Drivers:**

- Large-scale infrastructure and industrial projects under Vision 2030 (Saudi Arabia).
- Demand for high-reliability heating systems in the petrochemical and metals sectors.

Key Trends:

- Adoption of modular high-capacity heating units.
- Investment in localised manufacturing of heating components.

Notable Activity:

- In 2024, Honeywell partnered with SABIC to implement advanced thermal systems in its chemical processing plants (Honeywell, Dec 2024).

J. Latin America (Key Markets: Brazil, Mexico, Chile)**Market Drivers:**

- Growth in food processing, automotive, and metal processing sectors.
- Government initiatives to modernise industrial equipment.

Key Trends:

- Gradual shift to energy-efficient electric heaters.
- Increasing exports of heating systems from Mexico to the U.S.

Notable Activity:

- Brazil's industrial modernisation fund (announced in 2024) earmarked USD 120 million for upgrading thermal systems in the aluminium and paper sectors (Ministry of Industry, Brazil, Oct 2024).

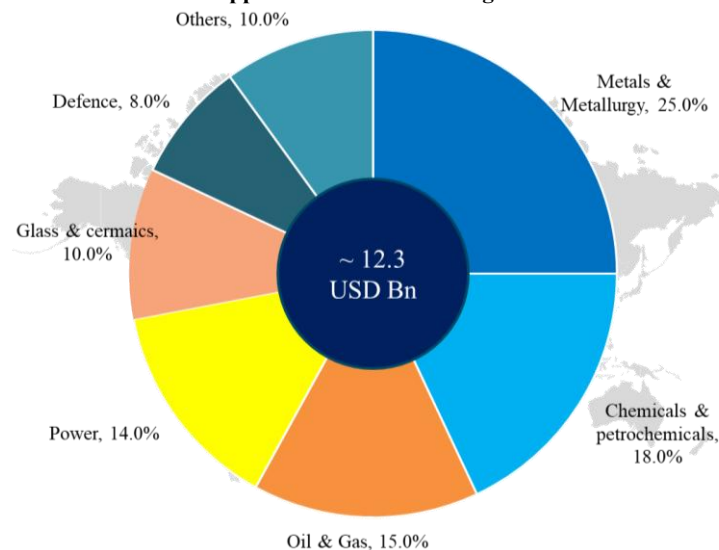
Adding to its product strength, Tempens has also built a global footprint with physical presence in key regions, including its joint venture in Indonesia (PT Tempens Asia Jaya), one of the market leaders (in terms of revenue) in temperature sensors as of March 31, 2025. This international presence reinforces Tempens' positioning as a trusted player not only in India but also across global markets.

4.3.3 Heating Solutions: End User Application Area (Global)

The global industrial heating solutions market, valued at USD 12.3 billion (CY2024), underpins critical processes across manufacturing and energy-intensive sectors. Demand is concentrated in:

- Metals & Metallurgy (~25%) – Large furnaces for annealing, forging, and casting in steel, aluminum, and foundry operations, supported by infrastructure growth in China, the U.S., and Europe.
- Chemicals & Petrochemicals (~18%) – Electric and immersion heaters for distillation, pipelines, and reactors in Gulf nations, the U.S. Gulf Coast, and China.
- Oil & Gas (~15%) – Immersion, thermal-fluid, and induction heaters for crude heating, pipeline upkeep, and processing.
- Power (~14%) – Electric heaters, heat pumps, and solar/biomass systems for steam generation and pre-heating in power plants.
- Glass (~10%) – High-temperature furnaces for melting, moulding, and annealing, driven by solar PV and architectural demand.
- Defence (~8%) – Immersion, circulation, and duct heaters for equipment, fuels, and personnel comfort.
- Other niches (~10%) – Pharmaceuticals, automotive/EV, and textiles needing tailored, often cleanroom-ready solutions.

Growing infrastructure spending and energy-transition investments are sustaining market momentum across traditional and emerging applications.

Exhibit 4.15: End-user application Global Heating Solutions Market CY2024

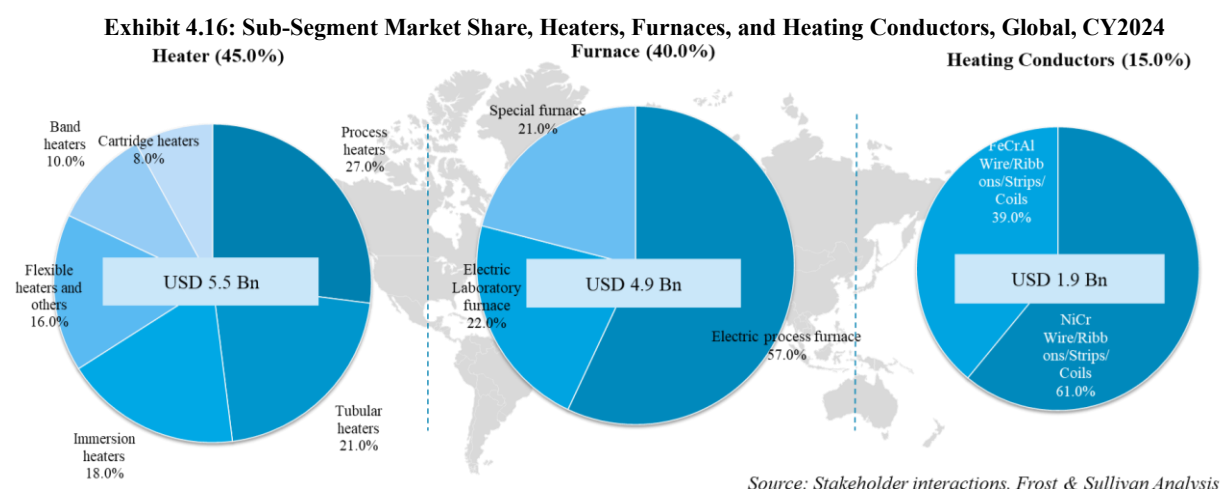
Source: Stakeholder Interactions, Frost & Sullivan Analysis

4.3.4 Heating Solutions: Sub-Segment Market Share, Heaters, Furnaces, and Heating Conductors, Global, CY2024 (Global)

A. Heaters

Electric process heating systems command a significant position globally, accounting for approximately 27% of the total market value. Their adoption spans a wide range of industries — from chemicals, food processing, and automotive manufacturing to oil & gas and electronics — largely due to their precision, controllability, and lower operational emissions compared to fossil-fuel-based heating methods. With ongoing decarbonization efforts, the share of electric heating is expected to rise further, especially in regions like Europe and North America where energy transition policies are stringent.

Tubular heaters account for roughly 21% of the global market, underscoring their adaptability for both radiant and convection heating. Their modular design allows them to be custom-formed for diverse uses, including air, surface, and immersion heating, which makes them a favored choice in industries with varied process requirements.



Immersion heaters represent about 18% of the global market, making them one of the most widely used heater types worldwide. Their appeal lies in their efficiency in directly heating liquids, making them indispensable in applications such as water heating, oil heating, and process fluids in manufacturing plants. Their versatility — spanning domestic, commercial, and industrial applications — ensures a steady and resilient demand base across geographies.

Band heaters hold around 10% of the global market and cater mainly to specialized industrial needs, particularly in plastics processing, extrusion, and packaging equipment. Although their share is smaller, their role is critical in applications requiring uniform heating around cylindrical surfaces, such as barrels and nozzles. This niche positioning shields them from significant competition from other heating technologies.

Overall, the global industrial electric heating market shows a diverse technology mix, with each segment playing a specific role in serving industry-specific needs. As industrial decarbonization accelerates and electricity becomes cleaner, the relative shares of these technologies could shift, with electric heating solutions poised for steady growth.

B. Furnace

The global furnace market is broadly segmented into electric laboratory furnaces, electric process furnaces, and special furnaces such as vacuum and induction furnaces. Each segment serves distinct industrial needs and reflects the maturity and diversity of the worldwide manufacturing and research landscape.

- Electric Process Furnaces form the largest segment globally, making up approximately 57% of the market. These furnaces are widely used in heavy industries for heat treatment, melting, annealing, sintering, and other thermal processing operations. Industries such as steel production, automotive manufacturing, ceramics, glass, and chemical processing rely heavily on electric process furnaces for efficient and controlled thermal processing at industrial scales.
- Electric Laboratory Furnaces account for approximately 22% of the global furnace market by value. These furnaces are primarily used in research and development, quality control, material testing, and educational applications. Their demand is driven by sectors such as pharmaceuticals, materials science, metallurgy, and academia, where precise temperature control and small-scale heating are critical.
- Special Furnaces, including vacuum furnaces, and other advanced furnace types, constitute approximately 21% of the global market. These furnaces cater to specialized applications requiring high-purity atmospheres, precise temperature control, or unique heating methods. Their usage is prominent in aerospace, electronics, high-tech materials manufacturing, and specialty metal processing industries.

Overall, the global furnace market reflects a mature industrial ecosystem with a strong emphasis on large-scale process furnaces, balanced by steady demand for laboratories and special furnace segments driven by innovation and technological advancement.

C. Heating Conductors

Nickel-Chromium (NiCr) wire: NiCr wire accounts for 61% of the global heating conductor market. Known for its high resistivity, excellent oxidation resistance, and stable performance at elevated temperatures, NiCr is widely used in electric heating elements for furnaces, industrial heaters, and domestic appliances. Its durability and ability to operate in oxidizing environments make it the default choice for many high-performance applications.

Iron-Chromium-Aluminium (FeCrAl) wire: FeCrAl wire represents 39% of the market. It offers higher maximum operating temperatures than NiCr and exhibits good oxidation resistance, particularly in air. FeCrAl is often preferred in applications requiring cost efficiency and where long service life at high temperatures is essential, such as in certain furnace linings, kilns, and industrial heaters.

4.3.5 Heating Solutions: Sub-Segmentation Key End User Application Area (Global)

Technology evolution, energy transition imperatives, and regional specialization across North America, Europe, and the Asia-Pacific shape the global heating solutions market.

Heaters are the largest segment worldwide, widely used in making machinery, energy-efficient devices, and systems that need precise temperature control. Countries like Germany, South Korea, Japan, and the U.S. are leading the demand for high-performance cartridge and flexible heaters, driven by their strong industries in electronics, semiconductors, and Electric Vehicles (EVs). Flexible and infrared heaters are growing fast because they are lightweight and compact—ideal for use in electronics, aircraft, and medical devices. In EVs, these heaters help manage the temperature of batteries and power systems, especially in Europe and China.

Furnaces, particularly high-temperature and tube types, are essential for developing advanced materials, making semiconductors, and producing aerospace components. There is a clear global trend toward

switching from gas-based to electric furnaces, especially in Europe and North America, to meet climate goals and improve energy efficiency.

Heating Conductors are a smaller but important part of the market. They are critical for building and repairing heating systems. Nickel-Chromium (NiCr) conductors lead global trade due to their strong, stable performance in tough conditions. In Asia, Iron-Chromium-Aluminium (FeCrAl) types are also widely used, offering a good balance of high-temperature capability and cost-efficiency.

Exhibit 4.17: Global Heating Solutions Market — Sub-Segmentation with Applications, CY2024

CATEGORY	SUB-SEGMENT	% SHARE WITHIN CATEGORY	KEY GLOBAL END-USE APPLICATIONS
Heaters (45%)	Process heaters	27%	Large-scale industrial processes like drying, curing, melting, chemical processing, and heat treatment.
	Tubular heaters	21%	Air heating, surface heating, ovens, packaging machinery, plastics processing, and general industrial heating.
	Immersion heaters	18%	Heating liquids and gases in water tanks, oil heaters, chemical baths, HVAC systems, and boilers.
	Flexible Heaters & Others	16%	Freeze protection, medical devices, aerospace, electronics, semiconductor manufacturing, and heating irregular surfaces
	Band Heaters	10%	Plastics extrusion, injection molding, pipe heating, packaging machinery, and sealing applications.
	Cartridge Heaters	8%	Mold heating, die heating, packaging machinery, food processing, and precision heating applications.
Furnaces (40%)	Electric Laboratory Furnaces	22%	Research labs, educational institutions, material testing, quality control, small-batch thermal processing.
	Electric Process Furnaces	57%	Industrial heat treatment, melting, annealing, sintering in steel, automotive, ceramics, glass, chemical sectors.
	Special Furnaces	21%	Vacuum furnaces, induction furnaces, controlled atmosphere processes in aerospace, electronics, specialty metals.
Heating Conductors (15%)	NiCr Wire/Ribbon/Strip/Coil	61%	Aerospace-grade resistive heating, domestic and industrial heaters, and global furnace element manufacturing
	FeCrAl Wire/Ribbon/Strip/Coil	39%	High-temp applications in furnaces, toasters, infrared emitters, the nuclear and space industry

4.3.6 Heating solution: Key Growth Drivers, Trends, Investment Trends (Global)

G. Growth Drivers

The global heating solutions market is witnessing renewed momentum, driven by a combination of policy shifts, industrial modernisation, decarbonization efforts, and regional infrastructure development. As of

early 2025, several factors are influencing sustained demand growth across both developed and emerging economies.

Industrial Decarbonization and Electrification

Governments and industries worldwide are investing in electrified heating solutions to decarbonise industrial processes, especially in sectors like chemicals, steel, glass, and food processing.

- For instance, the European Union's RePower EU initiative, updated in late 2024, explicitly allocates 2.5 billion Euros towards clean industrial heat technologies, including electric resistance heaters and induction furnaces, to reduce fossil fuel dependence in process industries.
- In the U.S., the Department of Energy's Industrial Efficiency and Decarbonization Office (IEDO) launched a USD 350 million funding round in Q4 2024 for pilot projects using advanced electric heating systems in thermal-intensive sectors like ceramics and foundries.

These policies are directly pushing industries to replace conventional fossil fuel-based furnaces with high-efficiency electric and hybrid solutions.

Surge in Renewable-Integrated Heating Systems

The integration of heating equipment with renewable sources, such as solar thermal or green hydrogen, is becoming a defining characteristic of next-generation heating solutions.

- In Japan, several district-level projects in late 2024 started combining solar thermal collectors with thermal storage systems for space and industrial heating. The Japanese government earmarked Yen 100 billion (approx. USD 690 million) for such systems in its Green Innovation Fund.
- In Germany, industrial furnace makers like SMS Elotherm reported a 24% Y-o-Y increase in orders for hybrid electric/hydrogen-compatible furnaces by Q4 2024, as steel manufacturers prepare for future hydrogen availability.

Upgrades and Retrofitting of Ageing Industrial Infrastructure

In regions like North America and Western Europe, many industrial plants built before the 1990s are now undergoing heating system retrofits to meet both safety and energy-efficiency standards.

- In Canada, the Net Zero Accelerator fund (CAD 8 billion) has prioritised the retrofitting of heating and thermal systems in the metal and pulp & paper sectors. By early 2025, nearly 34 major facilities had applied for support to replace outdated gas-fired furnaces with advanced modular electric heaters.
- The UK's Industrial Energy Transformation Fund (IETF) also reported a 30% rise in heating system retrofit applications between Q3 and Q4 2024, mostly from SMEs in chemicals and plastics

Stringent Energy Efficiency Norms and Thermal Safety Standards

Evolving regulations around thermal efficiency, workplace safety, and emissions are compelling industries to upgrade or replace existing heating infrastructure.

- The IEC and ISO standards for industrial heating systems were revised in late 2024 to include higher minimum efficiency benchmarks for electric heaters and furnaces.
- Countries like South Korea and Australia introduced new mandatory efficiency labelling and thermal hazard control norms for industrial heating equipment beginning January 2025.

H. Trends

Electrification of Industrial Heating Systems

- Electric heating solutions are preferred over fossil-fuel-based systems due to better control, energy efficiency, and alignment with net-zero goals.
- Markets like Germany, the Netherlands, and Japan have introduced tax incentives for transitioning from gas heaters to electric induction systems.

Integration of Smart & IoT-enabled Heating Systems

- Growth in adoption of predictive maintenance and cloud-connected heating units in process industries.
- Example: Honeywell Thermal Solutions launched its Smart Combustion platform in October 2024, offering real-time analytics for furnaces and heaters.

Rapid Uptake in Emerging Markets (Asia Pacific, LATAM)

- Countries like India, Vietnam, and Brazil are witnessing a surge in industrial capacity expansions, leading to higher heating solution adoption.
- Example: Tata Steel's expansion in Odisha and Vedanta's aluminium plant upgrades both include large-scale high-temperature furnace installations.

Focus on Sustainability and Circular Economy

- Heat recovery systems and low-waste furnaces are gaining traction. Some heating manufacturers are adopting closed-loop systems for thermal applications.
- Example: Kanthal, part of Sandvik, introduced a new sustainable heating element made from 80% recycled materials in Q4 2024.

I. Investment Trends

The global heating solutions industry has witnessed a wave of strategic investments over the past year, driven by the urgent need to decarbonise industrial operations, adopt energy-efficient technologies, and support growing demand from high-temperature sectors like metals, chemicals, EV manufacturing, and semiconductors. Leading global players are investing heavily in expanding production capacity, setting up smart manufacturing facilities, and developing sustainable electric heating systems.

These investments span geographies — from North America and Europe to Asia — and reflect a robust confidence in the long-term demand for industrial heaters, furnaces, and thermal systems. The table below highlights some of the most significant investments made between late 2024 and early 2025.

Exhibit 4.18: Recent Global Investments in the Heating Solutions Sector

COMPANY	COUNTRY	INVESTMENT	PURPOSE	DATE
Air Liquide	USA	USD 1,200 Million	Green hydrogen facilities using industrial heaters	Jan 2025
Bosch Thermotechnology	Germany	USD 385 Million	Smart electric heating system R&D and production	Dec 2024
Tata Steel	India	USD 215 Million	Expansion of blast furnace and heating infrastructure in Odisha	Nov 2024
Thermon Group	USA	USD 80 Million	Expanding industrial heating production in Texas	Dec 2024

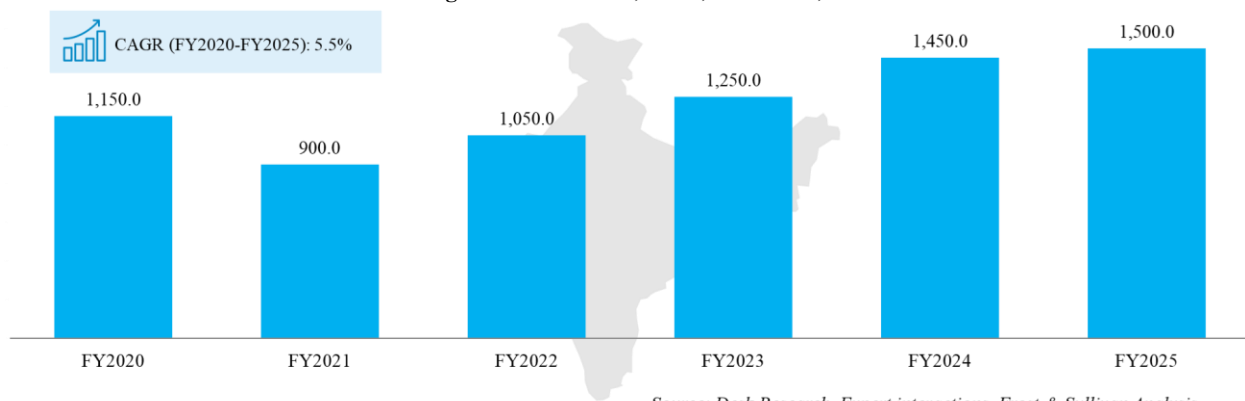
Danfoss	Denmark/China	USD 132 Million	New electric heating tech plant in Tianjin, China	Oct 2024
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4.4 Heating Solutions: India Market

Between FY2020 and FY2025, the Indian market for electrifiable heating solutions is estimated to have grown from about INR 1,150 crore in FY2020 to roughly INR 1,500 crore in FY2025, implying a modest 5.5% CAGR. Growth was uneven: FY2020 reflected a steady pre-pandemic base of around INR 1,150 crore. FY2021 saw a sharp contraction to nearly INR 900 crore as COVID-19 delayed CAPEX projects and slowed industrial activity. A gradual recovery began in FY2022, with the market rebounding to about INR 1,050 crore as postponed maintenance and small replacements restarted. By FY2023, demand reached roughly INR 1,250 crore, supported by the resumption of brownfield expansions and a nascent interest in electrified systems in segments such as chemicals and food processing. FY2024 showed stronger momentum at about INR 1,450 crore as supply chains stabilised, fuel prices became more volatile, and several process industries began pilot deployments of electric boilers and heaters.

Despite this recovery, the overall level of electrification remained low through FY2025. Industrial electricity tariffs were still relatively high compared with natural gas and liquid fuels, and large-capacity electric process-heating technologies were only beginning to mature. Most end users preferred conventional combustion-based equipment for major projects, reserving electric solutions for niche or small-load applications. Policy support for industrial decarbonization was limited, and the reliability of power supply in certain clusters also discouraged adoption. Consequently, replacement demand dominated the market in these years, while CAPEX-driven electrified systems saw slower uptake.

Exhibit 4.19: Heating solutions market, India, in INR Cr, FY2020 – FY2025



Source: Desk Research, Expert interactions, Frost & Sullivan Analysis

4.5 Heating Solutions: India Sector Outlook

The industrial heating market in India is expanding steadily, driven by modernisation, energy efficiency, and the replacement of ageing equipment across sectors such as oil & gas, metals, chemicals, and emerging industries. Demand is shaped by process-critical applications requiring precise and reliable heating, as well as growing regulatory and safety standards. Opportunities exist for advanced, customizable, and efficient heating technologies, reflecting India's shift toward sustainable and optimised industrial processes. In line with India's Atmanirbhar Bharat mission and government programs such as Make in India, Production Linked Incentive (PLI) schemes, and the Defence Indigenisation Policy, Tempsons has been actively engaged in indigenisation initiatives with leading government companies in sectors such as steel, power, and defence. Also, Tempsons' backwards-integrated manufacturing capabilities make them one of the few companies in India with this degree of operational integration as of March 2025. Defence indigenisation policies are pushing local manufacturing of critical systems.

4.5.1 Refinery Sector: Growth Drivers and Outlook

India's refinery sector continues to grow, driven by rising domestic fuel consumption, expanding petrochemical feedstock demand, and government incentives to upgrade downstream infrastructure. CAPEX data indicates that high-capex projects, such as IOCL's Panipat expansion (15→25 MMTPA, CAPEX INR 38,231 Cr) and Gujarat/Koyali expansions, dominate the landscape, accounting for ~60% of the heating investments, with low-capex units contributing the remainder. The strategic focus on high-complexity units, including CDUs, VDUs, FCCUs, hydrocrackers, and reformers, reflects India's push for cleaner fuel production. Looking forward, refinery modernisation is expected to accelerate, with electrifiable heating and energy-efficient systems playing a critical role in meeting environmental norms while ensuring operational reliability.

Exhibit 4.20: List of upcoming refinery projects, India, FY2026E – FY2031E

PROJECT	OWNER	CAPACITY ADDITION (MMTPA)	CAPEX (INR CR)
Panipat expansion (15→25)	IOCL	10	38,231
Gujarat/Koyali expansion (13.7→18)	IOCL	4	18,936
Numaligarh expansion (3→9)	NRL	6	28,026
Rajasthan/Barmer greenfield (9)	HRRL	9	71,814
Barauni expansion (6→9)	IOCL	3	16,724
Bina expansion + petchem (7.8→11)	BPCL	3	48,926
Nagapattinam greenfield (9)	CPCL	9	36,354
Total		44	259,011

Source: Desk Research, Frost & Sullivan Analysis

4.5.2 Petrochemical Sector: Growth Drivers and Outlook

The Indian petrochemical industry is entering a strong growth phase, supported by rising domestic demand for polymers, government-led 'substitution policies, and the development of large-scale integrated coastal complexes. India has historically been dependent on imports for a wide range of polymers, intermediates, and speciality chemicals; however, the current wave of investments is aimed at bridging this gap by enhancing domestic self-sufficiency and reducing trade deficits. Heating applications in this sector are wide-ranging and energy-intensive, covering cracking furnaces, reformers, polymerisation units, distillation systems, and process heat exchangers. These processes are critical to producing high-value products such as polyethylene, polypropylene, and other derivatives that serve as raw materials for packaging, textiles, automotive, and construction industries.

CAPEX analysis highlights that high-capex greenfield facilities dominate the current investment pipeline. Large projects such as the Haldia Cuddalore complex (CAPEX of INR 19,181 crore) and the Kakinada SEZ cracker (CAPEX of INR 32,000 crore) reflect the industry's preference for scale-driven complexes, which integrate feedstock flexibility, refining, and petrochemical operations to capture higher margins. These high-capex plants are capital-intensive due to the requirement of large cracking furnaces and distillation trains, but they are designed to achieve world-scale production efficiencies and global competitiveness. At the same time, low-capex expansions, debottlenecking exercises, and downstream unit additions are being

undertaken to optimize existing capacity, improve process flexibility, and expand product portfolios. Together, this dual track of high-capex greenfield projects and low-capex incremental expansions indicates an industry that is simultaneously scaling up and fine-tuning operations.

Exhibit 4.21: List of upcoming Petrochemical projects, India, FY2026E – FY2031E

PROJECT NAME	TYPE	TARGET COMMISSIONING	CAPEX (INR CR)
VADODARA DEBOTTLENECKING & EXPANSION	Expansion	FY2026	2,270
Lepetkata Expansion	Expansion	FY2027	387
Haldia Cuddalore Complex	Greenfield	FY2027	19,181
Haldia Balasore Complex	Greenfield	FY2028	42,623
Hazira Debottlenecking & Expansion	Expansion	FY2028	10,000
Panipat Naphtha Cracker + HDPE	Expansion	FY2029	5,595
Kakinada SEZ Cracker (Greenfield)	New Unit	FY2031	32,000
Nanavali (Dighi Port) Complex	New Unit	FY2031	2,274
Paradip PCPIR Project	New Unit	FY2031	3,511
Total			117,841

Source: Desk Research, Frost & Sullivan Analysis

The sector's outlook remains robust over the medium to long term, underpinned by continued growth in polymer consumption, a strong policy push for “Atmanirbhar Bharat” (self-reliant India), and India's evolving role as a global manufacturing hub. With per capita polymer consumption in India still significantly below global averages, demand is expected to remain resilient, creating opportunities for sustained capacity expansion. Over time, the sector will also be shaped by sustainability imperatives, with companies increasingly exploring energy efficiency, circular economy initiatives, and greener feedstock integration, further strengthening the industry's long-term prospects.

4.5.3 Fertiliser Sector: Growth Drivers and Outlook

The Indian fertiliser sector is a critical pillar for food security and agricultural productivity, and its expansion is driven by strong government support, rising demand for urea and complex fertilisers, and policies aimed at modernising outdated facilities. Growth is fueled by initiatives to enhance crop yields, revamp legacy plants, and promote energy-efficient, environmentally compliant production methods. Within this context, heating applications remain indispensable across ammonia synthesis, syngas reforming, urea granulation, and high-capacity steam generation—processes that require stable, high-intensity heat. CAPEX analysis reveals a balanced pipeline of brownfield revivals and greenfield nano urea plants, with high-capex projects contributing around 60% of total heating investments. This share is important because larger, high-capex facilities present greater opportunities for electrifiable heating, particularly in reformers and steam systems, which are traditionally fossil-fuel-fired. The electrifiable heating opportunity is concentrated in areas such as syngas reforming and large steam generation, where electric alternatives could feasibly replace conventional heaters and boilers. Projects such as the Namrup. IV Ammonia-Urea Plant (CAPEX of INR 10,000 crore) and the Vidarbha Fertiliser Plant exemplify these opportunities, because their scale and process intensity make them suitable candidates for adopting such technologies in the future. The sector outlook is stable, with steady growth supported by India's structural dependence on fertilisers and continued government intervention. Looking ahead, the opportunity lies in

the gradual adoption of low-carbon and electrifiable heating solutions, which, if realised, would enhance energy efficiency, reduce emissions, and future-proof fertiliser production against tightening environmental norms.

Exhibit 4.22: List of upcoming Fertiliser projects, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	TYPE	COMMISSIONING FY	CAPACITY (MMTPA)	CAPEX (INR CR)
Namrup IV Ammonia-Urea Plant	Assam	Brownfield	FY28	1.27	10,000
Vidarbha Fertilizer Plant	Maharashtra	Greenfield	FY29	1.27	10,000
Thal Plant Expansion	Maharashtra	Expansion	FY29	0.5	4,000
Deoghar Nano Urea Plant	Jharkhand	Greenfield	FY30	0.5	4,000
Sindri Plant Revival	Jharkhand	Brownfield	FY30	0.5	4,000
Gorakhpur Plant Revival	UP	Brownfield	FY30	0.5	4,000
Barauni Plant Revival	Bihar	Brownfield	FY30	0.5	4,000
Talcher Fertilizer Plant	Odisha	Greenfield	FY31	1.27	10,000
HURL Barauni	Bihar	Brownfield	FY31	0.5	4,000
HURL Sindri	Jharkhand	Brownfield	FY31	0.5	4,000
HURL Gorakhpur	UP	Brownfield	FY31	0.5	4,000
HURL Talcher	Odisha	Brownfield	FY31	0.5	4,000
Total				8.31	66,000

Source: Desk Research, Frost & Sullivan Analysis

4.5.4 Metals & Steel Sector: Growth Drivers and Outlook

India's metals and steel sector, a cornerstone of industrial growth, is poised for significant expansion driven by infrastructure, urbanization, automotive, engineering, and renewable energy demand, supported by "Make in India" and the National Infrastructure Pipeline. With current capacity of about 160 MTPA, the industry targets ~300 MTPA by FY2030E under the National Steel Policy. Heating processes—blast furnaces, basic oxygen and electric arc furnaces, reheating mills, and heat-treatment units—remain among the largest sources of industrial thermal demand. A strong pipeline of projects underlines growth momentum: JSW Steel's Dolvi expansion (5 MTPA, INR 12,000 Cr), SAIL's IISCO upgrade at Burnpur (4.5 MTPA, INR 7,500 Cr), NMDC's Nagarnar greenfield plant (3 MTPA, INR 25,500 Cr), and JSW's Utkal and Kadapa units (1 MTPA each, INR 5,000 Cr). At the top end, JSW's proposed Gadchiroli facility (25 MTPA, INR 1,00,000 Cr) represents one of India's largest private investments, while ArcelorMittal's Hazira upgrade (2 MTPA, INR 5,000 Cr) and BC Jindal's Odisha project (INR 1,500 Cr) add breadth. Collectively, these initiatives represent ~59 MTPA of fresh capacity and over INR 166,500 Crores of capital expenditure by FY2030E, balancing large integrated greenfield facilities with brownfield modernisation and energy-efficiency programs. Rising domestic consumption, supportive policy measures, and growing adoption of sustainable technologies—such as scrap-based electric arc furnaces, efficiency upgrades, and early hydrogen-DRI pilots—position India to meet its internal demand while strengthening its competitiveness in global steel markets.

Exhibit 4.23: List of upcoming Metal & Steel projects, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	TYPE	COMMISSIONING FY	CAPACITY ADDITION (MMTPA)	CAPEX (INR CR)
JSW Dolvi Expansion	Dolvi, Maharashtra	Expansion	FY27	5.00	12,000
SAIL IISCO Expansion	Burnpur, West Bengal	Expansion	FY27	4.50	7,500
JSW Utkal Steel Plant	Paradeep, Odisha	Greenfield	FY28	1.00	5,000
JSW Kadapa Steel Plant	Kadapa, Andhra Pradesh	Greenfield	FY28	1.00	5,000
ArcelorMittal Hazira Expansion	Hazira, Gujarat	Expansion	FY28	2.00	5,000
NMDC Nagarnar Steel Plant	Jagdarpur, Chhattisgarh	Greenfield	FY29	3.00	25,500
JSW BPSL Potka Plant	Potka, Jharkhand	Greenfield	FY29	1.00	5,000
BC Jindal Odisha Facility	Odisha	Greenfield	FY26	0.00	1,500
JSW Gadchiroli Integrated Plant	Gadchiroli, Maharashtra	Greenfield	FY29	25.00	100,000
SAIL Vision 2030	Pan-India	Expansion	FY30	16.14	0
Total				58.64	166,500

Source: Desk Research, Frost & Sullivan Analysis

Note: We had included project details that are available in public domain from reliable sources

4.5.5 Cement Sector: Growth Drivers and Outlook

India's cement sector is set for sustained growth on the back of urbanisation, housing demand, and government infrastructure spend (roads, rail, smart cities). Production is highly energy-intensive, with clinkerisation and rotary kilns driving most of the thermal load, making efficiency a key lever for cost and emissions.

Exhibit 4.24: List of upcoming Cement projects, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	TYPE	COMMISSIONING FY	CAPACITY ADDITION (MTPA)	CAPEX (INR CR)
UltraTech Expansion	Multiple Locations	Expansion	FY26	18	10,000
Nuvoco Vistas Expansion	Eastern India	Expansion	FY26	4	200
Shree Cement Expansion	Rajasthan	Expansion	FY27	3	2,000
Ramco Cements Expansion	Tamil Nadu	Expansion	FY27	2	1,200
Dalmia Bharat Expansion	Odisha	Expansion	FY28	2	1,200
Total			FY26–28	29	14,600

Source: Desk Research, Frost & Sullivan Analysis

Capacity addition remains robust: UltraTech's 18 MTPA project exemplifies large-scale, tech-enabled expansion, while players like Nuvoco Vistas focus on low-capex upgrades and grinding-unit debottlenecking. Together, these strategies aim to meet rising consumption while improving fuel use and environmental performance.

Despite being among the world's biggest producers, India's per-capita cement use is well below global averages, supporting a long runway for demand. Over FY25-30, the sector is expected to balance scale-up, process efficiency, alternative fuels, and decarbonisation, reinforcing its role in India's industrial and infrastructure build-out.

4.5.6 Emerging / Green Hydrogen Sector: Growth Drivers and Outlook

India's green hydrogen sector is emerging as a pillar of the clean-energy transition, supported by the National Hydrogen Mission, decarbonisation goals in steel, refining and fertilisers, and export opportunities. Hydrogen production is energy-intensive, with electrolyzers, feed-water heating, compression and storage requiring reliable thermal systems — creating opportunities for efficient heating solutions. Investments are gathering pace, with about INR 18,500 crore of capital expenditure expected between FY2027 and FY2029 across large industrial hubs and pilot projects. Major commitments include L&T Energy Green Tech and Waaree Clean Energy (INR 3,600 crore each, Gujarat), AM Green Ammonia (INR 4,000 crore, Andhra Pradesh) and Reliance's green hydrogen hub (INR 2,000 crore). Mid-scale and pilot plants – such as GH2 Solar (INR 420 crore) and Matrix Gas (INR 80 crore) – are testing technologies and building operating expertise. Another INR 6,000 crore pipeline for FY2030–FY2031 points to integrated, high-CAPEX complexes combining renewable power with hydrogen production.

Exhibit 4.25: List of upcoming projects in Emerging Markets, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	COMMISSIONING FY	CAPACITY ADDITION (MTPA)	CAPEX (INR CR)
Oriana Power Ltd	Rajasthan (est.)	FY27E	0.01	400
Suryadeep KA1 Project Pvt Ltd	Karnataka (est.)	FY27E	0.019	760
L&T Energy Green Tech Ltd	Gujarat (est.)	FY28E	0.09	3,600
GH2 Solar Pvt Ltd	Tamil Nadu (est.)	FY27E	0.0105	420
Green Infra Renewable Energy Farms Pvt Ltd	Gujarat (est.)	FY28E	0.09	3,600
Waaree Clean Energy Solutions Pvt Ltd	Gujarat (est.)	FY28E	0.09	3,600
AM Green Ammonia (India) Pvt Ltd	Andhra Pradesh (est.)	FY29E	0.09	4,000
Reliance Green Hydrogen & Green Chemicals Ltd	Gujarat	FY29E	0.049	2,000
Matrix Gas and Renewables Ltd	Maharashtra (est.)	FY27E	0.0015	80
Total			0.45	18,460

Source: Desk Research, Frost & Sullivan Analysis

Note: Inclusion of est. means that the project's location has been indicated or proposed, but it has not yet been formally confirmed, announced, or finalised.

The outlook for the green hydrogen sector in India is highly favourable, backed by clear policy direction, global partnerships, and a fast-maturing ecosystem of domestic and international investors. Over the next decade, growth is expected to accelerate as industrial clusters adopt hydrogen as a replacement for fossil fuels, export-oriented projects gain traction, and technology costs decline with scale. India's vast renewable energy base offers a competitive advantage in producing cost-effective green hydrogen, strengthening the long-term potential of the sector. As a result, green hydrogen is expected to play a central role in India's decarbonization strategy, while also creating new industrial opportunities and export revenues.

4.5.7 Defence Sector: Growth Drivers and Outlook

The Indian defence sector is witnessing increasing investments in sustainable infrastructure, driven by strategic priorities such as energy security, operational self-reliance, and net-zero building initiatives for military installations. As the armed forces expand and modernize, there is a growing emphasis on developing facilities that are energy-efficient, resilient, and capable of functioning in remote or challenging environments. Heating and thermal systems play a key role in this context, particularly for accommodation, kitchens, workshops, and operational support buildings, ensuring habitability, equipment functionality, and process continuity in extreme climates.

CAPEX trends in FY2026- FY2027 highlight a mix of high-capex and pilot initiatives, reflecting a phased approach to modernization. Flagship projects such as the Geothermal-Based Net Zero Energy Building in Jhansi demonstrate large-scale commitment to sustainable infrastructure, integrating innovative thermal and energy systems to reduce operational costs and environmental footprint. Concurrently, smaller pilot installations, such as solar-heated shelters in Ladakh, are being deployed to validate technology performance, train personnel, and build operational experience before scaling up to larger bases. This dual approach underscores a strategy of cautious innovation combined with strategic scaling.

Exhibit 4.26: List of upcoming projects in Defence sector, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	TYPE	COMMISSIONING FY	CAPEX (INR CR)
Geothermal-Based Net Zero Energy Building	Jhansi, UP	Greenfield	FY26	2,083
Solar Heating for Ladakh Shelters	Ladakh	Pilot	FY27	2,083
Total				4,166

Source: Desk Research, Frost & Sullivan Analysis

The outlook for defence infrastructure is steady and promising, supported by India's focus on sustainable, self-reliant military facilities. Over the medium term, investments are expected to continue in modernizing barracks, workshops, and logistical hubs, with energy efficiency and renewable integration forming key priorities. These developments not only enhance operational readiness and resilience but also contribute to India's broader sustainability goals, positioning the defence sector as a pioneer in deploying modern, low-carbon infrastructure across critical national installations.

4.5.8 Glass Industry: Growth Drivers and Outlook

India's glass industry is modernising to meet growing demand from construction, automotive, solar, electronics, and packaging. As an energy-intensive sector, efficient furnaces and heating systems are vital for quality, cost control, and decarbonisation. Planned CAPEX of about INR 5,150 crore between FY2026E and FY2031E reflects a clear split between energy-efficiency retrofits and capacity expansion. Notable projects include Asahi India Glass's green hydrogen pilot (INR 200 crore, FY2026E) and waste-heat recovery plan (INR 300 crore, FY2027E), Saint-Gobain's INR 1,200 crore float glass addition at Bhiwadi (FY2028E), Borosil Renewables' INR 950 crore solar-glass expansion in Gujarat (FY2031E), and Gold Plus Glass's INR 2,500 crore greenfield float and solar-glass plant in Karnataka (FY2029E).

These investments point to a dual focus: retrofits that cut energy use and emissions, and large-scale plants to capture fast-rising domestic and export demand. Supported by steady industrial growth, urbanisation, and energy-efficient practices, the sector is poised for moderate growth while balancing scale, cost competitiveness, and sustainability.

Exhibit 4.27: List of upcoming projects in Glass Industry, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	TYPE	COMMISSIONING FY	CAPEX (INR CR)
Asahi India Glass – Green Hydrogen Integration	Soniyana, Chittorgarh, Rajasthan	Retrofit (Decarbonization pilot)	FY2026	200
Asahi India Glass – Waste Heat Recovery (2 lines)	Multiple locations	Retrofit	FY2027	300
Saint-Gobain Float Glass Expansion	Bhiwadi, Rajasthan	Brownfield / Expansion	FY2028	1,200
Gold Plus Glass – Karnataka Float & Solar Glass Plant	Belgaum, Karnataka	Greenfield	FY2029	2,500
Borosil Renewables – Solar Glass Expansion	Gujarat	Brownfield	FY2031	950
Total			FY2026E – FY2031E	5,150

Source: Desk Research, Frost & Sullivan Analysis

4.5.9 Chemical Industry: Growth Drivers and Outlook

The Indian chemical sector is experiencing steady growth, driven by rising domestic demand for polymers, specialty chemicals, and downstream products, as well as policies promoting import substitution and local manufacturing. Key drivers include expanding pharmaceutical, agrochemical, and industrial applications, which increase the need for high-quality chemical intermediates and specialty products. Thermal processes, such as reactors, distillation units, dryers, and steam generation systems, are central to production efficiency, product quality, and operational reliability, making effective heating solutions a critical part of both new plants and modernization initiatives.

CAPEX trends in FY2026 reflect a balanced approach between high-capex retrofits and smaller low-capex projects. Large-scale retrofits and greenfield units allow the integration of advanced thermal management technologies and process optimization, improving energy efficiency and throughput, while low-capex projects focus on incremental upgrades in smaller units to maintain competitiveness and flexibility. Illustrative projects, such as retrofitting thermal battery systems and upgrading process heaters and reactors, demonstrate the sector's ongoing commitment to operational efficiency and energy optimization.

Exhibit 4.28: List of upcoming projects in Chemical Sector, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	TYPE	COMMISSIONING FY	CAPEX (INR CR)
Thermal Battery Systems for Chemical Plants	Various Locations	Retrofit	FY26	2,500
Total				2,500

Source: Desk Research, Frost & Sullivan Analysis

The sector outlook remains favorable, supported by sustained industrial growth, expanding domestic demand, and government policies promoting chemical manufacturing. Over the medium term, continued investment in process optimization, modernization, and energy-efficient operations is expected, enabling chemical manufacturers to improve productivity, maintain product quality, and strengthen their position in domestic and global markets. The sector is set to grow steadily, with operational efficiency and sustainability at the core of future expansion.

4.5.10 Power Sector: Growth Drivers and Outlook

The Indian power sector is entering a phase of accelerated growth, underpinned by rising electricity demand across residential, commercial, and industrial segments, and reinforced by strong government support for capacity expansion and cleaner technologies. Rapid urbanization, industrial expansion, and rural electrification continue to fuel demand, while policy frameworks such as the National Electricity Policy and targeted programs for high-efficiency generation and nuclear energy integration provide long-term direction.

Heating and thermal systems—including boilers, heat recovery steam generators (HRSGs), preheaters, and reheaters—remain integral to efficiency and reliability across both conventional and advanced plants. Between FY2026E and FY2031E, planned CAPEX of nearly INR 238,000 crore signals a highly diversified investment pipeline comprising supercritical and ultra-supercritical thermal projects, gas-based expansions, waste-to-energy facilities, and a new wave of nuclear capacity additions.

On the thermal front, Odisha and Chhattisgarh are set to host large-scale greenfield plants, with CAPEX of INR 20,000 crore (supercritical, FY2026) and INR 22,000 crore (ultra-supercritical, FY2027), respectively. These projects reflect India's continued emphasis on high-efficiency coal-based power to meet baseload requirements. In Gujarat, a brownfield gas-based HRSG expansion (INR 6,000 crore, FY2028) demonstrates a shift toward flexible, lower-carbon capacity, while Maharashtra's INR 18,500 crore retrofit of a supercritical plant (FY2030E) underscores the industry's focus on modernizing and extending the life of existing assets. Waste-to-energy initiatives are also emerging, with notable projects in Delhi NCR (INR 2,000 crore, FY2029) and Karnataka (INR 3,500 crore, FY2031, including district heating integration).

Exhibit 4.29: List of upcoming projects in Power Sector, India, FY2026E – FY2031E

PROJECT NAME	LOCATION	TYPE	COMMISSIONING FY	CAPEX (INR CR)
Supercritical Thermal Power Plant Boiler Systems	Odisha	Greenfield	FY26	20,000
Ultra-Supercritical Thermal Power Plant	Chhattisgarh	Greenfield	FY27	22,000
Gas-Based Power Plant (Expansion HRSG Units)	Gujarat	Brownfield	FY28	6,000
Waste-to-Energy Plant	Delhi NCR	Greenfield	FY29	2,000
Supercritical Thermal Plant (Replacement / Retrofit)	Maharashtra	Retrofit	FY30	18,500
Waste-to-Energy + District Heating Project	Karnataka	Greenfield	FY31	3,500
Kudankulam Nuclear Power Project (Units 5 & 6)	Tamil Nadu	Nuclear (PHWR)	FY29	50,000
Gorakhpur Nuclear Power Project (Units 1 & 2)	Haryana	Nuclear (PHWR)	FY30	23,000
Chutka Nuclear Power Project (Units 1 & 2)	Madhya Pradesh	Nuclear (PHWR)	FY31	25,000
Kaiga Nuclear Expansion (Units 5 & 6)	Karnataka	Nuclear (PHWR)	FY31	18,000
Mahi Banswara Nuclear Project (Units 1–4)	Rajasthan	Nuclear (PHWR)	FY32	50,000
Total			FY2026E – FY2031E	238,000

Source: Desk Research, Frost & Sullivan Analysis

The most significant addition to the sector comes from nuclear power, where India is scaling up its Pressurized Heavy Water Reactor (PHWR) fleet to strengthen long-term energy security. Flagship projects

include Units 5 & 6 of Kudankulam in Tamil Nadu (INR 50,000 crore, FY2029), the Gorakhpur project in Haryana (INR 23,000 crore, FY2030), the Chutka project in Madhya Pradesh (INR 25,000 crore, FY2031), and the Kaiga expansion in Karnataka (INR 18,000 crore, FY2031). The Mahi Banswara project in Rajasthan, with four reactors and a CAPEX of INR 50,000 crore (FY2032), represents one of the largest nuclear investments in India to date.

This investment pipeline reflects a balanced strategy: advancing cleaner coal and gas-based efficiency, scaling up waste-to-energy projects, and substantially expanding nuclear capacity. Together, these developments will not only meet India's growing electricity needs but also enhance grid reliability, diversify the generation mix, and reduce long-term carbon intensity.

The sector outlook remains highly favorable, supported by sustained demand growth, strong policy backing, and technology-driven improvements across thermal, nuclear, and renewable-linked projects. Over the medium to long term, the combination of high-efficiency thermal systems, flexible gas capacity, waste-to-energy initiatives, and a major expansion of nuclear power positions India's electricity sector for robust, sustainable, and secure growth.

4.6 Demand potential for heating solutions in India

4.6.1 Methodology Adopted

Heating demand potential across sectors has been estimated using a consistent approach:

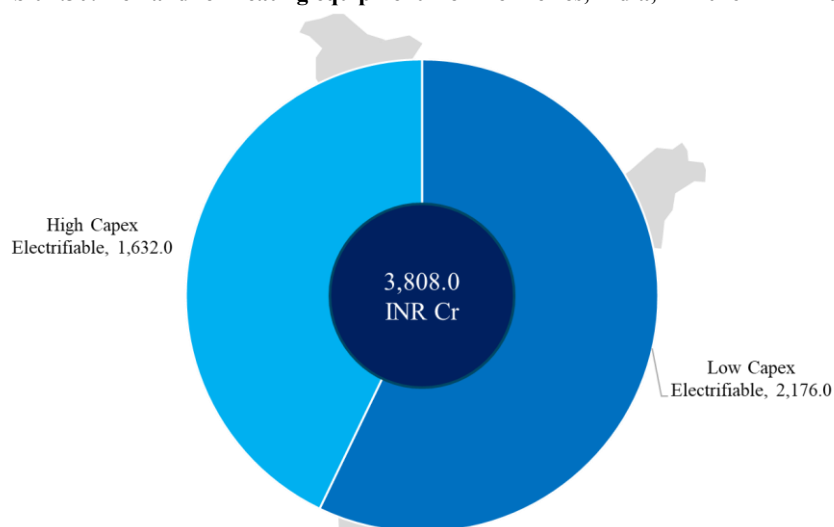
- Identify announced/ongoing CAPEX for FY2026E–FY2031E.
- Apply benchmark shares of heating equipment within total CAPEX (based on project data and industry norms).
- Segment into high- and low-capex systems, with corresponding Electrifiability factors.
- Aggregate to derive the electrifiable heating opportunity.
- Assumptions were validated against engineering benchmarks and discussions with industry participants.

4.6.2 Refineries

Planned refinery projects (Panipat, Gujarat, Numaligarh, Barmer, Barauni, Bina, Nagapattinam) involve INR 259,011 crore CAPEX through FY2031E, with ~7% (INR 18,132 crore) attributable to heating equipment such as fired heaters and reformers. Around 60% of this spend is high-capex, but only ~15% is electrifiable, while 30% of low-capex systems can transition to electric. The cumulative electrifiable potential is ~INR 3,800 crore, largely in auxiliary heaters and modular solutions, indicating gradual substitution of fuel-based systems.

In India, heating demand continues to be dominated by fossil fuels and steam-based systems, particularly in energy-intensive industries. However, mid-voltage electric solutions are beginning to emerge as viable alternatives, especially where efficiency, precision, and decarbonization are critical. Smaller heating systems are already proving easier to electrify, while larger, fuel-based systems—traditionally reliant on high-capacity heaters—could over time be replaced by modular, medium-voltage solutions.

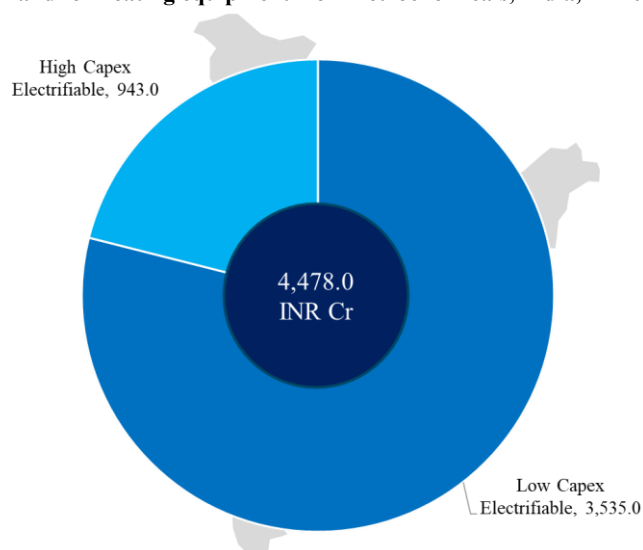
In this context, medium-voltage electric heating solutions, though still niche, represent a possible pathway for gradual substitution. Over time, these systems could complement conventional fuel-based units, especially in cases where modularity, operational efficiency, or emissions reduction targets become a priority. However, the overall electrification trajectory in Indian refineries is expected to be evolutionary rather than disruptive, reflecting the sector's reliance on established fuel and steam infrastructure.

Exhibit 4.30: Demand for heating equipment from refineries, India, FY2026E – FY2031E

Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

4.6.3 Petrochemicals

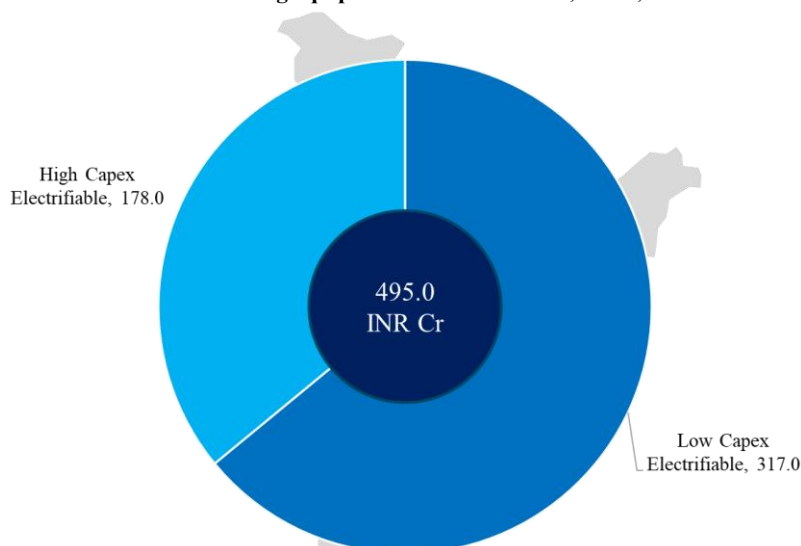
Nine cracker and polymer projects (FY2026E–FY2031E) represent INR 117,841 crore CAPEX, of which ~10% (INR 11,784 crore) is for heating. About 40% is high-capex (crackers/reformers) and 60% low-capex (polymerization). Electrification is higher in auxiliaries (50%) than large units (20%), giving ~INR 4,500 crore electrifiable demand. Growth is anchored in new crackers and polymer capacity, but large heaters remain fossil-reliant.

Exhibit 4.31: Demand for heating equipment from Petrochemicals, India, FY2026E – FY2031E

Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

4.6.4 Fertilisers

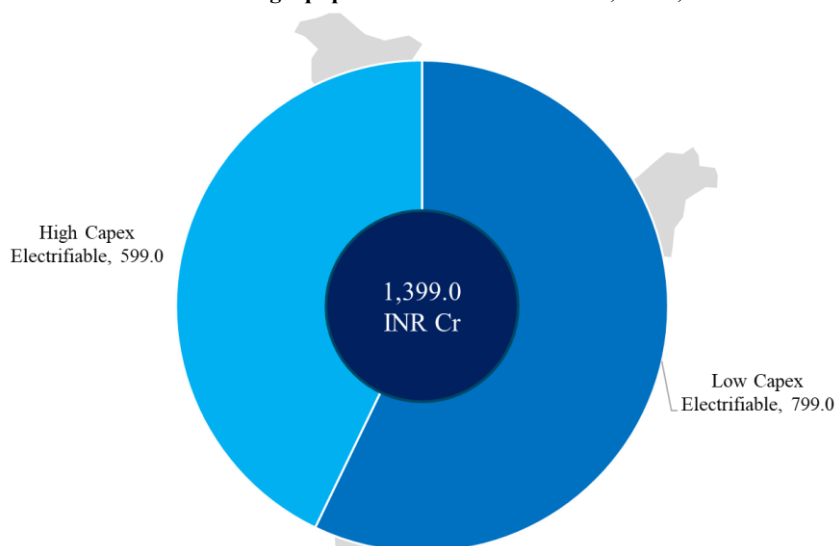
Twelve ammonia/urea projects worth INR 66,000 crore CAPEX allocate ~3% (INR 1,980 crore) to heating. High-capex synthesis units form 60% of spend, though only ~15% is electrifiable; auxiliaries offer ~40% potential. This yields INR 495 crore electrifiable demand, mostly from dryers and evaporation systems.

Exhibit 4.32: Demand for heating equipment from Fertilisers, India, FY2026E – FY2031E

Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

4.6.5 Metals & Steel

Nine integrated/brownfield steel projects (~INR 166,500 CAPEX) spend ~4% on heating (~INR 6,660 crore). Large furnaces dominate (60%) but are hard to electrify (15% potential), while ~30% of low-capex reheating/rolling systems are addressable. Overall electrifiable demand is ~INR 1,400 crore, mainly in modular lines and auxiliary units.

Exhibit 4.33: Demand for heating equipment from Metals & Steel, India, FY2026E – FY2031E

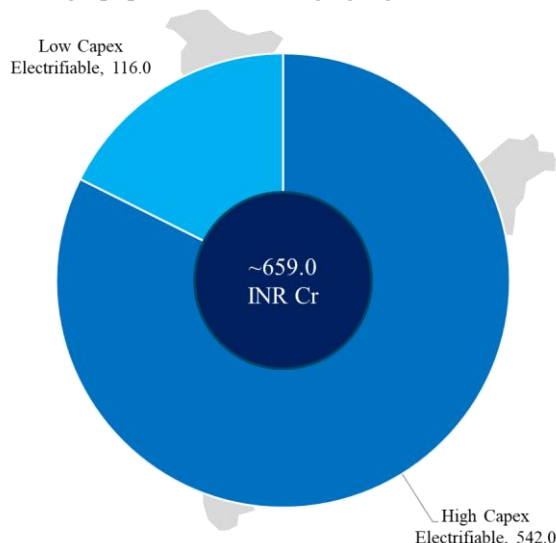
Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

4.6.6 Emerging Market Segment

Green hydrogen is emerging as a key pillar in India's clean energy push, supported by the National Hydrogen Mission and rising global demand for low-carbon fuels. Heating plays a critical role across electrolysis, hydrogen compression and storage, and ammonia synthesis, where reliable and efficient thermal systems drive cost competitiveness. The heating market in upcoming hydrogen projects between FY2026E and FY2031E is estimated at about INR 1,291 crore, with roughly 70% accounted for by high-capex primary process heaters and 30% by lower-capex systems such as feedwater and compression heaters.

Around INR 659 crore of this demand is electrifiable, creating opportunities for advanced electric heating solutions such as large-scale hubs and pilot facilities that come online.

Exhibit 4.34: Demand for heating equipment from Emerging segments market, India, FY2026E – FY2031E



Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

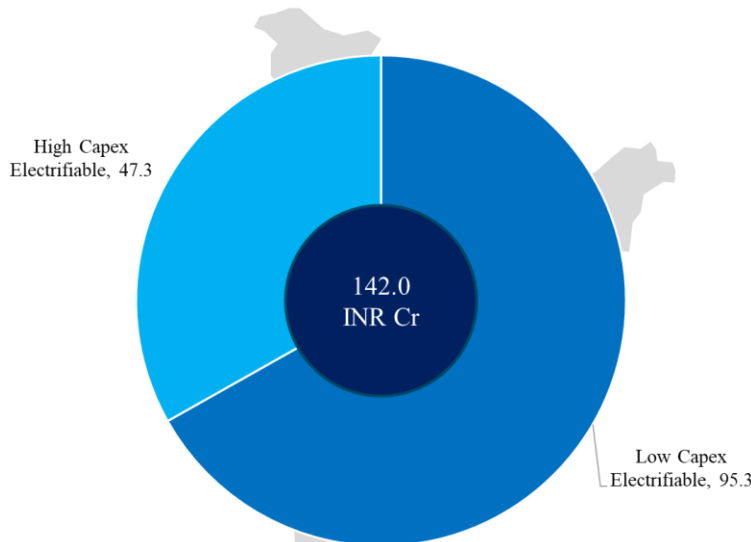
Step 5: Key Processes / Applications: These electrifiable heating solutions are relevant for processes such as electrolysis, hydrogen compression, storage, blending, ammonia synthesis (Haber-Bosch), and ammonia production, depending on the project.

4.6.7 Other Segments (Cement, Glass, Chemical, Defence)

Together, niche segments such as cement, defence, chemicals, and glass represent a modest but important pocket of opportunity for electrifiable heating in India.

- Cement remains the largest contributor, with about INR 76.65 Cr of electrifiable demand, driven mainly by auxiliary low-capex applications like grinding and storage systems where electric solutions can replace conventional fuels.

Exhibit 4.35: Demand for heating equipment from Other segments (Cement, Defence, Glass, Chemical), India, FY2026E – FY2031E



Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

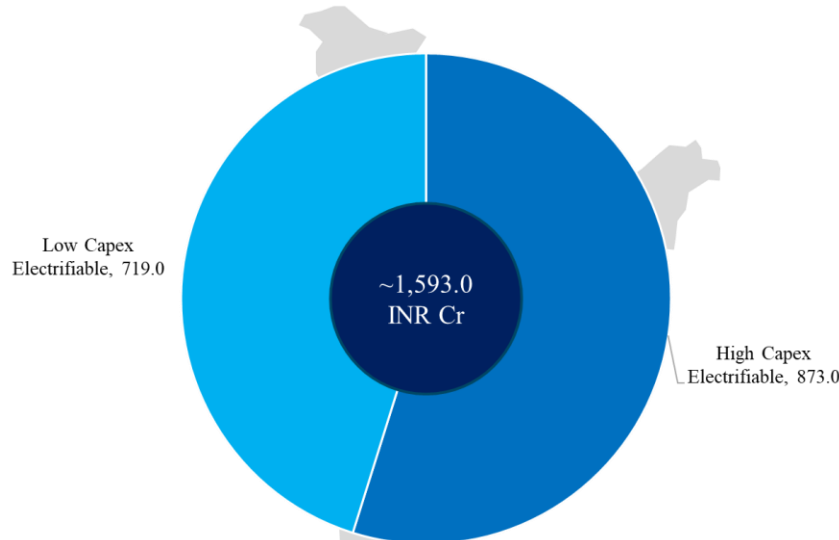
- Defence projects (INR 28 Cr) include heating systems for net-zero accommodation and specialised shelters in challenging climates, where compact electric systems suit decentralised needs.
- Chemicals offer a smaller opportunity (~ INR 11 Cr), focused on process heaters, dryers, and steam generation for emerging technologies such as thermal batteries.
- Glass industry investments roughly INR 27 Cr, stemming from electrification of preheating, recuperators, and portions of primary furnace operations.

Overall, these sectors contribute an estimated INR 142 Cr (FY2026–FY2031E cumulative) of electrifiable heating demand. While each segment is relatively small on its own, their aggregation highlights a steady, specialised market for mid-voltage or modular electric heating solutions, particularly in auxiliary and precision-driven processes.

4.6.8 Power Sector

Eleven power projects (thermal, WtE, nuclear) with INR 238,000 crore CAPEX allocate ~3–4% (INR 8,800 crore) to heating. High-capex boilers and steam generators form ~70% but have only ~12–15% electrification scope, while auxiliaries offer ~25–32%. Total electrifiable potential is ~INR 1,600 crore, centred on modular preheaters and dryers.

Exhibit 4.36: Demand for heating equipment from Power Sector, India, FY2026E – FY2031E



Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

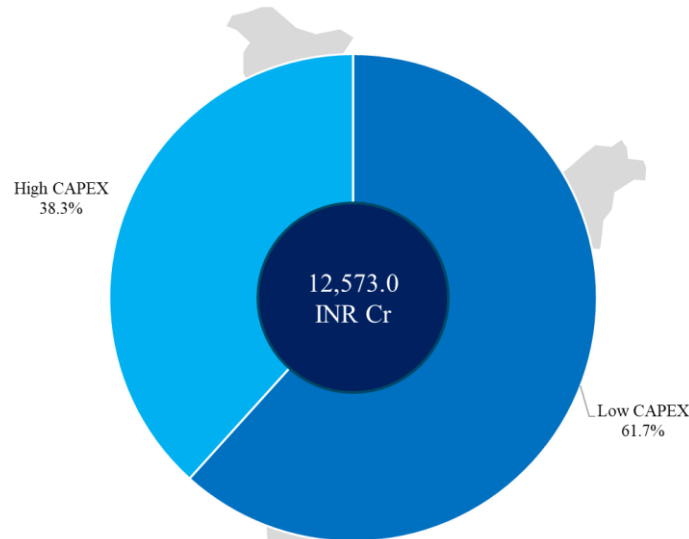
4.7 Overall demand potential by segment and by type of heating equipment (New Projects)

The total demand potential for heating equipment across ten key industrial and emerging segments has been estimated using the methodology applied for individual sectors. The combined CAPEX for all sectors amounts to INR 892,228 Cr.

Applying sector-specific heating solution percentages, the total heating solutions market is estimated at INR 49,402 Cr. Considering the electrification potential for high-capex and low-capex solutions, the total electrifiable heating market amounts to INR 12,573 Cr for FY2026E–FY2031E, of which INR 4,815 Cr is attributed to high-capex heating equipment and INR 7,758 Cr to low-capex equipment. On an average annualised basis, this corresponds to INR 2,096 Cr per year, representing the potential market for electrified heating equipment, including process heaters, boilers, pre-heaters, and specialised heating solutions. These solutions are applicable across diverse sectors such as refineries, petrochemicals, metals & steel, cement, green hydrogen and other emerging energy projects, defense, glass, chemicals, and power generation.

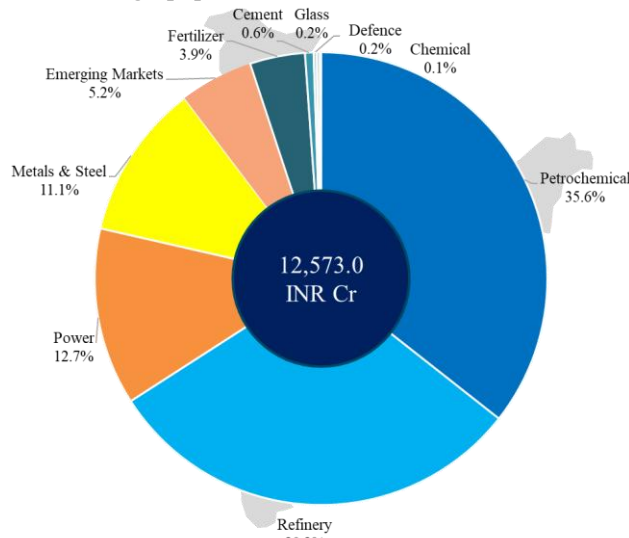
The contribution by sector to the total electrifiable heating market is dominated by petrochemical, refinery and power segments, followed by metals & steel and emerging market, while defence, glass, chemical, and cement contribute smaller portions.

Exhibit 4.37: Overall demand by type of heating equipment, India, New Projects, FY2026E – FY2031E



Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

Exhibit 4.38: Demand for heating equipment across sectors, India, New Market, FY2026E – FY2031E



Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

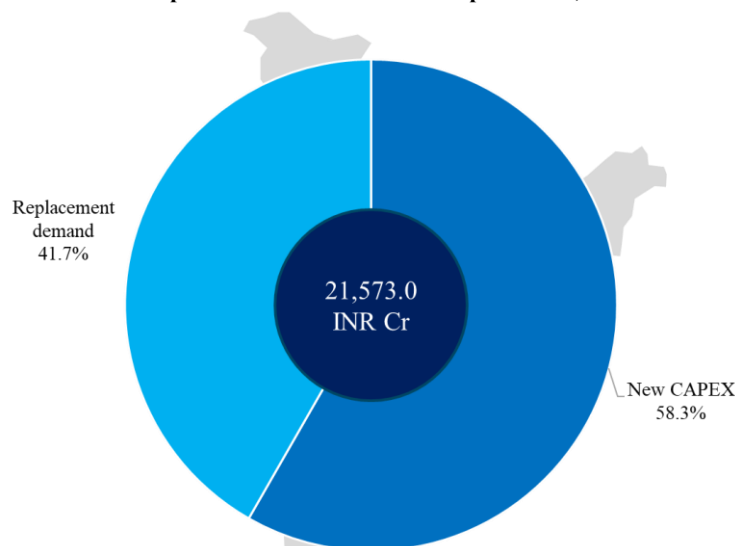
4.8 Demand potential: New CAPEX vs Replacement market

The overall demand potential for electrifiable heating solutions in India should be viewed through two lenses: new demand from planned CAPEX projects and replacement demand from the existing installed base of heating equipment.

Based on updated project-level data across refineries, petrochemicals, fertilizers, metals & steel, cement, power, and other sectors, the electrifiable portion of CAPEX-driven heating demand during FY2026E–FY2031E is estimated at INR 12,573 Cr, representing new systems expected to be deployed through greenfield and brownfield expansions.

Meanwhile, the installed base of heating systems, accumulated over past decades and estimated at INR 120,000 Cr, is substantially larger than these incremental additions. Assuming an average equipment life of 15–20 years, approximately 5% of the installed base is expected to be replaced annually, translating into an electrifiable replacement demand of INR 9,000 Cr over FY2026E–FY2031E.

Exhibit 4.39: Demand potential: New CAPEX vs Replacement, FY2026E – FY2031E



Source: Capex Analysis, Stakeholder Interactions, Frost & Sullivan Analysis

Taken together, the total market opportunity for electrifiable heating solutions during FY2026E–FY2031E is projected at INR 21,573 Cr, with new CAPEX-led demand and replacement demand contributing to roughly equal measure. This underscores the importance of considering both project-based capacity creation and the recurring replacement cycle when evaluating the long-term potential for electrified heating equipment, including process heaters, boilers, pre-heaters, and specialized heating solutions.

This underscores the importance of considering both project-based capacity creation and the recurring replacement cycle when evaluating the long-term potential for electrified heating equipment, including process heaters, boilers, pre-heaters, and specialized heating solutions. Within this opportunity, the Project/OEM business represents a high-barrier, approval-driven segment, often characterised by larger, competitive orders focused on one-time project setup. For companies such as Tempsens, obtaining registration and product certifications involves strict criteria, creating significant entry barriers for prospective competitors due to the specialised and high-stakes nature of engineered heating products and the demanding approval processes for both project-based and replacement supply.

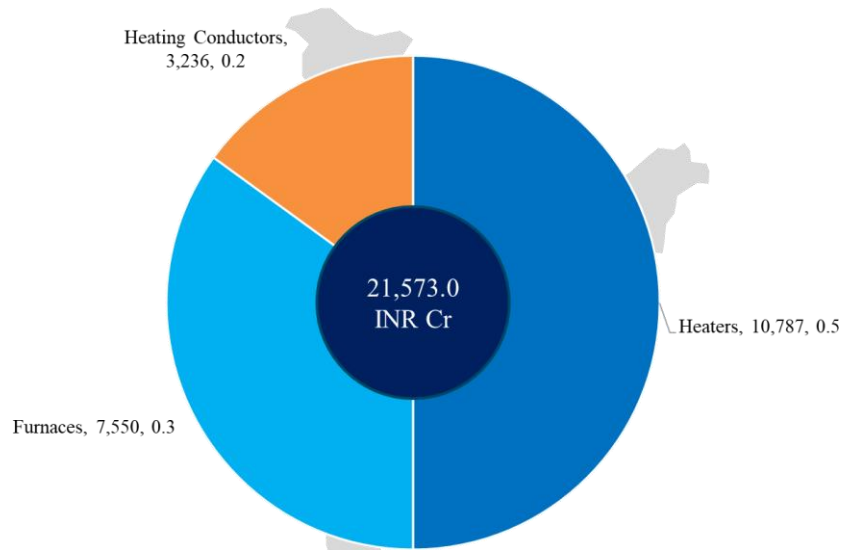
4.9 Heating Solutions: Product-Wise Segmentation (India)

Over the six-year period (FY2026E – FY2031E), the electrifiable heating equipment market in India, with a cumulative potential of INR 21,573 Cr, combines demand from both new CAPEX-driven projects and replacement of existing equipment. The market is expected to be dominated by heaters, which account for approximately INR 10,787 Cr (50%) of the total. Heaters are widely deployed across refineries, petrochemical, and fertiliser segments, reflecting their broad applicability in process heating.

Furnaces constitute the second-largest segment at INR 7,550 Cr (35%), driven primarily by metals & steel, cement, and chemical industries where high-temperature processing is integral to production. Heating conductors, with a market size of INR 3,236 Cr (15%), support trace heating in pipelines, feedwater systems, and emerging sectors such as green hydrogen production.

The market distribution highlights the ongoing shift toward electrification, particularly in high-capex projects and segments where energy efficiency, emission reduction, and precise process control are increasingly prioritized. Electrifiable solutions are being adopted not only in new projects but also during refurbishment and replacement cycles, ensuring that the market remains resilient even when overall CAPEX-driven project activity fluctuates.

Exhibit 4.40: India heating solutions cumulative electrifiable market split, New and Replacement, FY2026E – FY2031E



Source: Expert Interactions, Frost & Sullivan Analysis

4.9.1 Heating Solutions: Sub-Segmentation for individual product (India)

A. Heaters

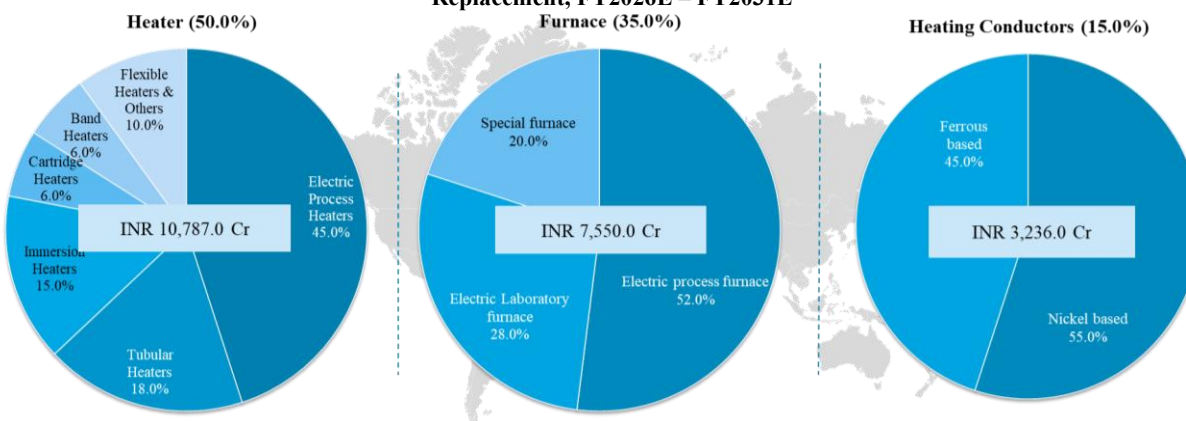
The industrial heater market in India over FY2026–31 is projected to account for INR 10,787 Cr, forming the largest share of the electrifiable heating solutions market. This reflects the diverse industrial landscape, strong process industry base, and the increasing shift toward energy-efficient thermal solutions. Within this segment, electric process heaters (~45%) dominate, driven by applications across chemicals, oil & gas, pharmaceuticals, and food processing, where precise and reliable heating is critical. Tubular heaters (~18%) are widely used in industrial ovens, plastic processing, packaging, and HVAC systems, benefiting from the growth of SMEs and smaller-scale industrial units. Immersion heaters (~15%) find usage in tanks, process vessels, and water heating, particularly in chemical plants, textiles, and water treatment. Niche products such as cartridge heaters (~6%) and band heaters (~6%) support specialised processes in plastics, rubber, and automotive industries. Flexible heaters and others (~10%) cater to custom and emerging applications in electronics, defence, aerospace, and R&D, and their adoption is expected to expand with the growth of advanced manufacturing.

B. Furnaces

The electrifiable furnace market is estimated at INR 7,550 Cr over FY2026E – FY2031E. Electric process furnaces (~50%) dominate due to widespread deployment in metals processing, heat treatment, and high-temperature industrial manufacturing, particularly in steel, aluminium, automotive, and heavy engineering sectors. Laboratory furnaces (~30%) benefit from India's expanding R&D, testing, and educational infrastructure, sustaining a higher-than-global share.

Special furnaces (~20%) include niche, custom-designed units for aerospace, defence, advanced ceramics, and strategic industries. While capital costs and industry scale limit their penetration, growth is expected in line with increasing localisation in high-value sectors.

Exhibit 4.41: Sub-Segment Market Share, Heaters, Furnaces, and Heating Conductors, Cumulative, New and Replacement, FY2026E – FY2031E



Source: Expert interactions, Frost & Sullivan Analysis

C. Heating Conductors

The heating conductor market, comprising ferrous- and nickel-based conductors, forms ~15% of the total electrifiable market (INR 3,236 Cr). Ferrous-based conductors (~45%) are primarily applied in moderate-temperature industrial applications such as pipeline and trace heating, while nickel-based conductors (~55%) serve high-temperature and corrosive environments, including chemical plants, green hydrogen facilities, and specialty sectors.

4.9.2 Heating Solution: Sub-Segmentation Key End User Application Area (India)

India's industrial heating equipment market is diversified across three primary categories — heaters, furnaces, and heating conductors — each catering to distinct operational needs and end-use sectors. Within heaters, electric process heaters hold the largest share due to their widespread adoption in continuous, high-precision applications across petrochemicals, oil & gas, food & beverage, pharmaceuticals, and chemicals. Tubular and immersion heaters follow, serving industries that require versatile, durable, or direct liquid heating solutions, while cartridge, band, and flexible heaters address specialized and localized heating needs. The furnace segment is driven largely by electric process furnaces for steel, cement, glass, and ceramics, complemented by laboratory and special furnaces for research, high-precision manufacturing, and niche sectors such as aerospace and semiconductors. Heating conductors, comprising NiCr and FeCrAl wires and ribbons, remain integral to a wide range of industrial and OEM applications, valued for their reliability, high-temperature performance, and corrosion resistance. This segmentation highlights the diverse demand drivers underpinning India's industrial heating market and the sector's role in enabling both large-scale and specialised industrial processes.

Exhibit 4.42: India Heating Solutions Market – Sub-Segmentation with Applications, FY2025

CATEGORY	SUB-SEGMENT	% SHARE WITHIN CATEGORY	KEY END-USE APPLICATIONS IN INDIA
Heaters (50%)	Electric process heaters	45%	Petrochemicals, oil & gas refineries, food & beverage processing, pharmaceuticals, and chemical manufacturing — where large volumes of fluids or gases require precise, high-temperature heating in continuous processes.
	Tubular heaters	18%	HVAC systems, commercial ovens, dryers, plastic extrusion, and packaging equipment —

			valued for their versatility, durability, and ability to fit into various heating assemblies.
	Immersion heaters	15%	Water treatment plants, boilers, chemical tanks, and industrial washing systems — commonly used where direct liquid heating is required for efficiency and uniform temperature distribution.
	Cartridge heaters	6%	Injection molding machines, sealing equipment, and die-casting applications — providing high-watt density heating in compact spaces for localized, rapid heat delivery
	Band heaters	6%	Plastic processing (e.g., extrusion barrels, injection molding), drum heating, and other cylindrical surface heating applications — valued for their ability to deliver even, controllable heat.
	Flexible Heaters & Others	10%	Aerospace, electronics, medical devices, and instrumentation — where lightweight, adaptable heating solutions are required for complex or irregular surfaces.
Furnaces (35%)	Electric process furnace	52%	Steel & metal manufacturing, cement plants, glass production, ceramics processing, large-scale chemical plants.
	Electric laboratory furnace	28%	R&D labs, universities, material testing centres, electronics manufacturing, ceramics & pharmaceutical labs.
	Special furnace	20%	Aerospace & defence component manufacturing, nuclear fuel processing, high-precision casting, semiconductor manufacturing.
Heating Conductors (15%)	NiCr Wire/Ribbon/Strip/Coil	55%	General-purpose resistance wires in appliances, kilns, plastic machines, and heaters
	FeCrAl Wire/Ribbon/Strip/Coil	45%	High-temperature furnaces and OEM segments where longevity and corrosion resistance are vital

4.10 Brief Competitive Mapping

The Indian industrial heating market is characterised by a clear dominance of domestic suppliers, who together accounted for close to 89% of reported domestic revenues in FY2024. This position of strength is underpinned by the scale and breadth of operations of a few large Indian companies, supported by a long tail of smaller local manufacturers catering to regional and niche demand. Global companies, while present, command a relatively modest share of around 11% of the market, reflecting their focus on technology-led and specialised high-temperature applications rather than volume-driven domestic demand

Looking ahead, the domestic share is expected to increase further. In addition, an incremental pool of approximately INR 200–250 Cr is anticipated to come from smaller, fragmented Indian players that are not fully captured in the core dataset. This expansion will tilt the competitive balance further in favour of local suppliers, potentially raising their aggregate share into the low-90s, while global companies' share declines correspondingly.

Exhibit 4.43: Competition mapping heating solutions

S. NO.	COMPANY	ORIGIN	HEATERS	FURNACES	HEATING CONDUCTORS
1	Tempsens	Indian	✓	✓	✓
2	Anupam Heaters	Indian	✓	—	—
3	Chromalox	Global	✓	✓	✓
4	Electrifer	Indian	✓	—	—
5	Ex Heat Process Heat India	Global	✓	✓	—
6	FATI	Global	✓	✓	—
7	HIPL India Pvt. Ltd.	Indian	✓	—	—
8	Watlow	Global	✓	✓	✓
9	Aswathi Industries	Indian	✓	✓	—
10	Thermopads	Indian	✓	—	✓
11	Hind High Vacuum Company	Indian	✓	✓	—
12	Vacuum Tech	Indian	✓	✓	—
13	Telelec	Indian	✓	—	✓
14	Thermon	Global	✓	—	✓

Source: Secondary Research, Frost & Sullivan Analysis

The strategic dynamics are shaped by this structural tilt. Domestic players benefit from strong price competitiveness, established customer networks, and faster delivery cycles, which make them the natural beneficiaries of both project-based and replacement demand. Global companies, on the other hand, continue to occupy a strategic niche, offering differentiated technologies, advanced materials, and solutions for specialised processes where performance and reliability carry greater weight than cost.

In this environment, the competitive balance is expected to remain firmly in favour of Indian suppliers. However, global firms can maintain relevance by focusing on differentiated segments, forging partnerships with domestic players, or expanding local assembly capabilities. At the same time, domestic suppliers are likely to deepen their presence by moving up the value chain through improved quality standards, certifications, and greater emphasis on R&D-led product development.

Tempsens' competitive position is defined by several key factors, including high entry barriers in industries Tempsens works in, its strong presence in a demanding market, and its unique product and global capabilities. The process of qualifying as a supplier for a major Indian PSU in the engineering and electrical equipment industry demonstrates the high entry barriers in the thermal engineering sector, especially for mission-critical products.

End Users typically require extended qualification periods, in-depth testing, and comprehensive field trials before approving new suppliers for mission-critical applications. Within this demanding environment, Tempsens has emerged as one of the largest manufacturers of electrical heaters in India (in terms of installed capacity), with a production capacity of 316,000 units per annum as of March 31, 2025. Tempsens is also one of the few players with the capability to manufacture low-voltage process heaters and is actively conducting R&D on developing medium-voltage heaters, underlining its commitment to innovation.

4.11 Heating Solutions: Import (India)

India's heating solutions market remains significantly import-dependent, with total imports valued at around INR 365 Cr in FY2025. The market is heavily concentrated, with the top 10 global suppliers together accounting for over INR 230 Cr of imports, or nearly 65% of the total value. This reflects the dominance of a few established international players in meeting India's demand for advanced heating technologies.

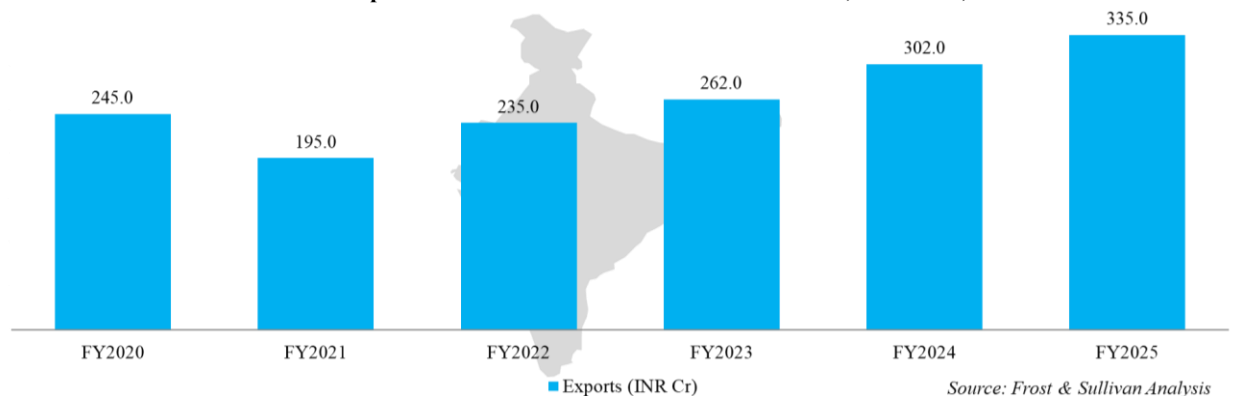
Leading companies such as Thermon Inc., Heat Trace Limited, Alleima (Kanthal), Zoppas Industries, and nVent Thermal are at the forefront, supported by other majors like Heatwell, Hotset GmbH, and IRCA S.p.A. Their stronghold in India is driven by their technological expertise, product reliability, and global presence across diverse industries such as oil & gas, petrochemicals, power, and specialized manufacturing. The high concentration of imports from these top players not only highlights India's reliance on foreign technologies but also signals untapped opportunities for domestic firms to localize advanced solutions and gradually reduce dependence on imports.

4.12 Heating Solution: Exports (India)

India's exports of industrial heating solutions have steadily expanded, rising from INR 245 crore in FY2020 to INR 335 crore in FY2025, reflecting the sector's resilience and competitiveness. The COVID-19 pandemic led to a steep contraction in FY2021, but recovery was swift, driven by renewed demand in global process industries, energy projects, and R&D applications. Since FY2022, exports have grown at a double-digit pace, with FY2024 showing a strong 15.6% YoY increase and FY2025 delivered another 12.2% rise.

This sustained growth reflects multiple structural advantages: India's cost-efficient manufacturing base, availability of skilled engineering talent, and the ability of domestic suppliers to meet global quality and certification requirements. Large Indian players such as Thermopad account for a substantial portion of export revenues.

Exhibit 4.44: Estimated Export Market for Industrial Heaters from India, in INR Cr, FY2020–FY2025



4.13 Heating Solution: Key Growth Drivers, Trends, and Challenges (India)

A. Key Growth Drivers – India (Heating Solutions)

Indigenisation: The heater industries in India are seeing a clear move towards indigenisation and reduction of import dependency. Leading players are working closely with government and industrial partners in steel, power, defence, and other process-intensive sectors to develop and manufacture advanced furnace cameras, and heating solutions domestically. This shift strengthens process safety and supports the operational requirements of high-temperature environments, while reducing reliance on imported technologies.

Industrial Expansion Across Core Sectors: India's continued growth in sectors such as steel, cement, chemicals, and automotive manufacturing is fueling demand for industrial heating solutions. For instance, India's steel production reached 136 million tonnes in FY2024 (Source: Ministry of Steel), necessitating the extensive use of industrial furnaces and high-efficiency heaters in production processes.

Push for Energy Efficiency and Electrification: As part of the government's energy transition goals, industries are encouraged to adopt energy-efficient electric heating systems over conventional fossil-fuel-

based ones. The Perform Achieve and Trade (PAT) scheme by BEE promotes the use of energy-efficient technologies in energy-intensive sectors.

Urbanisation and Infrastructure Growth: Rising investments in real estate, commercial construction, and infrastructure (INR 10 lakh crore in infra projects budgeted in Union Budget 2024–25) increase demand for HVAC systems and heating elements embedded in modern construction, such as floor heating cables and industrial boilers.

B. Key Trends – India (Heating Solutions)

Electrification of Heating Systems: There is a gradual shift from traditional oil/gas-fired systems to electric and induction-based heating solutions. This is driven by environmental regulations and the reliability of electric systems, especially in applications requiring precision like electronics manufacturing.

Modular and Smart Heating Solutions: Growing demand for plug-and-play, smart, and IoT-integrated heating systems. These allow better temperature control, predictive maintenance, and energy optimisation, appealing to both OEMs and industrial users.

Localisation of Manufacturing: Companies are setting up local manufacturing for heaters and furnaces to reduce import dependency. For example, Tempsens and other domestic players are expanding capacity to cater to rising industrial needs.

Export-oriented Demand: India is emerging as a base for manufacturing and exporting heating components, especially for developing countries in Southeast Asia, the Middle East, and Africa. Export of temperature control and heating equipment from India grew by approximately 18% YoY in 2023–24.

As India accelerates its industrial modernisation, the demand for smarter, more efficient heating systems and advanced conductor technologies is expected to remain strong over the next decade.

C. Regulatory Framework & Policies

Technology Innovation & Government Schemes

- **PLI Scheme for White Goods (2021):** Encourages use of energy-efficient components including heating coils and conductors in appliances.
- **National Electric Mobility Mission & Green Hydrogen Policy:** While not directly targeting heating, these push industries toward electrification and renewables, which indirectly boosts electric heating equipment.

Standards and Compliance

- BIS standards apply to key heating products, including IS 302 for electric heaters and IS 7466 for industrial furnaces.
- Growing enforcement of energy performance standards by the Bureau of Energy Efficiency (BEE).

Environmental & Safety Regulations

- Increasing scrutiny under Pollution Control Board norms for thermal emissions and workplace safety (especially for furnace operations).
- Rules under the Factories Act require thermal insulation, safe temperature thresholds, and exhaust systems in industrial heating setups.

Incentives & Grants

- **Subsidies under MSME Technology Upgradation Program:** Reimbursement up to 25% for technology modernisation, including heating and automation systems.
- **State-level solar thermal schemes:** Some states, like Rajasthan and Gujarat, offer capital subsidies for solar-based or hybrid heating solutions used in process industries.

D. Threats and Challenges

- **High Upfront Costs and Long Payback Periods:** Industrial heaters, furnaces, and advanced electric heating systems often involve significant capital expenditure. Many MSMEs and cost-sensitive industries hesitate to adopt new technologies due to the relatively long payback period, especially when energy prices fluctuate.
- **Volatility in Raw Material Prices:** Key materials such as nickel, chromium, stainless steel, and special alloys used in heating elements are prone to global price swings. Sudden increases affect manufacturing costs and squeeze margins for OEMs and suppliers.
- **Dependence on Imported Components:** Despite growing localisation, specialised heating elements, temperature sensors, and control modules are still imported from Europe, Japan, and China. Disruptions in global supply chains (e.g., freight rate spikes, geopolitical tensions) can delay projects and raise costs.
- **Competition from Low-Cost Alternatives:** Domestic manufacturers face pricing pressure from unorganised players offering cheaper, low-spec heaters and furnaces. This erodes margins for quality-focused companies and discourages investment in R&D.

5. OPERATIONAL BENCHMARKING

5.1 Operational Benchmarking

Tempsens is a uniquely positioned player in thermal engineering and cable solutions. Given its business model and diversified product portfolio, there are no directly listed companies in India or internationally that are present across all the segments/product categories as Tempsens. Hence, it is not possible to provide a direct peer comparison, and peers have been considered across individual segments.

5.1.1 Tempsens Instruments India Limited.

PARAMETERS	DETAILS
Company Overview	Tempsens Instruments India Limited is a global leader in Thermal and Cable Solutions, with state-of-the-art manufacturing facilities (including Subsidiaries and Joint Ventures) in India, Indonesia, UAE, and South Korea. With decades of expertise, the company has built a strong reputation for integrating technology and engineering to deliver advanced solutions in the thermal and cable domain. Tempsens offers a comprehensive portfolio of high-quality thermal engineering products, including Contact and Non-contact Temperature Sensors—such as Thermocouples, RTDs, Thermowells, Infrared Pyrometers, and Thermal Imagers—along with Cables & Wires, Industrial Electrical Heaters, Temperature Calibrators, and Industrial Electrical Furnaces. All solutions are designed and customized to meet diverse customer requirements.
Key Products	- Temperature Sensing Solutions - Electrical Heating Solutions - Specialized Cables
Headquarter	Udaipur, Rajasthan
Financials (Revenue) – INR Mn	- FY2025 – 3,785 - FY2024 – 2,748 - FY2023 – 2,369
Facilities	Tempsens, its subsidiaries, and its Joint Ventures have eight manufacturing facilities in India, and three internationally in the UAE, Indonesia, and South Korea. These facilities enable the company to serve its customers worldwide as a global leader in thermal and cable solutions.
Manufacturing facilities (including Joint Ventures)	- Udaipur, Rajasthan, India - PT Tempsens Asia Jaya, Jakarta, Indonesia - Tempsens Gulf LLC, Ajman, United Arab Emirates - Tempsens Korea Co., Ltd, Seoul, South Korea
Patents, R&D spend	Tempsens and its subsidiaries has 9 patents, Company's total R&D spend for FY2025 stood at INR 33.95 million
Certifications	All manufacturing facilities in India (except Unit 5) are certified for ISO 9001:2015, ISO 14001:2015, and ISO 45001:2018, and additionally one of its manufacturing units hold the ZED (Zero Defect Zero Effect) certification. Tempsens UAE is also certified for ISO 9001:2015, ISO 14001:2015, and ISO 45001:2018.

	- One ISO/IEC 17025:2017 accredited calibration laboratory in Udaipur, India, and a KAN-accredited laboratory in Jakarta, Indonesia operated by our Joint Venture (PT Tempsens Asia Jaya). - Product Certification - ATEX, IECEX, UL, CE, Ex d, EAC, UL, BIS, U Stamp, R Stamp, National Board "NB", ECAS, CE, EX ia, and PESO
Number of Employees and Engineers	- As of March 31, 2025, company had 707 permanent employees - As of March 31, 2025, company contracted 1,012 contract workers

5.1.2 Thermo Cables Limited

PARAMETERS	DETAILS
Company Overview	Thermo Cables Limited, a member of the Thermo Group, is a multi-product, multi-service organization. Since its establishment in 1990, the company has grown into a leading manufacturer of specialty cables, catering to a wide spectrum of industries including Railways, Navy, Defence, Renewable Energy, Nuclear Power, Process Industries, Oil & Gas, and the Power sector.
Key Products	- Instrumentation, Control & Power Cables - Thermocouple Extension / Compensating Cables - Fire-Resistant & Fire Survival Cables - Railway Signaling & Rolling Stock Cables - Electron Beam Cross-Linked (EBXL) Special Cables - High-Temperature & Special Insulated Cables (PTFE, Silicone, Fiberglass, etc.) - Solar PV Cables - Marine & Offshore Cables - Flexible Rubber, Trailing & Battery Cables - Communication Cables (Telephone, Coaxial, Data Cables)
Headquarter	Hyderabad, Telangana
Financials (Revenue) – INR Mn	- FY2025 – N.A. - FY2024 – 7,071 - FY2023 – 6,129
Facilities	Thermo Cables currently operates two manufacturing facilities; present in 60+ countries
Manufacturing facilities	Thermo Cables currently operates two manufacturing facilities, both in Telangana, India (Hyderabad–Jeedimetla and Jadcherla–Mahbubnagar), with its global headquarters in Hyderabad.
Patents, R&D spend	N.A.
Certifications	- Thermo Cables Limited is certified by CE/CPR, UL, EAC, TUV, LRS, and ABS, ensuring compliance with the highest international industry standards. - ISO 9001, 14001 & 45001 Certified Organization
Number of Employees and Engineers	1,000+

5.1.3 Thermon India Pvt Ltd

PARAMETERS	DETAILS
Company Overview	Thermon Group Holdings, Inc. is a global leader in industrial process heating solutions, headquartered in Austin, Texas. The company specializes in process heating, flow assurance, temperature maintenance, freeze protection, and environmental monitoring, serving process industries worldwide.
Key Products	- Electric and steam-based heat tracing cables - Boilers and heating systems (electric, electrode, and gas-fired) - Industrial blankets, heated tubing bundles, and pre-insulated tubing systems - Controls, monitoring systems, and engineering design services - Temporary power distribution and lighting solutions - Environmental and transportation heating products under brands like Ruffneck, Norsemen, Catadyne, Caloritech, Vapor Power, and others
Headquarter	Austin, Texas, in the United States
Financials (Revenue) – INR Mn – India entity	- FY2025 – N.A. - FY2024 – 594 - FY2023 – 504
Facilities	Thermon's facilities include a core network of manufacturing plants in the USA, Canada, Europe, and India, with newer additions of Oakville and Orillia plants, bringing the total to at least 12 manufacturing locations globally. They operate a headquarters in Austin, Texas, and have additional offices and subsidiaries worldwide, such as in Mexico City, Calgary, and South Africa.
Manufacturing facilities	Thermon Holdings has numerous manufacturing locations worldwide, with specific facilities in the USA, Canada (including Oakville and Orillia, Ontario), Europe (such as the Netherlands and Germany), and India. They also operate through a global network of subsidiaries and affiliates in other countries, although not all are manufacturing sites.
Patents, R&D spend	- Thermon has around 92 patents globally, of which 59 are granted. Most patents are filed in the USA, followed by filings in Canada and Europe. - Thermon appears to allocate somewhere between 3% to 5% of its revenue toward R&D
Certifications	Thermon has obtained a 100% ISO 9001 certification for all their eleven global manufacturing locations.
Number of Employees and Engineers	Between 1,405 and 1,568.

5.1.4 Wika Instruments India Pvt Ltd

PARAMETERS	DETAILS
Company Overview	The WIKA Instruments India Pvt Ltd is a global leader in pressure and temperature measurement and a benchmark in level, force, flow, and calibration technology. With a broad portfolio of high-precision products, innovative solutions, and comprehensive services, WIKA stands as a trusted partner for diverse industrial measurement needs.

Key Products	- Pressure Measurement Instruments (Mechanical & electronic pressure gauges, Pressure transmitters & transducers etc.) - Temperature Measurement Instruments (RTD, Thermocouples etc.) - Level Measurement Instruments - Force Measurement Instruments - Flow Measurement Instruments
Headquarter	Klingenberg am Main, Germany
Financials (Revenue) – INR Mn – India entity	- FY2025 – N.A. - FY2024 – 3,780 - FY2023 – 3,118
Facilities	WIKA has over 45 subsidiaries and more than 15 production facilities across more than 45 countries, alongside a presence in the USA.
Manufacturing facilities	- WIKA India operates in four Indian states: Maharashtra, Tamil Nadu, Uttar Pradesh, and Haryana - Pune (Maharashtra) — The original facility, also houses calibration, level, and SF₆ gas units; and recently a Force Measurement Production Unit. - Chennai — A plant that manufactures pressure switches and temperature switches. - Ghaziabad and Faridabad (Uttar Pradesh / NCR region) — Plant(s) involved in manufacturing valves & manifolds, flow elements, switches, etc. - WIKA has “high-tech production facilities” in many countries; some of the owned manufacturing sites are in: Germany, Australia, Brazil, China, India, Italy, Canada, Poland, Switzerland, South Africa, USA.
Patents, R&D spend	The parent company WIKA Alexander Wiegand SE & Co. KG is reported to have ~272 patents in total
Certifications	ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, ISO 50001:2018
Number of Employees and Engineers	- WIKA Group has around 11,200 employees globally. - In India, WIKA Instruments India Pvt. Ltd. has about 590 employees as of March 2024.

5.2 Financial Benchmarking

Exhibit 5.1: Revenue from the operation of key competitors, value (in INR Million), Total Income (in INR Million), Export/ Outside India Revenue, value (in INR Million), FY2023 – FY2025

Company Name	Revenue from Operations			Total Income			Export/ Outside India Revenue		
	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023
Tempsens	3,785.26	2,748.10	2,369.43	3,824.68	2,780.42	2,399.83	1,002.14	586.36	512.34
Thermo Cables	N.A.	7,070.71	6,129.26	N.A.	7,195.73	6,236.03	N.A.	2,962.26	2,268.90
Thermon	N.A.	593.90	503.80	N.A.	603.40	508.90	N.A.	N.A.	N.A.
Wika	N.A.	3,780.00	3,117.60	N.A.	3,827.70	3,148.80	N.A.	702.20	575.10

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis

MRO orders provide a stable, recurring revenue stream for Tempsens, less dependent on capital expenditure cycles and strongly linked to process uptime, regulatory compliance, and lifecycle management.

Exhibit 5.2: EBITDA (in INR Million), EBITDA Margin (in %), PAT (in INR Million), FY2023 – FY2025

Company Name	EBITDA			EBITDA Margin			PAT		
	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023
Tempsens	973.22	611.27	499.98	25.45%	21.98%	20.83%	625.55	409.19	332.33
Thermo Cables	N.A.	1182.66	855.70	N.A.	16.73%	13.96%	N.A.	747.03	521.96
Thermon	N.A.	82.77	81.57	N.A.	13.94%	16.19%	N.A.	54.00	53.50
Wika	N.A.	385.50	300.50	N.A.	10.20%	9.64%	N.A.	150.00	96.80

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis

Exhibit 5.3: PAT Margin (in %), RoE (in %), RoCE (in %), FY2023 – FY2025

Company Name	PAT Margin			RoE			RoCE		
	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023
Tempsens	16.36%	14.72%	13.85%	14.08%	20.02%	21.20%	23.08%	22.82%	23.79%
Thermo Cables	NA	10.38%	8.37%	N.A.	35.51%	38.43%	N.A.	47.02%	46.08%
Thermon	NA	8.95%	10.51%	N.A.	17.27%	20.69%	N.A.	26.02%	30.73%
Wika	NA	3.92%	3.07%	N.A.	5.39%	3.67%	N.A.	6.97%	5.21%

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis

Exhibit 5.4: Net Working Capital Days (in days), Debt/ EBITDA, Debt/ Equity, FY2023 – FY2025

Company Name	Net working capital days			Debt/ EBITDA			Debt/ Equity		
	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023	FY 2025	FY 2024	FY 2023
Tempsens	193	152	168	0.74	0.49	0.53	0.16	0.15	0.17
Thermo Cables	N.A.	98	70	N.A.	0.17	0.34	N.A.	0.10	0.21
Thermon	N.A.	52	26	N.A.	-	-	N.A.	-	-
Wika	N.A.	119	130	N.A.	2.50	2.97	N.A.	0.35	0.34

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis