INDUSTRY REPORT ON INDIAN STP, TERTIARY TREATMENT, MSW MANAGEMENT & BIOGAS MARKET

SUBMITTED TO

SFC ENVIRONMENTAL TECHNOLOGIES LTD.

20 August 2025, Industry Report

1. MACROECONOMIC OVERVIEW OF GLOBAL ECONOMY

1.1 Real GDP review and outlook

The global economy is expected to grow by 2.8% in CY2025E and 3.0% in CY2026E (Source: IMF's April 2025). India is projected to grow at 6.2% 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.

The IMF's forecast reflects the impact of several global risks. Renewed trade tensions between the United States and China have led to a fresh round of tariffs, including a 100% tariff by the U.S. on Chinese electric vehicles and increased duties on semiconductors, batteries, and solar products. These policies have triggered countermeasures and introduced uncertainty into global trade and investment flows. The IMF estimates these disruptions could reduce global GDP by up to 0.5% points over the medium term. Ongoing geopolitical tensions are affecting global supply chains, especially for food and energy. Disruptions along major shipping routes, including the Red Sea, have increased transport costs and delayed deliveries. These issues are adding to business costs and could affect when and how central banks adjust interest rates in different countries.

Exhibit 1.1: Real GDP Growth – Historic and Forecast, World, CY2019 – CY2029E

Source: IMF April 2025 forecast, Frost & Sullivan analysis

Exhibit 1.2: 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%**	**2.8%**	**3.0%**	**3.2%**	**3.2%**	**3.2%**
United States	2.6%	-2.2%	6.1%	2.5%	2.9%	2.8%	1.8%	1.7%	2.0%	2.1%	2.1%
China	6.1%	2.3%	8.6%	3.1%	5.4%	5.0%	4.0%	4.0%	4.2%	4.1%	3.7%
India	**3.9%**	**-5.8%**	**9.7%**	**7.6%**	**9.2%**	**6.5%**	**6.2%**	**6.3%**	**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%	1.5%	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%	3.0%	3.5%	4.0%	3.7%	3.7%
Africa	3.1%	-1.4%	4.6%	4.3%	3.3%	3.2%	3.9%	4.1%	4.3%	4.4%	4.5%
Latin America and Caribbean	0.2%	-6.9%	7.4%	4.2%	2.4%	2.4%	2.0%	2.4%	2.7%	2.7%	2.7%

Source: IMF April 2025 forecast, Frost & Sullivan analysis

1.2 Inflation

Global inflation averaged 5.7% in CY2024, reflecting a continued moderation from the peak levels seen in CY2022. This trend follows a decline from 6.6% in CY2023 and 8.6% in CY2022. The easing reflects the gradual resolution of earlier supply disruptions, normalisation 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 stabilise 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 1.3: Inflation Rate – Historic and Forecast, World, CY2019 – CY2029E

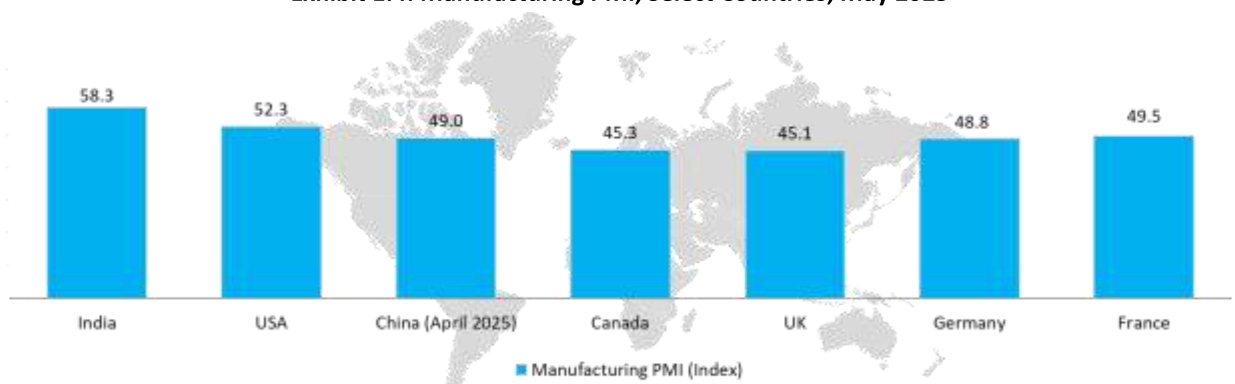
Country / Region	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024	CY2025E	CY2026E	CY2027E	CY2028E	CY2029E
World	3.5%	3.3%	4.7%	8.6%	6.6%	5.7%	4.3%	3.6%	3.3%	3.2%	3.2%
United States	1.8%	1.3%	4.7%	8.0%	4.1%	3.0%	3.0%	2.5%	2.1%	2.2%	2.2%
China	2.9%	2.5%	0.9%	2.0%	0.2%	0.2%	0.0%	0.6%	1.4%	1.8%	1.9%
India	4.8%	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 April 2025 forecast, Frost & Sullivan analysis

1.3 Manufacturing Purchasing Managers Index (PMI)

Manufacturing activity showed varied trends across major economies in May 2025. India continued to lead, with a manufacturing PMI of 58.3, supported by strong domestic demand and a steady rise in new orders. While firms reported an increase in input costs, they were able to pass these on to customers, suggesting resilience in pricing power. In the United States, the PMI rose to 52.3, indicating an expansion in activity. This was attributed to improved business sentiment and stability in global trade flows, helping ease earlier concerns related to external demand. In contrast, China's manufacturing PMI fell to 49.0 in April, slipping back into contraction. The decline reflected weak export orders and a cautious domestic investment climate, amid ongoing trade-related uncertainties and soft consumer demand.

Exhibit 1.4: Manufacturing PMI, Select Countries, May 2025



Source: Trading Economics April-May 2025, Frost & Sullivan analysis

Europe continued to face pressures, with Germany (48.8) and France (49.5) both recording figures just below the neutral 50 mark, though modest improvements were visible. The gradual recovery in external orders and restocking helped support output levels, but manufacturers remained cautious due to subdued domestic consumption and elevated input costs. The UK posted a PMI of 45.1, pointing to a sharper slowdown. Manufacturers cited weak order inflows and ongoing cost concerns as reasons for the contraction. Canada's PMI also fell to 45.3, reflecting soft demand and hesitancy among firms, linked in part to uncertainty around trade policy and broader economic conditions. Overall, global manufacturing continues to reflect a mixed picture, with some economies seeing signs of improvement while others remain under pressure from external demand challenges and cost-related headwinds.

1.4 Growth drivers impacting the growth of the global economy

Consumer Spending and Labor Markets: In many regions, consumer spending remains a primary driver of growth. This is supported by ongoing employment gains and wage increases, which enhance household purchasing power. Lower interest rates and reduced savings rates further encourage consumption.

Investment and Technological Advancements: Investment activity is recovering, particularly in sectors undergoing digital transformation. Advances in artificial intelligence and automation are reshaping global value chains, leading to increased efficiency and new business opportunities.

Fiscal Policies and Government Spending: Governments in various countries are implementing fiscal measures to stimulate growth. Increased public spending, especially in infrastructure and social programs, is contributing to economic activity.

Trade Dynamics and Emerging Markets: Emerging markets, notably India, continue to exhibit growth, driven by domestic demand and export activities. However, global trade dynamics are affected by policy uncertainties and tariff changes, influencing investment decisions and supply chains.

Monetary Policy Adjustments: Central banks are adjusting monetary policies in response to inflation trends. While some regions experience easing inflation, others face persistent price pressures, leading to varied interest rate strategies that impact investment and consumption patterns.

2. MACROECONOMIC OVERVIEW OF INDIAN ECONOMY

2.1 Indian Macro-economic overview

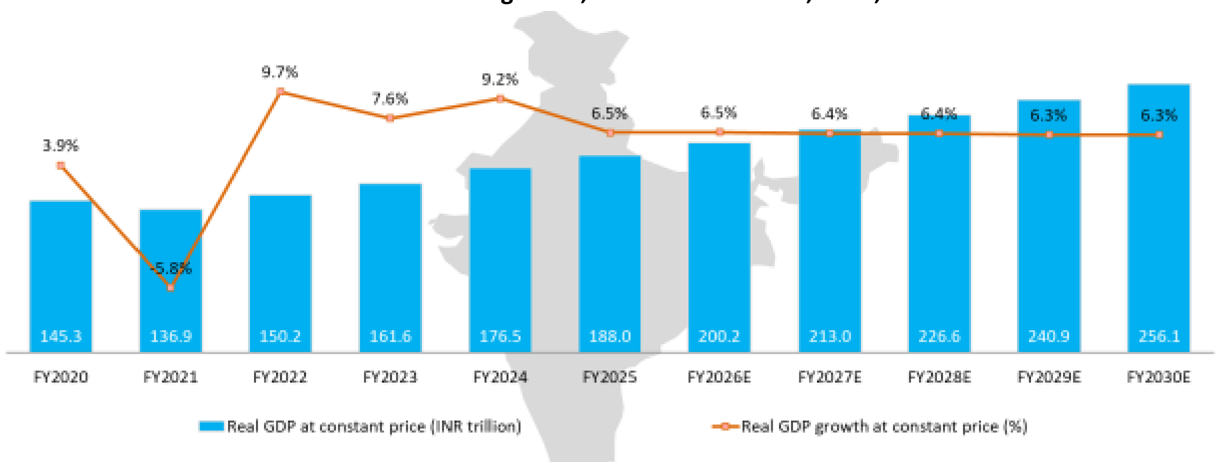
The Union Budget FY2026 outlines a total expenditure of INR 50.65 lakh crore with a capital outlay of INR 11.21 lakh crore (3.1% of GDP) and a fiscal deficit target of 4.4% of GDP. The Budget identifies four engines of growth: Agriculture, MSMEs, Investment, and Exports. Key announcements include the launch of agri-focused programs like the Dhan-Dhaanya Krishi Yojana, missions for pulses and cotton self-reliance, and MSME support through revised classifications, credit cards for micro units, and an INR 10,000 crore startup fund. 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.

2.2 Review and outlook of Real GDP growth in India

The Reserve Bank of India (RBI) has projected India's real GDP growth at 6.5% for both FY2025 and FY2026, indicating sustained economic momentum despite global uncertainties. For FY2025, the RBI slightly revised its earlier forecast downward by 20 basis points, citing increased global volatility. However, domestic factors remain supportive. Growth is expected to be driven by favourable monsoon conditions boosting agricultural output, early signs of revival in the manufacturing sector, strong resilience in services, and an uptick in investment activity supported by robust government infrastructure spending and healthy balance sheets in banks and corporates. External risks such as global trade disruptions and geopolitical tensions continue to pose a challenge, especially for merchandise exports. For FY2026, the RBI maintains its 6.5% growth forecast, calling the outlook "evenly balanced." The economy is expected to benefit from improved consumption demand, sustained public capital expenditure, and government initiatives like the Production-Linked Incentive (PLI) scheme and the National Manufacturing Mission.

Exhibit 2.1: Annual Real GDP and growth, value in INR trillion, India, FY2020 - FY2030E



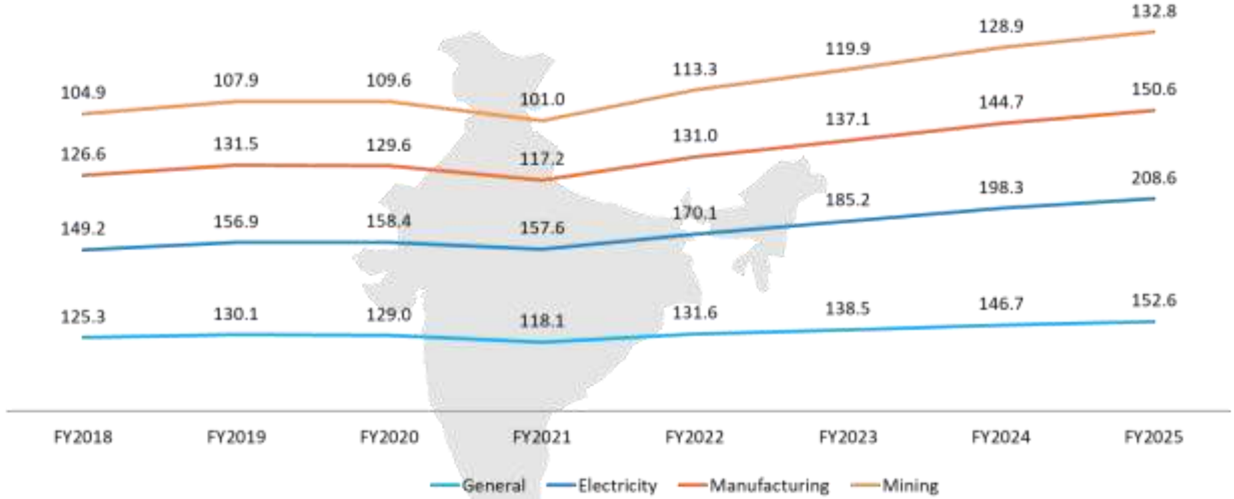
Source: MoSPI (Annual Estimates of GDP at constant price, 2011-12 series), IMF, ADB, S&P, Frost & Sullivan Analysis

2.3 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.

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.

Exhibit 2.3: India - Index of Industrial Production (IIP) by sectors, FY2018 - FY2025

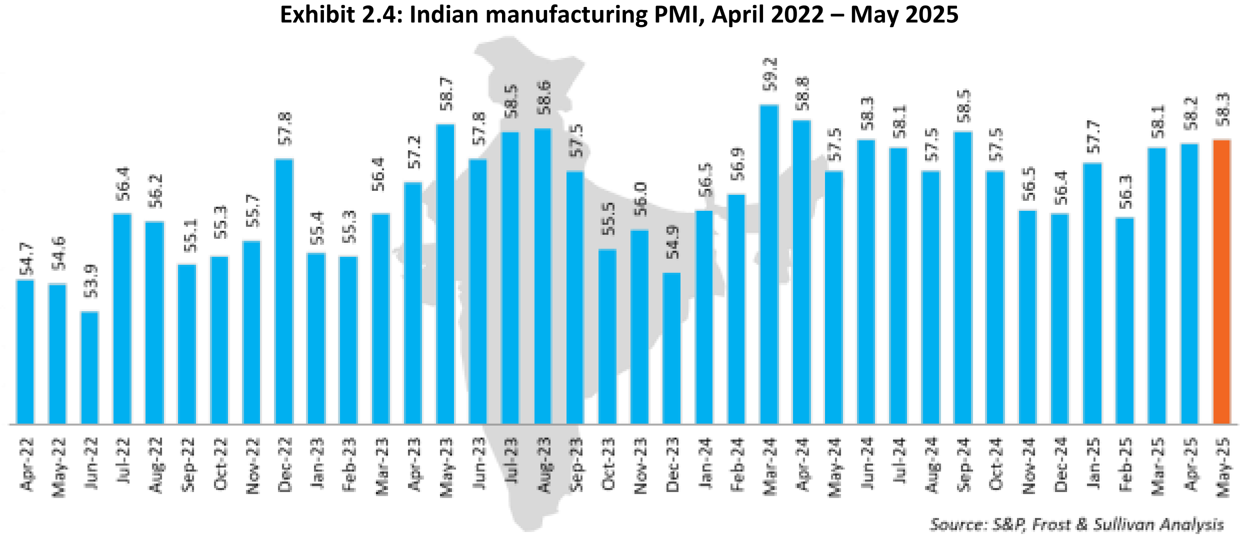


Source: MoSPI (Annual Estimates of GDP at constant price, 2011-12 series); RBI (Reserve Bank of India); Frost & Sullivan Analysis

2.4 India manufacturing PMI (Purchasing Managers Index)

India's manufacturing sector demonstrated consistent growth from April 2022 through May 2025, as reflected in the HSBC India Manufacturing Purchasing Managers' Index (PMI). The PMI remained above the 50-point threshold, indicating sustained expansion. In May 2025, the PMI edged up to 58.3 from 58.2 in April. This growth was supported by robust demand, increased hiring, and inventory accumulation, despite a slight moderation in output growth.

Exhibit 2.4: Indian manufacturing PMI, April 2022 – May 2025



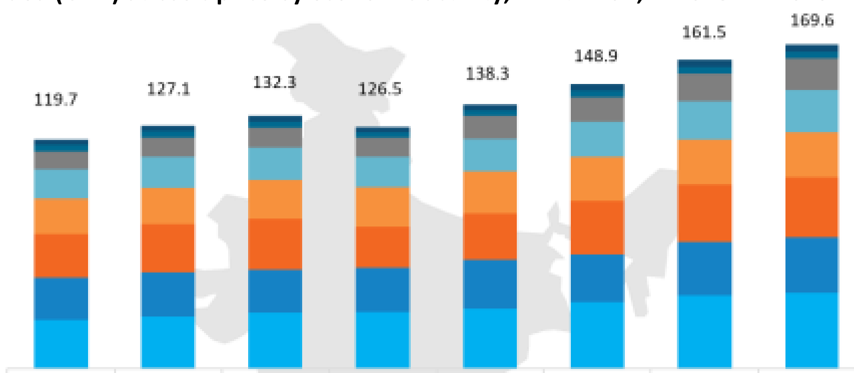
Source: S&P, Frost & Sullivan Analysis

The sector's resilience was bolstered by government initiatives like the Production Linked Incentive (PLI) schemes, which enhanced domestic manufacturing capacity. Additionally, India's strategic position in global supply chains, amidst shifting trade dynamics, attracted foreign investment. However, manufacturers faced challenges such as rising input costs, leading to the sharpest increase in output prices in over 11 years. Despite these pressures, business confidence improved in May, with firms expressing optimism about future sales and activity.

2.5 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.

Exhibit 2.5: India - Gross value added (GVA) at basic price by economic activity, INR trillion, FY2018 - FY2025*



	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025*
Electricity, Gas,Water supply & Other utility	2.7	2.9	3.0	2.8	3.1	3.5	3.8	3.9
Mining & Quarying	3.3	3.2	3.1	2.9	3.0	3.2	3.3	3.4
Construction	9.6	10.2	10.4	9.9	11.9	13.0	14.4	16.5
Public administration, Defence & Other services	15.1	16.2	17.3	16.0	17.2	18.4	20.0	22.0
Agriculture, Forestry & Fishing	18.4	18.8	19.9	20.7	21.7	23.1	23.7	23.9
Trade, Hotels,Transport& Communication services	23.1	25.4	27.0	21.5	24.6	27.9	29.9	31.3
Manufacturing	22.1	23.3	22.6	23.2	25.6	25.2	28.3	29.0
Financial, Real estate & Professional services	25.4	27.1	29.0	29.5	31.2	34.6	38.1	39.6

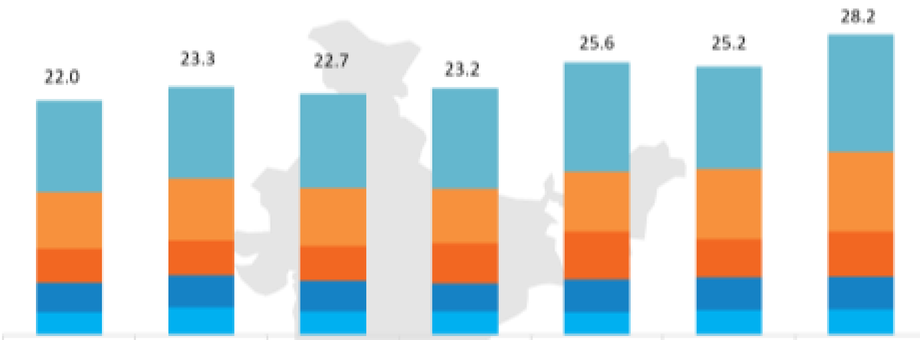
** Second Advance Estimates*

Source: National Statistical Office; Frost & Sullivan Analysis

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, reflecting growing investments in automation, industrial modernization, and infrastructure development. This growth signals that Indian manufacturers are increasingly focusing on improving productivity and technology adoption rather than just volume growth.

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



	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024
Other manufacturing goods	8.6	8.6	8.9	9.5	10.3	9.6	11.0
Machinery and Equipments	5.3	5.8	5.4	5.1	5.6	6.6	7.5
Metal Products	3.2	3.3	3.3	3.8	4.5	3.6	4.2
Textiles,apparel and leather products	2.8	3.0	2.9	2.6	3.1	3.1	3.1
Food products,beverages and tobacco	2.1	2.6	2.2	2.2	2.1	2.3	2.4

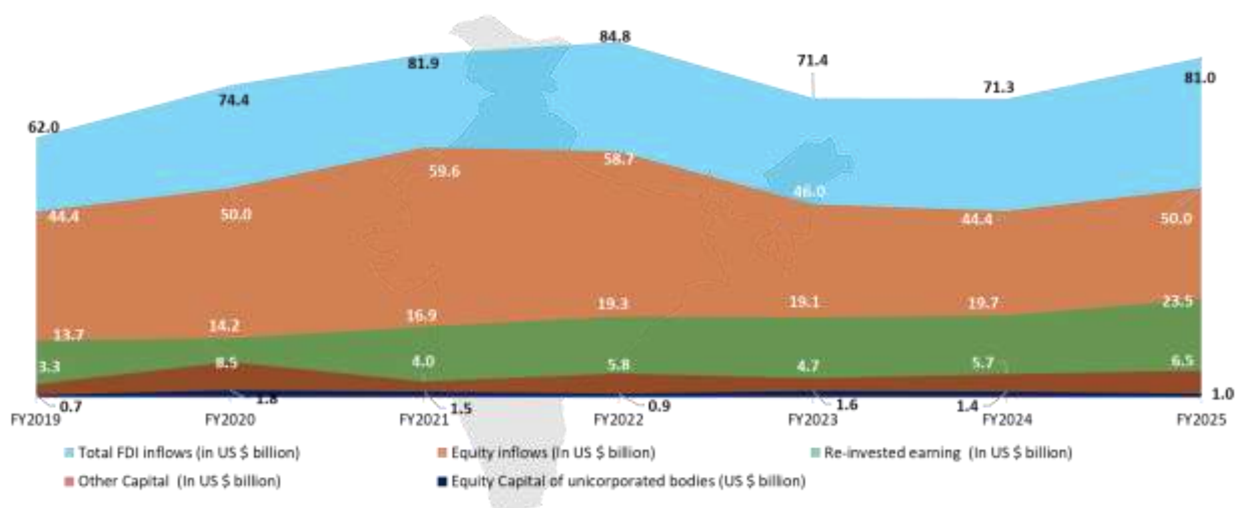
Source: National Statistical Office; Frost & Sullivan Analysis

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.

2.6 Foreign Direct Investment (FDI)

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 2.7: 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.

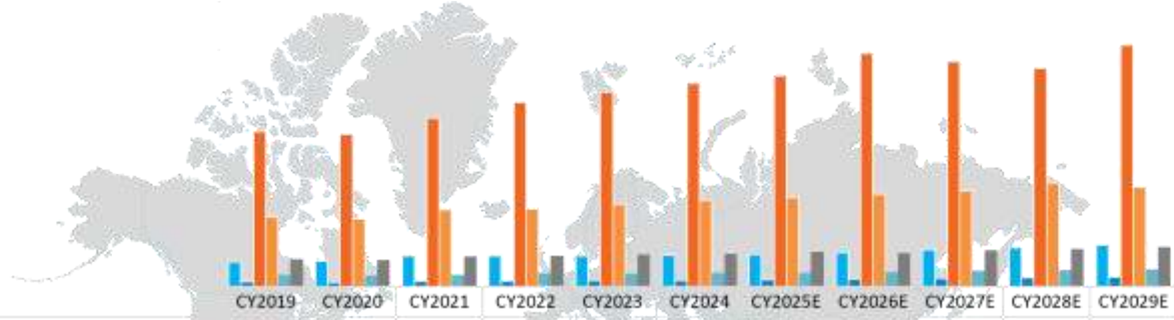
In FY2025, total FDI inflows rebounded to USD 81.0 billion, reflecting renewed investor interest amid improving macroeconomic stability and strong domestic consumption trends. The rebound was led by a pickup in equity inflows (USD 50.0 billion) and a significant increase in reinvested earnings (USD 23.5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

2.7 Per capita income – India vs. leading global economies

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. To transition into a true middle-income economy, India must grow its per capita income by over 2.1x. Much of this future growth will depend on expanding formal employment, ensuring wider access to quality education and healthcare, and driving industrial productivity. 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.

Exhibit 2.8: India vs. Global – Per capita income of India vs leading economies (USA, China, Europe and Southeast Asia), value in USD, CY2019 - CY2029E



	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024	CY2025E	CY2026E	CY2027E	CY2028E	CY2029E
China, People's Republic of	10,334.5	10,695.5	12,877.5	12,968.2	12,960.7	13,312.7	13,687.3	14,534.2	15,519.1	16,558.9	17,575.9
India	2,050.2	1,915.6	2,250.2	2,361.1	2,546.8	2,711.4	2,878.5	3,136.0	3,426.3	3,743.8	4,089.5
United States	65,561.3	64,454.2	71,231.6	77,801.4	82,253.9	85,812.2	89,105.2	98,547.4	95,087.4	92,096.5	101,880.8
Europe	29,310.4	28,363.1	32,581.5	32,871.3	34,949.4	36,590.7	37,557.9	38,985.1	40,407.7	43,577.0	41,958.3
Southeast Asia	4,972.3	4,649.2	5,079.1	5,457.0	5,577.6	5,749.5	5,946.3	6,249.8	6,594.7	6,977.5	7,377.8
World	11,553.6	11,147.3	12,610.5	13,030.3	13,474.0	13,933.3	14,741.6	14,213.3	15,328.5	15,968.6	16,605.3

World	India	China	USA	Europe	Southeast Asia (SEA)
CAGR (CY19-24): 3.8%	CAGR (CY19-24): 5.8%	CAGR (CY19-24): 5.2%	CAGR (CY19-24): 5.5%	CAGR (CY19-24): 4.5%	CAGR (CY19-24): 3.6%
CAGR (CY24-29E): 3.6%	CAGR (CY24-29E): 8.6%	CAGR (CY24-29E): 5.7%	CAGR (CY24-29E): 3.5%	CAGR (CY24-29E): 2.8%	CAGR (CY24-29E): 5.1%

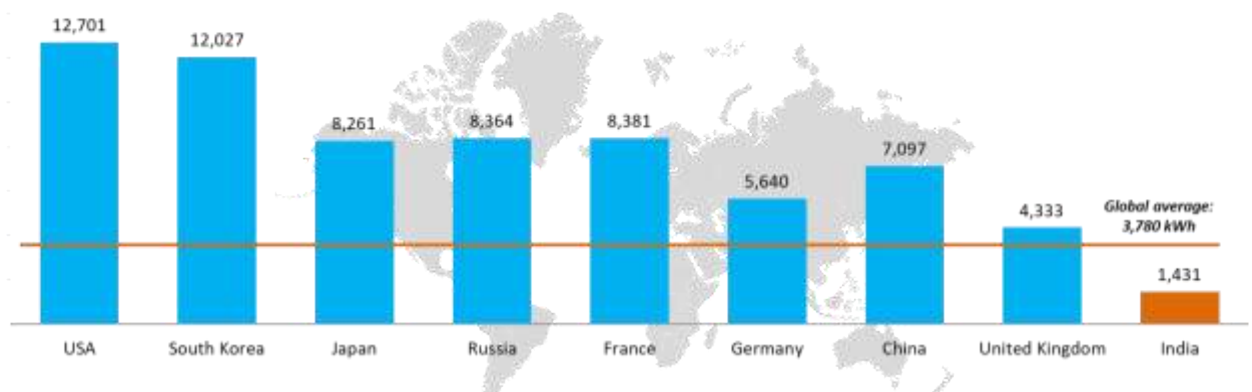
Source: IMF, World Economic Outlook; Frost & Sullivan Analysis

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.

2.8 Per capita electricity consumption

Per capita electricity consumption is a key indicator of a country's development and industrial maturity. While many factors, such as household income, industrial activity, electrification levels, and appliance penetration, influence consumption, population size also plays a moderating role. Among the world's top 10 economies, India continues to have the lowest per capita electricity consumption at 1,431 kWh in 2024, well below the global average of 3,780 kWh. In contrast, mature economies such as the United States (12,701 kWh) and South Korea (12,027 kWh) consume nearly 9–10 times more power per person. India's relatively low figure reflects both its large population and the ongoing journey toward wider electrification and energy access.

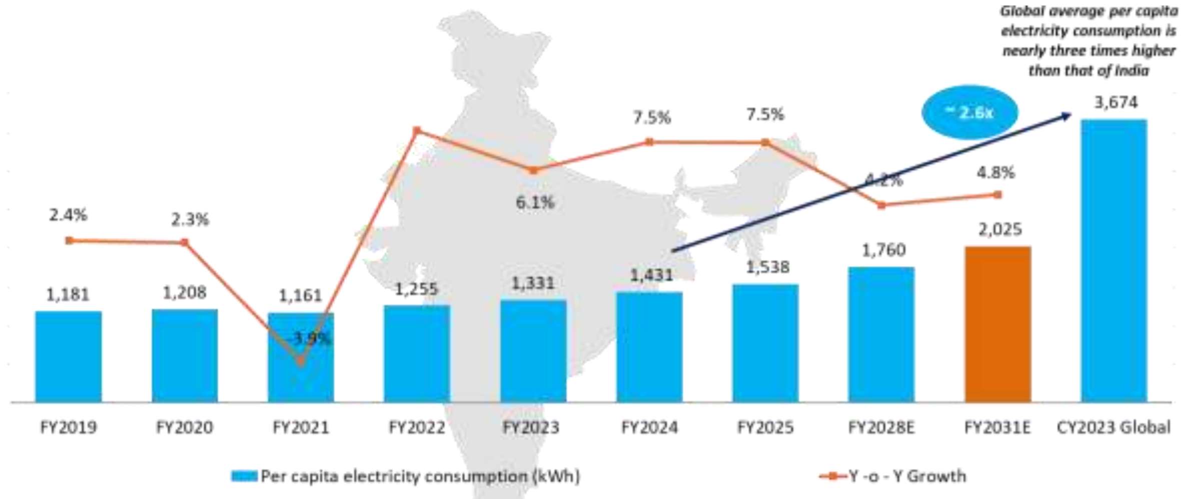
Exhibit 2.9: Per capita electricity consumption of global leading economies vs India, in kWh, CY2024



Source: Statista, Frost & Sullivan Analysis

That said, the progress has been steady and encouraging. India's per capita electricity consumption has grown from 1,181 kWh in FY2019 to 1,431 kWh in FY2024, supported by increasing rural electrification, higher economic activity, and growing adoption of electrical and digital appliances. The growth momentum has remained healthy at over 6–8% annually in recent years. Looking ahead, with continued investments in infrastructure, digitalisation, and manufacturing, and assuming the long-term elasticity of electricity consumption to GDP growth remains around 0.8, India's per capita electricity usage is expected to cross 1,700 kWh by FY2028 and may approach 2,000 kWh by FY2031. This rising trajectory is a positive signal for sectors dependent on energy demand and is reflective of India's broader economic transformation.

Exhibit 2.10: Per capita electricity consumption of India and growth, in kWh and %, FY2019 – FY2031E



Source: Central Electricity Authority, Statista, Frost & Sullivan Analysis

The government of India launched Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) in December 2014 for the rural areas with the objective of electrification of all un-electrified villages as per Census 2011. Similarly, Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) was launched in October 2017 to achieve universal household electrification by providing electricity connections to all un-electrified households in rural areas and all poor households in urban areas of the country. For DDUGJY, the total allocation was INR 44,033 crore, with significant progress made in the electrification of villages and households. These programs have successfully electrified nearly all households across the length and breadth of the country. In FY2025, India has achieved universal electrification as villages and households across the country have been electrified, marking a significant milestone in India's power sector (Source: PIB).

3. INDIA EMERGING AS A GLOBAL MANUFACTURING HUB

3.1 India emerging as a global manufacturing hub

In FY2025, India's merchandise exports reached USD 437.4 billion, maintaining momentum despite global headwinds. With a target of USD 1 trillion by FY2030, the government continues to strengthen the manufacturing sector, which currently contributes about 17% to GDP and employs over 62 million people. Efforts are underway to increase this share to 25%, supported by robust Production-Linked Incentive (PLI) schemes. Key reforms—such as the Goods and Services Tax (GST), reduction in corporate tax rates, and the establishment of Project Development Cells (PDCs)—have boosted investor confidence, with FDI inflows rising to USD 81.0 billion in FY2025, up from USD 45.2 billion in FY2015. Programs like the Phased Manufacturing Programme (PMP) are further anchoring India's position as a global manufacturing and export hub.

3.2 India's competitiveness among the leading manufacturing economies

India's economic growth is driven by strong domestic consumption and private investment, supported by initiatives like "Make in India" and "Atmanirbhar Bharat." These programmes aim to boost manufacturing in key sectors, reduce import dependence, and drive innovation. With a young, cost-effective workforce and the "Skill India" programme focusing on modern skills, India remains competitive despite rising wages. As global manufacturing shifts, India is poised to capture a larger market share due to its favourable demographics and policies. Southeast and South Asia are emerging as key manufacturing hubs, with India being a strong contender.

A. Comparison on key economic parameters:

India continues to stand out as a high-potential economy among its global manufacturing peers. With a population of ~ 1.44 billion and a large working-age demographic (nearly 977.8 million), India enjoys a demographic dividend that many economies, such as China and Thailand, are beginning to lose due to aging populations. India's median age of 28.4 years is notably lower than China (39.2 years) and Thailand (40.1 years), signaling a sustained supply of labor in the coming decades. In contrast, countries like Mexico and Vietnam also have relatively young populations (median ages of 32.6 and 33.0 years respectively), but their total working-age populations are significantly smaller than India's.

From a macroeconomic standpoint, India reported the highest GDP growth among the peer group at 6.2%, indicating strong economic momentum. While China remains the second-largest economy globally with a GDP of USD 18.7 trillion, its growth rate has moderated to 5.0%, partly due to demographic and structural challenges. Vietnam's growth of 7.1% and Mexico's growth of 1.5% further underscore India's relative resilience. Overall, India's combination of youthful population, strong economic growth, and stable inflation positions it favorably as a future manufacturing and investment hub among global emerging economies.

Exhibit 3.1: Comparison on key economic parameters – India vs. China, Thailand, Vietnam, and Mexico, CY2024

PARAMETERS		INDIA	CHINA	THAILAND	VIETNAM	MEXICO
Total Population (Million)*		1,438.0	1,410.7	71.7	101.3	130.9
Population in age 15-64 years (Million)*		977.8	965.7	48.8	68.0	87.9
Median age (Years)		28.4	39.2	40.1	33.0	32.6
Annual GDP (USD Trillion)		3.9	18.7	0.5	0.5	1.9
GDP Growth (%)	CY2024	6.5%	5.0%	2.5%	7.1%	1.5%
	CY2029E	6.5	3.7	2.3	5.3	2.2
Inflation (%)		4.7%	0.2%	0.4%	3.6%	4.7%

** Data available till 2023*

Source: World Bank (Data Bank), IMF, UN (Population Data), Frost & Sullivan analysis

B. Labour market comparison:

India, with a labor force of over 607.7 million, is among the largest globally, but its workforce structure highlights several contrasts compared to key manufacturing peers. Female participation in the labor force remains notably low at 28.7%, reflecting deep-rooted social and structural barriers, whereas countries like Vietnam (48.6%) and China (45.1%) have managed to integrate a higher share of women into their economies. Labor force participation overall is also relatively subdued in India at 50.4%, compared to over 65.0% in most peers, which limits the country's full productive potential.

A closer look at employment quality reveals that only 20.9% of India's employed population are in formal wage or salaried roles, significantly lower than China (54.7%) and Mexico (68.6%). This indicates a largely informal economy, with limited social security and productivity-linked benefits. The share of employment in industry stands at 25.0%, which is broadly comparable with Mexico and Thailand but still below Vietnam's 33.4%—reflecting scope for further industrialization and job creation in manufacturing.

Despite these challenges, India's key competitive edge lies in its labor cost advantage. The real average daily wage in India is USD 6.5—far lower than peers such as China (USD 35.0), Mexico (USD 14.5), and Vietnam (USD 12.0). This cost efficiency positions India as an attractive destination for labor-intensive manufacturing, especially in light of global efforts to diversify supply chains away from China. However, to fully capitalize on this advantage, India must focus on increasing formal employment, enhancing female participation, and improving productivity through skill development and industrial policy support.

Exhibit 3.2: Labour market comparison - India vs. China, Thailand, Vietnam, and Mexico, CY2024

PARAMETERS	INDIA	CHINA	THAILAND	VIETNAM	MEXICO
Total Labour Force (Million)	607.7	773.1	40.6	57.1	61.0
Total Labour Force, Female (% of Total population)	28.7	45.1	45.8	48.6	40.1
Labour force participation rate (% of total population)	50.4	65.4	68.0	73.7	64.8
Employment in Industry (% of Total Employment)	25.0	28.8	*22.1	33.4	*25.0
Wage and salaried workers (% of Total Employment)*	20.9	54.7	47.9	47.0 #	68.6
Real Average Daily Wage	~ 6.5	~35.0	~10.4	~12.0	~14.5

** Data Available only until CY2023*
 # No update available beyond CY2023

Source: IMF, ILO, Statista, Frost & Sullivan analysis

C. Comparison of manufacturing ecosystem:

India is rapidly positioning itself as a key global manufacturing destination, backed by a strong policy framework, growing industrial base, and rising investor confidence. While its manufacturing value added currently stands at 14.8% of GDP, India is steadily climbing the ladder through targeted reforms and incentive-driven initiatives like Make in India and the PLI schemes.

Despite a lower export base (USD 0.47 trillion), India already contributes 3.3% of global manufacturing output, surpassing regional peers like Vietnam, Thailand, and Mexico.

Exhibit 3.3: Comparison of manufacturing ecosystem - India vs. China, Thailand, Vietnam, and Mexico, CY2024

PARAMETERS	INDIA	CHINA	THAILAND	VIETNAM	MEXICO
Manufacturing Value Added (% of GDP)	14.8%	28.0%	25.0%	25.9%	20.3%
Total Export (USD Trillion)	0.47	3.53	0.30	0.41	0.62
Total Imports (USD Trillion)	0.73	2.57	0.31	0.38	0.62
Manufacturing Risk Index (Rank)	2	1	5	11	12
Global manufacturing output (% share)	3.3%	32.0%	0.7%	0.7%	1.7%
FDI Investments (USD Billion)	81.0*	114.8	17.9**	36.9	38.2
Favourable government policies	High	High	High	Medium	Medium
Developed component ecosystem	Medium	High	High	Medium	Medium

Import and Export values mentioned are only for commodities and do not include services
Rank 1 indicates the most beneficial locations for global manufacturing
** Data for India available for FY 2025, other countries CY 2024*
*** Data available for the number of FDI promotion certificates issued*

Source: IMF, Statista, Frost & Sullivan analysis

With FDI inflows touching USD 81 billion, India stands as one of the most attractive investment destinations globally — second only to China. Government policies are rated highly favorable, and while the component ecosystem is currently rated medium, rapid progress is underway through localization mandates and ecosystem-building efforts.

3.3 Government policies and schemes driving manufacturing in India

India's manufacturing sector is undergoing a paradigm shift, driven by large-scale policy reforms and focused industrial support from the Government. At the center of this transformation is the Production Linked Incentive (PLI) Scheme, launched in 2020, which aims to improve domestic value addition, attract global and domestic investment, foster innovation, and boost export competitiveness across priority manufacturing sectors.

As of Budget 2025–26, the Government has scaled up PLI allocations across multiple sectors, signalling an aggressive push to accelerate India's industrial expansion. Key sectors such as Electronics and IT Hardware saw allocations jump from INR 5,777 crore in FY2024-25 (RE) to INR 9,000 crore, while Automobiles and Auto Components grew over 8x to ₹2,818.85 crore. Similarly, Textiles, Specialty Steel, and White Goods —witnessed significant increases in allocations for FY2025-26.

Cumulatively, the PLI scheme now covers 14 critical sectors with a total approved outlay of INR 1.97 lakh crore (USD 26+ billion). By FY2024, actual investments stood at INR 1.46 lakh crore, expected to surpass INR 2 lakh crore within FY2025. These investments have already resulted in production and sales worth INR 12.5 lakh crore, export generation exceeding ₹4 lakh crore, and the creation of 9.5 lakh jobs, projected to touch 12 lakh by next year.

The PLI scheme operates on a performance-linked disbursement model, offering financial incentives based on incremental output, thereby promoting technological depth and economies of scale. Sectors such as electronics, pharmaceuticals, automotive, telecom, and solar PV have emerged as the biggest beneficiaries, with India becoming a net exporter of mobile phones, producing 33 crore units in FY2023-24, and reducing reliance on critical imports in pharma and renewable energy segments.

Exhibit 3.4: Approved financial outlay under Production Linked Incentive (PLI) scheme

Sectors	Implementing Ministry/Department	Revised Estimate 2024–25	Budgetary Estimate 2025–26
Electronics Manufacturing & IT Hardware	Ministry of Electronics & Information Technology	5,777.0	9,000.0
Automobiles & Auto Components	Department of Heavy Industries	346.9	2,818.9
Pharmaceuticals	Department of Pharmaceuticals	2,150.5	2,444.9
Textile Products	Ministry of Textiles	45.0	1,148.0
White Goods (Air Conditioners and LED Lights)	Department for Promotion of Industry and Internal Trade	213.6	444.5
Specialty Steel	Ministry of Steel	55.0	305.0
Advanced Chemistry Cell (ACC) Battery Storage	NITI Aayog & Department of Heavy Industries	15.4	155.8

Source: DPIIT, Invest India, Frost & Sullivan Analysis

3.4 India emerging as the world's technology hub

As of 2024, the National Industrial Corridor Development Corporation (NICDC) oversees 11 industrial corridors under the National Industrial Corridor Development Programme (NICDP). These corridors are designed to enhance infrastructure, boost manufacturing capabilities, and promote economic growth across various regions of the country.

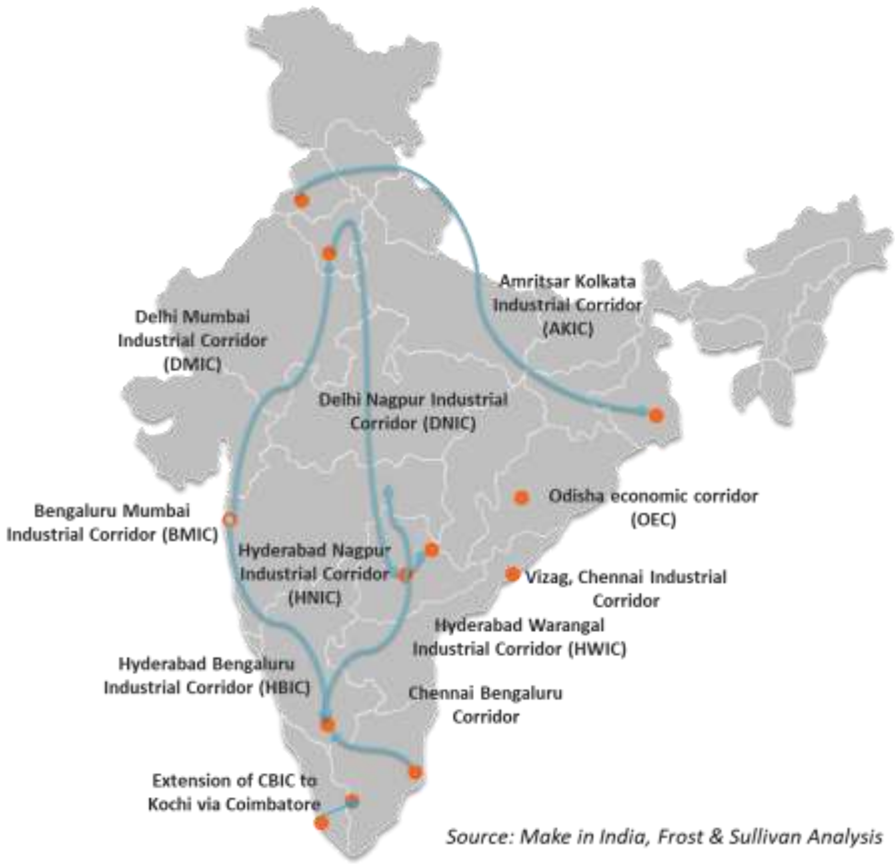
In addition to these, the Bharatmala Pariyojana, a significant highway development initiative, has identified 44 economic corridors in its first phase. These corridors aim to improve road connectivity, reduce logistics costs, and facilitate the movement of goods and people across the nation.

Furthermore, in the 2024 Union Budget, the Indian government announced the development of three new railway economic corridors under the PM Gati Shakti plan. These include:

- Energy, Mineral, and Cement Corridors
- Port Connectivity Corridors
- High Traffic Density Corridors

These initiatives aim to bolster multi-modal connectivity and reduce logistics costs across the nation. Collectively, these developments reflect India's commitment to enhancing its infrastructure and fostering economic growth through the strategic development of multiple economic corridors.

Exhibit 3.5: Development of 11 industrial corridors



Source: Make in India, Frost & Sullivan Analysis

4. OVERVIEW OF GLOBAL WASTEWATER TREATMENT MARKET

4.1 Overview of the Global Wastewater Treatment Market

As of 2025, the global wastewater treatment market remains stable in its strategic importance, driven by urban growth, industrialisation, and tightening environmental regulations. Governments and industries continue to invest in wastewater systems that support long-term sustainability goals, with a focus on circular water use, energy recovery, and compliance.

In Southeast Asia, circularity initiatives — particularly nutrient and energy recovery from sludge — are gaining traction. Europe and North America remain focused on addressing emerging contaminants through advanced treatment technologies. Reuse of treated wastewater continues to expand across water-scarce regions, including the Middle East, Latin America, and parts of Asia and North America.

Digital tools and energy-efficient systems are increasingly being adopted to improve operational performance. Overall, wastewater treatment is evolving from a purely regulatory function to a key element in broader environmental and resource management strategies.

4.2 Size of the global wastewater treatment market

The global water and wastewater treatment market stood at USD 880 billion in CY2024 and is projected to grow to USD 1,172 billion by CY2029E, reflecting a CAGR of approximately 5.9%.

Exhibit 4.1: Global water and wastewater treatment market size, Global, in USD billion, CY2019 – CY2029E

Exhibit 4.2: Global water and wastewater treatment market, Global, in USD billion, CY2019–CY2029E

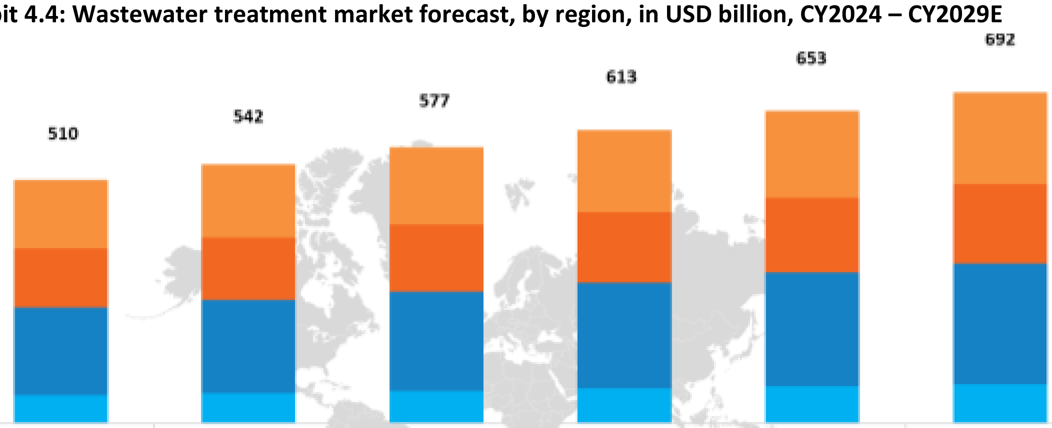
4.3 Global Wastewater treatment market split by region

The global wastewater treatment solutions market is projected to grow from USD 510 billion in CY2024 to USD 692 billion by CY2029E, registering a CAGR of 6.3%. The market is driven by stricter compliance mandates, rising demand for water reuse, and growing investments in municipal and industrial wastewater infrastructure.

Exhibit 4.3: Wastewater treatment market size by region, split by percentage, value in USD Bn, CY2024

Source: Frost & Sullivan knowledge repository and analysis

Exhibit 4.4: Wastewater treatment market forecast, by region, in USD billion, CY2024 – CY2029E



	CY2024	CY2025E	CY2026E	CY2027E	CY2028E	CY2029E
Americas	144	152	161	170	180	191
Europe	124	132	140	148	157	166
SEA	182	194	208	222	238	252
MEA	60	64	68	73	78	83

Source: Frost & Sullivan knowledge repository and analysis

This growth is driven by rapid urbanization, increased water quality awareness, water scarcity, and stringent regulations, with key investments in recycling and reuse systems across developing economies like China, India, Vietnam, and Indonesia.

4.4 Factors driving the growth of the wastewater treatment market by different regions

Middle East: Growth in the MEA wastewater treatment market is driven by rapid population growth, economic diversification, and a strategic shift away from oil dependency. GCC nations are prioritising sustainability and water reuse, with Saudi Arabia's Vision 2030 setting aggressive targets for treated wastewater recycling. Israel remains a global leader in reuse technologies, while countries like Jordan increasingly rely on treated wastewater for agricultural irrigation. In Sub-Saharan Africa, donor-led initiatives are supporting the expansion of basic sanitation and decentralised treatment systems.

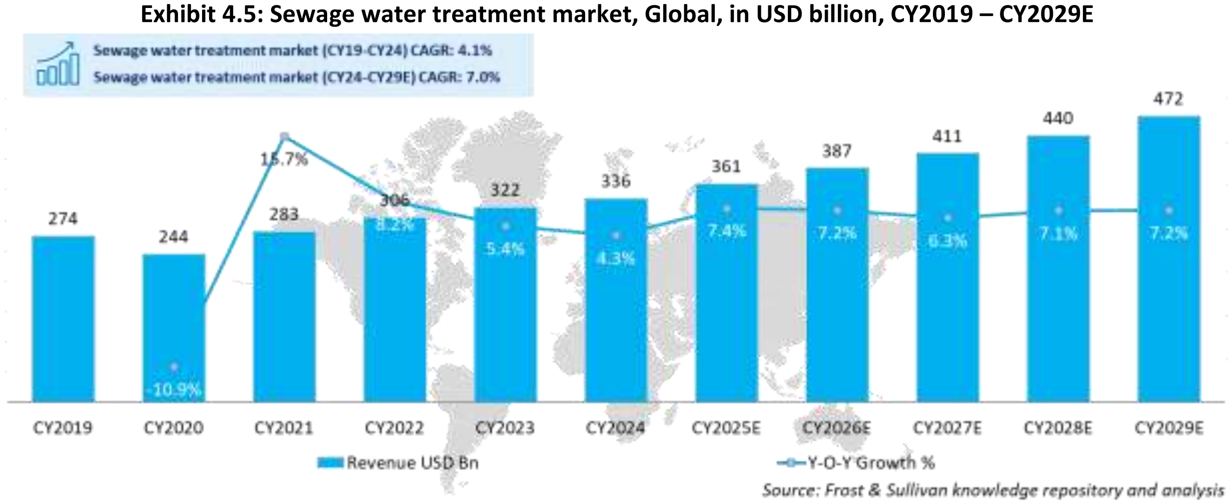
Southeast Asia: The SEA region is witnessing robust demand due to rapid urbanisation, industrial growth, and the adoption of circular economy principles. Governments are investing in infrastructure with a focus on resource recovery and smart technology integration. Singapore's Tuas South Water Reclamation Plant, with its use of sensors and automation, sets a regional benchmark. Projects like Vietnam's Da Nang Green City reflect growing commitments to energy efficiency, nutrient recovery, and sustainability in wastewater management.

Europe: Europe's wastewater market is largely shaped by stringent regulations and the need to modernise ageing infrastructure. The updated EU Urban Wastewater Treatment Directive (UWWTD) mandates stricter discharge norms, promoting upgrades to tertiary treatment and micropollutant removal. Countries like the Netherlands are at the forefront of water reuse and nutrient recovery, while the UK faces growing scrutiny over underinvestment and is under pressure to close infrastructure gaps.

4.5 Overview of the global Sewage treatment market

Sewage treatment remains a critical subset of the broader wastewater treatment sector, focused on the processing and management of wastewater originating from residential, commercial, and industrial sources. Over the past five years, the sector has seen steady expansion, rising from USD 274 billion in CY2019 to USD 336 billion in CY2024, with projections estimating the market to reach USD 472 billion by CY2029E. This growth is underpinned by a shift in perception: sewage water is no longer viewed merely as waste, but increasingly as a recoverable resource. Governments, utilities, and industries alike are investing in advanced treatment technologies that enable the conversion of biosolids into energy, nutrient recovery, and water reuse — helping to close the loop and align with circular economy goals.

Exhibit 4.5: Sewage water treatment market, Global, in USD billion, CY2019 – CY2029E

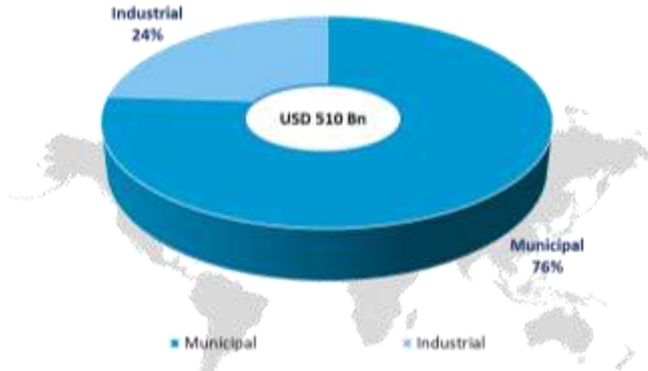


Source: Frost & Sullivan knowledge repository and analysis

Municipal Segment: Sewage treatment is crucial for municipal systems, managing over 76% of municipal wastewater from households, businesses, and institutions. This segment uses comprehensive treatment stages to ensure public health and hygiene.

Industrial Segment: Industrial sewage treatment accounts for about 24% of the total Industrial wastewater, with high contaminants, often requires extensive pre-treatment before discharge. Many industries use on-site treatment solutions to manage specific wastewater characteristics and reduce environmental impact

Exhibit 4.6: Wastewater treatment market split by end-user segment, Global, CY2024



Source: Frost & Sullivan knowledge repository and analysis

Exhibit 4.7: Primary, secondary, and tertiary sewage treatment

Primary Treatment	This involves physical processes like screening and sedimentation to remove large solids and organic matter
Secondary Treatment	This utilizes biological processes like activated sludge or trickling filters to break down organic matter through the action of microorganisms
Tertiary Treatment	This is an optional stage that provides additional treatment for specific purposes, such as removing nutrients or disinfecting the treated wastewater for reuse.

Source: Frost & Sullivan analysis

4.6 Global Sewage water treatment market split by regions

Southeast Asia continues to dominate the global sewage treatment market, driven by rapid urbanisation, growing population density, and sustained economic expansion. Countries like Indonesia, Vietnam, and the Philippines are making significant investments in wastewater infrastructure to address both sanitation challenges and flood risks. In CY2024, the region (excluding India) generated an estimated ~82,000 Million Litres per Day (MLD) of sewage, up from ~79,000 MLD in CY2023.

Europe generated approximately ~113,500 MLD of sewage in CY2024, maintaining its position as a mature but heavily regulated market. The region continues to push towards advanced tertiary treatment systems, driven by stricter compliance with EU directives and sustainability targets.

The Americas produced an estimated ~133,900 MLD of sewage in 2024. In the U.S. and Canada, tightening environmental regulations under frameworks like the Clean Water Act continue to encourage the adoption of advanced wastewater treatment technologies, including nutrient removal and energy recovery systems.

In the Middle East and Africa, sewage generation reached approximately ~61,300 MLD in CY2024. Water scarcity remains a critical challenge, prompting countries like Saudi Arabia and UAE to invest aggressively in sewage reuse and zero-liquid-discharge (ZLD) systems. Saudi Arabia's National Program for Wastewater Treatment is progressing toward its target of treating and reusing 70% of wastewater by 2030.

Exhibit 4.8: Sewage generation, in MLD, in countries of interest, CY2024

**Note: Southeast Asia numbers are excluding India*

Source: Frost & Sullivan knowledge repository and analysis

Exhibit 4.9: Sewage water treatment market size by region, split by percentage, CY2024

**Note: Southeast Asia numbers are excluding India*

Source: Frost & Sullivan knowledge repository and analysis

4.7 Factors driving the growth of the sewage water treatment market in the region

The global sewage water treatment market is experiencing notable growth driven by regional factors:

Middle East: Chronic water scarcity continues to be a major driver, with treated sewage water increasingly used for non-potable applications such as irrigation and landscaping. Gulf countries are expanding tertiary treatment capacity to support urban greening and sustainable tourism. For instance, Doha and Abu Dhabi continue to expand reuse networks, while plants in Sharm El Sheikh and NEOM (Saudi Arabia) are being upgraded with energy-efficient technologies to align with climate goals.

Southeast Asia: Urbanisation and industrial growth are putting pressure on aging sewage systems, accelerating demand for modern infrastructure. Vietnam, Indonesia, and the Philippines are investing in decentralised and modular treatment systems to quickly expand access in underserved areas. Singapore is piloting advanced bio-oxidation and membrane technologies as part of its NEWater roadmap, and regional governments are aligning more closely with ASEAN environmental targets.

Africa: Inadequate sanitation coverage continues to drive donor-led investment in sewage treatment, especially in peri-urban and rural areas. Countries like Kenya, Ghana, and Rwanda are receiving multilateral support (e.g., AfDB, World Bank) to build decentralised treatment plants. There is a growing focus on capacity-building, workforce training, and alignment with WHO wastewater safety planning to ensure long-term system sustainability.

4.8 Prominent technologies deployed for sewage treatment in these regions

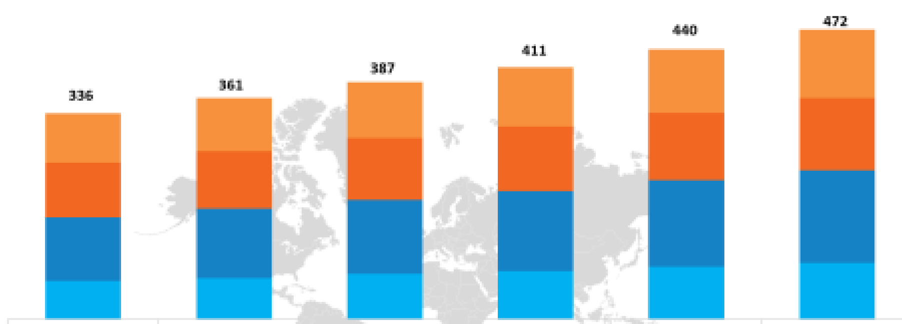
Exhibit 4.9: Comparison of sewage water treatment technologies, Southeast Asia (SEA) vs Middle East & Africa (MEA)

TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SEA (POTENTIAL PREFERENCE)	MEA (POTENTIAL PREFERENCE)
Membrane Bioreactors (MBR)	High-quality water; suitable for reuse and irrigation	High investment and operational cost	Moderate	Low (due to cost)
Advanced Oxidation Process (AOP)	Removes emerging contaminants	High energy consumption	Low	Moderate (for specific applications)
Activated Sludge Process	Widely used, established technology	Requires significant space and energy	High	Moderate (due to established infrastructure)
Constructed Wetlands	Low energy consumption, natural treatment process	Requires large land area	High	Moderate (limited land availability in some areas)
Sequencing Batch Reactors (SBR)	Operational flexibility, highly efficient	Requires longer treatment time	Moderate	Low (may not be as cost-effective in all areas)
Upflow Anaerobic Sludge Blanket Reactors (UASB)	High efficiency, compact design	-	Moderate	High (suitable for areas with space limitations)

4.9 Growth forecast for the sewage treatment market: Middle East, Southeast Asia, and Africa

The global sewage water treatment market is projected to grow from USD 336 billion in CY2024 to USD 472 billion by CY2029E, registering a CAGR of ~7.0%. This growth is driven by rising urban populations, increasing awareness of water reuse, and tightening environmental regulations across both developed and developing economies.

Exhibit 4.10: Sewage water treatment market forecast by region, in USD billion, CY2024 –2029E



	CY2024	CY2025E	CY2026E	CY2027E	CY2028E	CY2029E
Americas	80.6	86.6	90.8	96.5	103.4	110.8
Europe	89.0	93.8	100.5	104.8	110.0	117.9
SEA	104.1	113.6	121.8	131.5	140.9	150.9
MEA	62.1	66.7	73.4	78.1	85.8	92.0

Source: Primary interactions, Frost & Sullivan knowledge repository and analysis

Southeast Asia remains the largest regional market, driven by rapid urbanization and infrastructure upgrades, contributing ~31% of the global market in CY2024. MEA is the fastest-growing region (8.2%

CAGR), propelled by water reuse mandates and PPP-led investments. Europe and the Americas are experiencing steady growth due to regulatory upgrades and a shift toward advanced, energy-efficient wastewater treatment systems. Globally, the focus is shifting toward decentralized solutions, digital monitoring, and resource recovery.

4.10 Notable list of upcoming sewage treatment projects

Exhibit 4.11 provides a snapshot of various water infrastructure projects currently underway around the world. It encompasses a range of facilities, including sewage treatment plants that are geographically spread across the Middle East, Southeast Asia, Africa, and Europe.

Exhibit 4.11: List of upcoming sewage water treatment projects

REGION	PROJECT NAME	LOCATION	INVEST-MENT	CAPACITY (MLD)	TECHNOLOGY	STATUS	TENTATIVE TIMELINE
Middle East	Jebel Ali STP Phase 2	Dubai, UAE	N/A	1,050	Activated Sludge Reactors	In Progress	Completion by 2026–27
Middle East	SWPC – Tabuk ISTP Phase II	Tabuk, Saudi Arabia	USD 145.8 million	90	SBR (Sequencing Batch Reactor)	In Progress	Completion by 2026
Middle East	Rakwa Wastewater Infrastructure (PPP)	Ras Al Khaimah, UAE	N/A	60–150 (expansion)	New STP + Sewerage Network	Not Yet Started (Bidding)	Start by late 2025
Middle East	Al Haer ISTP	Riyadh, Saudi Arabia	USD 371 million	200	Likely MBR/SBR	Awarded, Not Yet Started	Construction from late 2025
Africa	MHHUD WWTP	Maghagha, Egypt	USD 19.4 million	30–60	Sedimentation, Biological, Filtration	In Progress	Completion by 2026
Southeast Asia	Nhieu Loc–Thi Nghe WWTP	HCMC, Vietnam	USD ~500 million	816	MBBR (Moving Bed Biofilm Reactor)	In Progress	Completion by June 2025
Americas	North End STP – Biosolids Upgrade	Winnipeg, Canada	N/A	Upgrade only	Biosolids Treatment Infrastructure	Planned	Start in 2025, finish by 2028

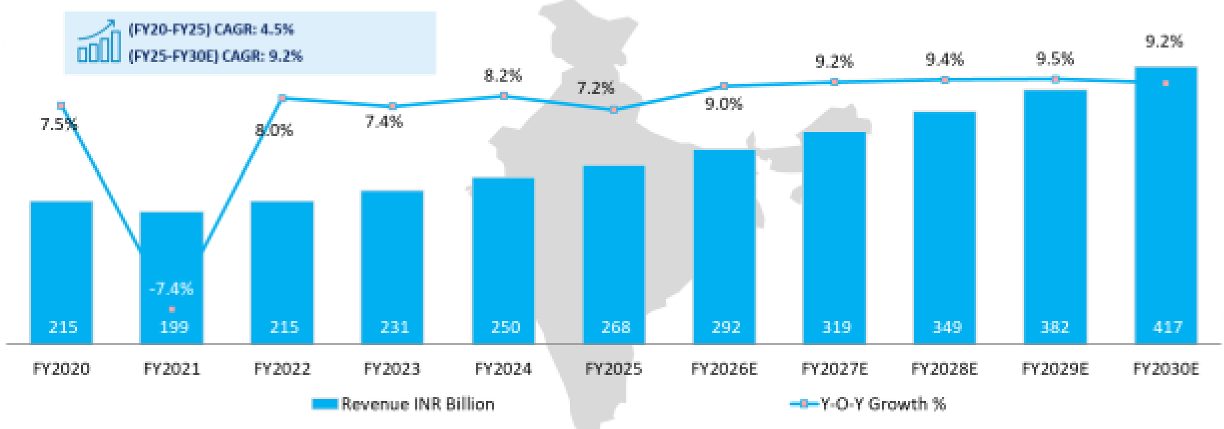
5. OPPORTUNITY LANDSCAPE OF INDIA'S SEWAGE TREATMENT MARKET

5.1 Overview of Indian Wastewater Treatment Market

India's wastewater treatment market is growing steadily, driven by opportunities in both the industrial and municipal sectors. The expansion is supported by high industrial activity, ongoing urbanization, economic growth, and increasing groundwater stress — all of which necessitate more effective wastewater management. The government's commitment to sustainability, coupled with financial incentives, continues to foster a favorable environment for adopting innovative treatment technologies. Notably, the market is witnessing a gradual shift from price-sensitive procurement to value-based approaches, with a growing number of Build, Own, Operate, and Transfer (BOOT) projects, typically spanning 15 to 30 years, that emphasize long-term performance and reliability.

Private sector participation is rising, particularly in the municipal segment through public-private partnerships (PPPs), which offer municipalities access to technical expertise and operational efficiencies while enabling private players to tap into long-term business opportunities. With many Indian cities still reliant on legacy systems, there is a strong push to modernize infrastructure to meet updated environmental and performance standards.

Exhibit 5.1(a): Water and wastewater treatment market size, in INR billion, India, FY2020 – FY2030E



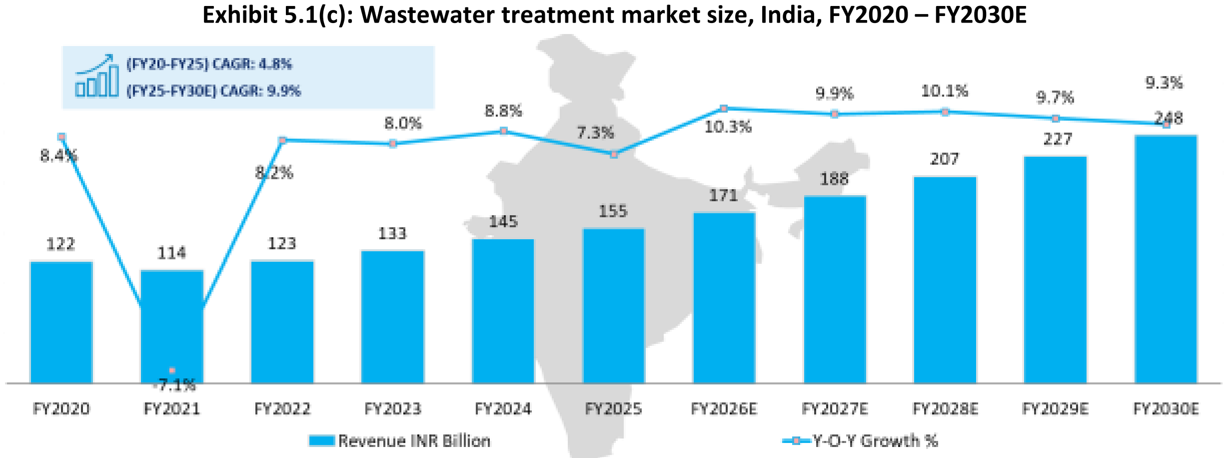
Source: Primary interactions, Frost & Sullivan analysis

Exhibit 5.1(b): Water and wastewater treatment market size and segmentation, India, FY2025

Source: Primary interactions, Frost & Sullivan analysis

The industry recorded a revenue of INR 268 billion in FY2025, reflecting a 7.2% year-on-year growth, and is expected to accelerate to 9.2% CAGR through FY2030E, supported by renewed project allocations and

Exhibit 5.1(c): Wastewater treatment market size, India, FY2020 – FY2030E



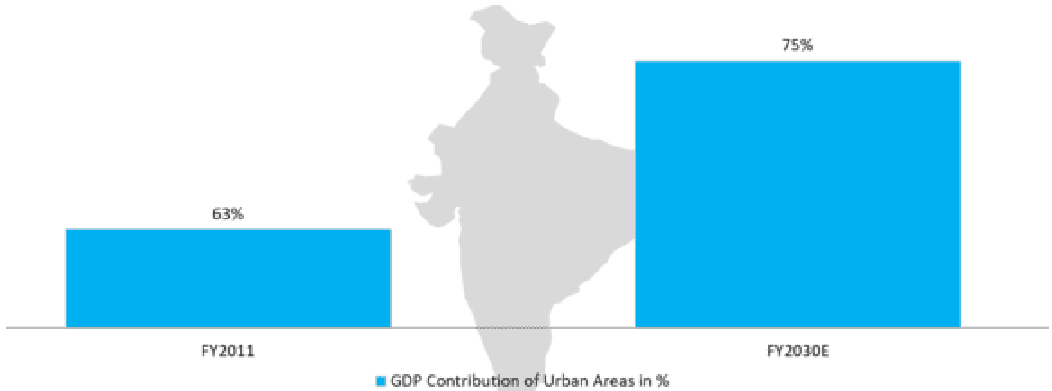
Source: Primary interactions, Frost & Sullivan analysis increasing adoption of digital monitoring. In terms of capital investment, for an STP sized between 20 MLD and 100 MLD, total costs typically range from INR 300 million to INR 1,000 million, depending on factors like land, technology, and site conditions. The C-Tech[1] package accounts for about 10–15% of the total cost, while disc filters and blowers contribute 5–8% each. The remaining budget typically covers civil works, electro-mechanical systems, instrumentation, and piping.

5.2 Factors and rules driving the Indian wastewater treatment market

A. Rising population and per capita consumption:

Urban India faces challenges in providing water and sanitation due to population growth and changing consumption patterns. Rising disposable incomes and urbanisation lead to more water-intensive lifestyles, increasing water use for activities like gardening and using appliances.

Exhibit 5.2: GDP contributions of urban areas, India, FY2011 and FY2030E



Source: Census 2011, Ministry of Urban Development's Smart Cities Mission Statement & Guidelines

Groundwater levels have declined in many urban areas due to uneven rainfall and overexploitation. The Central Groundwater Board (CGWB) reports a 0 to 2-metre decline in 33% of groundwater tables since 2010, with cities such as Delhi and Chennai experiencing declines exceeding 4 metres. Coastal cities like Chennai have adopted seawater RO desalination to address shortages. These factors result in increased wastewater volumes needing treatment.

B. Leachate Treatment for Municipal Solid Waste Landfill Management:

India's reliance on overflowing landfills and inadequate leachate management highlights a significant opportunity for advancements in wastewater treatment. Over 3,000 landfills lack proper leachate management systems, causing environmental damage. Although stringent regulations are in place, lax enforcement results in minimal compliance. However, anticipated stricter regulation enforcement, driven by a focus on sustainability and UN SDGs, is expected to boost the demand for effective leachate treatment technologies. Major urban centres in India will see increased demand for such solutions, presenting opportunities for companies with innovative leachate treatment technologies.

C. Decentralized solutions

India faces a hidden water crisis due to ageing or inadequate sewage systems in many urban areas, particularly smaller towns and peri-urban fringes. This leads to untreated wastewater contaminating groundwater and posing health risks. The demand for decentralised wastewater treatment solutions is

[1] Refer to section 5.11 on C Tech Technology

rising as these compact, on-site systems can treat wastewater at the source, easing the burden on centralised infrastructure and enabling local reuse for irrigation or sanitation.

D. Growing water scarcity and need for reuse

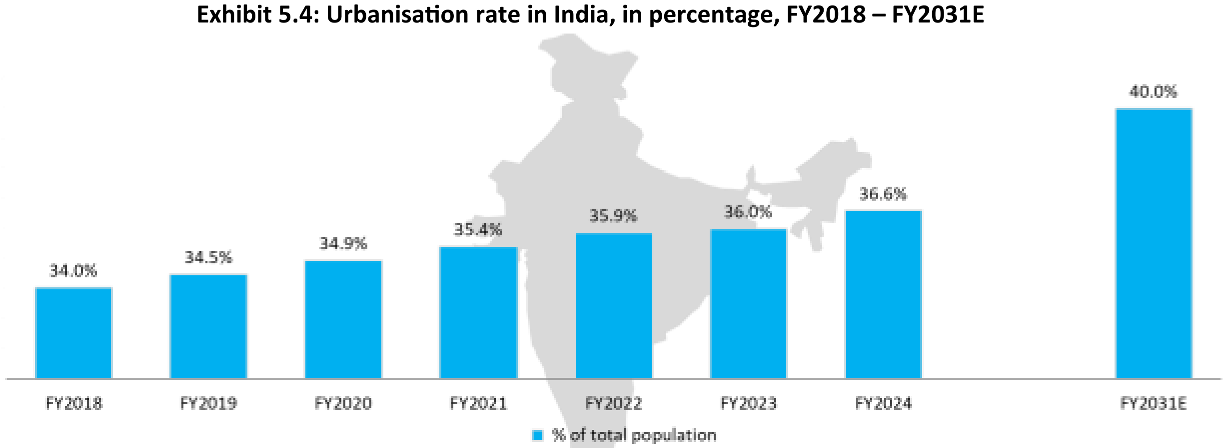
The pressing issue of water scarcity amplifies the urgency for effective water management practices, driving investment in innovative treatment technologies. Water scarcity is a growing threat across the globe, with burgeoning populations and climate change putting immense strain on freshwater resources. India's water future is poised for positive change, driven by a growing emphasis on wastewater treatment and reuse. By treating wastewater to appropriate standards, it can be used for non-potable purposes like irrigation or industrial processes, essentially creating new and reliable water source. The National Water Policy (2012) reinforces this approach by mandating effective wastewater treatment and promoting its reuse. Policy support, financial incentives, and a commitment to sustainability are advancing the role of treated wastewater in addressing India's water needs.

E. Urbanization and Industrial growth

Rapid urbanisation leads to increased wastewater generation due to denser populations and greater infrastructure development. Industries are another major source of wastewater, particularly water-intensive sectors like textiles and pharmaceuticals. The Regulatory Framework is as follows:

- **Town and Country Planning Acts of various states:** Often mandate provisions for wastewater treatment infrastructure in urban development plans.
- **Industry-specific regulations:** Certain industries, like textiles and pharmaceuticals, have specific regulations governing wastewater treatment and disposal within their respective environmental acts.

Exhibit 5.4: Urbanisation rate in India, in percentage, FY2018 – FY2031E



Source: Trade Economics, World Bank, Primary interactions, Frost & Sullivan analysis

F. Government initiatives and funding

The Indian government recognizes the importance of wastewater treatment and has launched several initiatives to accelerate infrastructure development. Key Programs are:

- **Atal Mission for Rejuvenation and Urban Transformation (AMRUT):** The AMRUT programme has significantly improved urban wastewater infrastructure, adding over 4,400 MLD of STP capacity under AMRUT 1.0. AMRUT 2.0 now targets 6,700 MLD, with a strong push toward water reuse. The Jal Hi Amrit (JHA) initiative, launched in late 2024, incentivises better STP performance—already 880 plants have enrolled.

- **National Mission for Clean Ganga (NMCG):** Invests in wastewater treatment projects along the Ganges River to clean the river. NMCG has constructed numerous sewage treatment plants (STPs) and improved sanitation infrastructure, leading to improved water quality in the Ganges.
- **Jal Jeevan Mission (JJM):** Aims to provide piped drinking water to rural households and requires investments in wastewater treatment to prevent contamination. JJM's focus on piped water reduces open defecation, decreasing raw sewage contamination. It also promotes decentralized wastewater treatment through greywater management plans in villages with piped water.

The growing emphasis on wastewater treatment and reuse could also create opportunities for vertically integrated players like SFC Environmental Technologies, which can provide a comprehensive range of services from treatment to reuse management.

G. Technological advancements and efficiency:

The Indian wastewater treatment market is witnessing a wave of tech-driven innovation. Start-ups and established companies are developing cost-effective and efficient treatment solutions tailored to India's specific needs. These innovations include:

- **Modular Treatment Plants**: These prefabricated units offer a faster and more cost-effective solution for setting up wastewater treatment facilities, particularly in smaller communities.
- **Internet of Things (IoT) Integration:** Integrating sensors and real-time monitoring systems allows for remote monitoring and optimization of wastewater treatment processes, leading to improved efficiency and reduced operational costs.
- **Low-Energy Treatment Technologies:** With rising energy costs, developing treatment technologies that require less energy consumption is crucial for the long-term sustainability of wastewater treatment solutions in India.

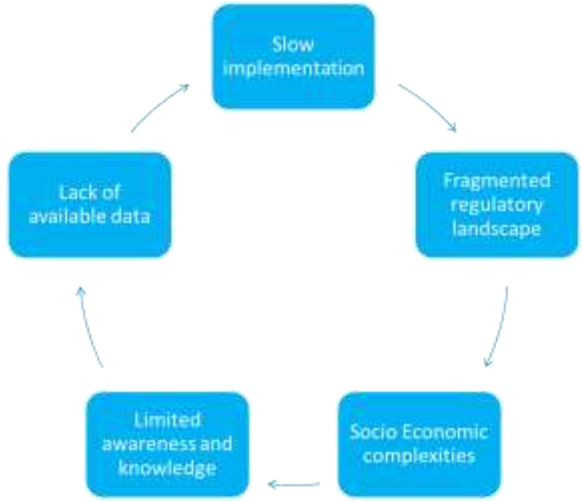
H. A shift of mindset:

Traditionally, wastewater in India has been seen as a waste product. However, there is a growing shift in perspective, with government initiatives and public awareness campaigns promoting wastewater as a resource. Treated wastewater can provide an alternative source for irrigation, addressing agricultural water scarcity and reducing reliance on freshwater. Advances in treatment technologies also enable the reuse of treated wastewater for non-potable urban applications, such as toilet flushing and park irrigation. This approach decreases freshwater demand and supports a more circular water economy in cities.

5.3 Market restraints for the Indian wastewater treatment market

With rapid urbanization, many Indian cities are facing significant waste management challenges. Consequently, wastewater treatment has emerged as a critical sector, promising not only environmental benefits but also the potential for water reuse and resource recovery. While the market presents a significant opportunity, its growth is not without its challenges. Beyond the frequently cited hurdles of infrastructure investment and technological adoption, several unconventional restraints hinder the sector's full potential. These restraints include:

Exhibit 5.5: Market restraints for the Indian wastewater treatment market



Source: Frost & Sullivan analysis

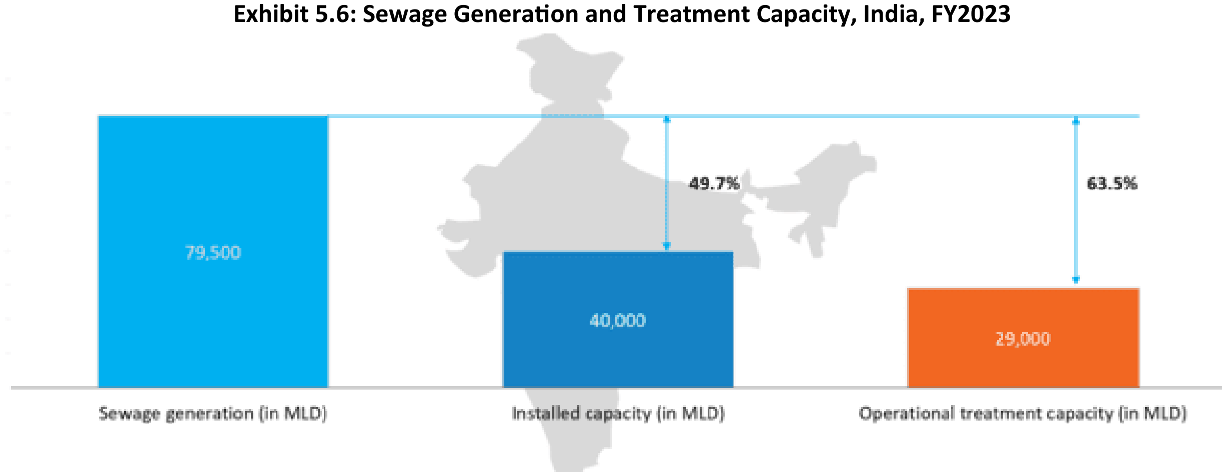
5.4 Indian sewage treatment market

India's sewage water treatment market is experiencing a surge driven by the urgent need for effective wastewater management. Expanding industries, and the alarming state of river pollution are all converging to create a critical situation. Fortunately, the Indian government recognizes this challenge and is taking steps to remedy this.

A. Sewage generation and treatment capacity in India

Stringent environmental regulations, a focus on sustainability, and infrastructure development are fostering innovation in wastewater treatment. India's urban population generates 79,500 million litres per day (MLD) of sewage, but the operational treatment capacity is only 29,000 MLD, leaving a shortfall of 50,500 MLD.

Exhibit 5.6: Sewage Generation and Treatment Capacity, India, FY2023



Source: Primary interactions, Frost & Sullivan analysis

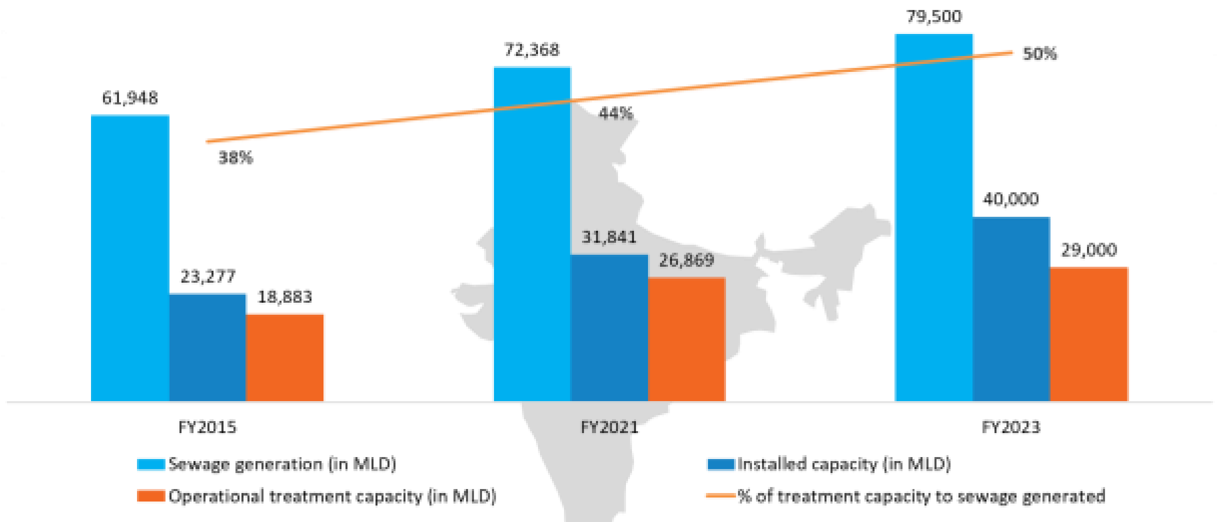
This results in 63.5% of sewage being untreated, leading to river and groundwater pollution, harming ecosystems, contaminating drinking water, and spreading waterborne diseases. Addressing these challenges requires new technologies to modernize outdated treatment plants and enhance the water cycle's sustainability.

B. Current inventory of Sewage Treatment plants in the country

Effective wastewater management is a cornerstone of environmental health and sustainable development. In India, significant efforts are underway to address the challenge of untreated sewage. A crucial aspect of this endeavor is maintaining a comprehensive inventory of existing Sewage Treatment Plants (STPs). According to the Central Pollution Control Board's (CPCB) latest report published in March 2021, India possesses a network of 1,093 Operational Sewage Treatment Plants (STPs) (no. of installed STPs being 1,469) spread across its 35 states and union territories as on June 30, 2020.

India's sewage generation for urban areas has steadily increased from 61,948 million liters per day (MLD) in FY2017 to 79,500 MLD in FY2023, reflecting urbanization and population growth. Over the same period, sewage processing capacity has risen from 23,277 MLD in FY2015 to 40,000 MLD in FY2023, indicating efforts to expand infrastructure but still lagging behind the growing sewage output. Projections show that by FY2029, sewage generation will reach 102,025 MLD, while processing capacity is expected to improve to 68,737 MLD, highlighting the need for continued investment to bridge the gap and meet environmental sustainability goals.

Exhibit 5.7(a): Sewage generation and treatment capacity in India, FY2015, FY2021 and FY2023

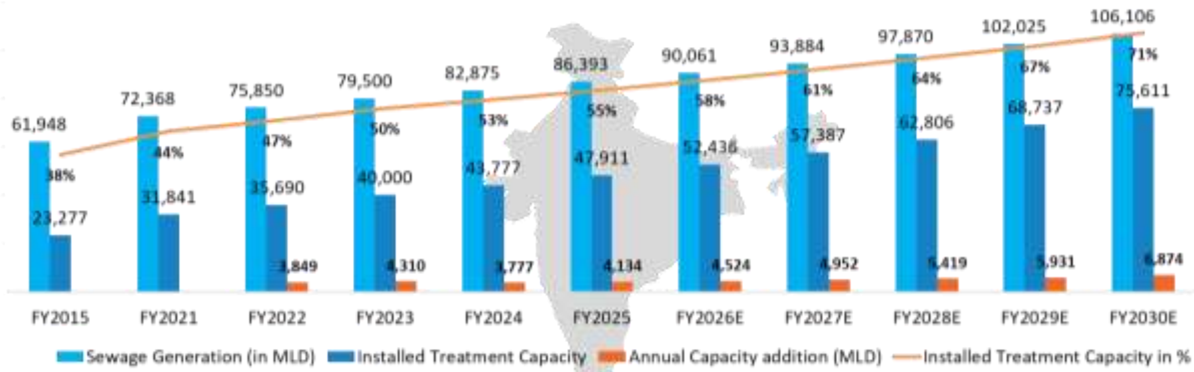


Source: National inventory of sewage treatment plants, Primary interview, Frost & Sullivan analysis

The data indicates a significant and consistent issue with the gap between sewage generation and processing capacity in India, yet it shows a promising trend of gradual improvement. From FY2015 to FY2030E, sewage generation is projected to increase from 61,948 MLD to 106,106 MLD. Although installed treatment capacity is also projected to increase from 23,277 MLD in FY2015 to an estimated 75,611 MLD in FY2030E, the gap between generated sewage and its processing remains substantial.

However, it is noteworthy that the gap is slowly narrowing over the years. In FY2015, the gap was 38,671 MLD, and it is projected to decrease to 30,495 MLD by FY2030E. Additionally, the percentage of sewage processed is expected to improve from 38% in FY2015 to an expected 71% by FY2030E, indicating progressive strides towards enhancing sewage treatment infrastructure.

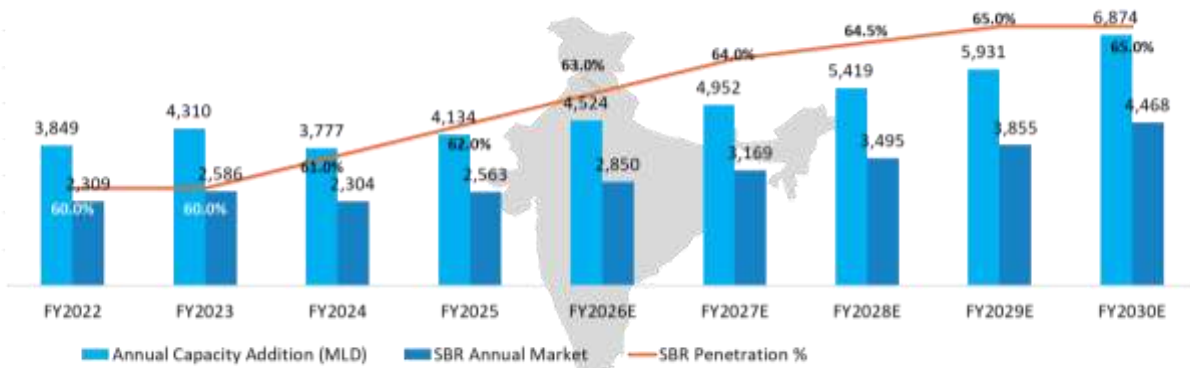
Exhibit 5.7 (b): Estimated sewage generation versus installed treatment capacity in India, FY2015 – FY2030E



Source: Primary interactions, Frost & Sullivan analysis

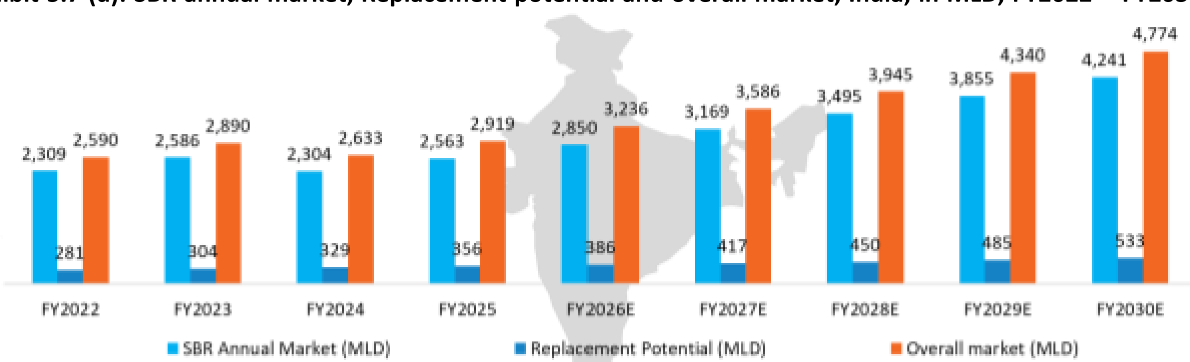
Despite these improvements, the persistent gap highlights the need for accelerated efforts in expanding sewage treatment facilities to keep pace with increasing urbanization and population growth. This challenge underscores the importance of investing in more efficient and scalable sewage treatment technologies and policies to bridge this gap more rapidly.

Exhibit 5.7 (c): Estimated annual capacity addition and penetration of SBR in India, FY2022 – FY2030E



Source: Primary interactions, Frost & Sullivan analysis

Exhibit 5.7 (d): SBR annual market, Replacement potential and overall market, India, in MLD, FY2022 – FY2030E



Source: Primary interactions, Frost & Sullivan analysis

The Sequential Batch Reactor (SBR) market is experiencing steady growth, driven by both new installations and replacement needs. The annual market for SBR systems is expected to increase from 2,309 MLD to 4,241 MLD between FY2022 and FY2030E. Replacement potential has also expanded, from 281 MLD in FY2022 and is anticipated to grow to 533 MLD by FY2030E. As a result, the overall annual market for SBR, which combines new demand and replacements, is projected to increase from 2,590 MLD in FY2022 to 4,774 MLD in FY2030E, reflecting rising investment in wastewater treatment infrastructure.

5.5 Guidelines and Governance in the Sewage Treatment Sector: Incentives and Penalties

The Indian government enforces regulations and incentives to ensure environmentally sound wastewater management in the sewage treatment industry. The Central Pollution Control Board (CPCB) mandates that certain infrastructures, including apartments, commercial projects, educational institutions, townships, and area development projects, must have sewage treatment plants (STPs) if they meet specific conditions. The regulations cover STP site selection, technology, operation, and maintenance to ensure effective and safe operation. These rules aim to promote compliance while also providing financial incentives and penalties to regulate the industry.

A. The Technology of STP

The approved STP technologies are:

- Sequential Batch Reactor (SBR) (Cyclic activated sludge technology (C-Tech) is the recent version of sequential batch reactor)
- Activated Sludge Process (ASP) (only when above 500 KLD sewage is generated).
- Membrane Bio Reactor (MBR)
- Moving Bed Bio Reactor (MBBR)

B. Regulations:

In India, housing projects over 20,000 square metres in metro cities must install private sewage treatment plants (STPs) with builders responsible for installation and five years of maintenance. Regulations have evolved since 2015, with the Central Pollution Control Board (CPCB) initially enforcing strict discharge rules, which were relaxed in 2017, leading to a decline in water quality. The National Green Tribunal (NGT) tightened these regulations in 2019, setting stricter standards for STPs on Biochemical Oxygen Demand (BOD), pH, Total Suspended Solids, Nitrogen, Chemical Oxygen Demand (COD), and Fecal Coliform levels. However, as of 2025, CPCB has updated and further strengthened discharge norms and these apply to both new and existing STPs, including those in residential complexes. The 2025 updates mark the government’s strongest push to ensure that STPs not only meet chemical discharge limits but also control pathogens and support treated water reuse.

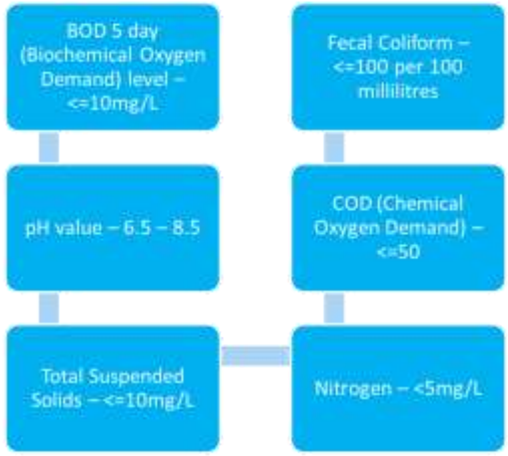
C. Incentive Structures for Investment and Participation:

The Indian government continues to promote investment in sewage treatment through the Hybrid Annuity Model (HAM) under the National Mission for Clean Ganga (NMCG). Under HAM, the government funds 40% of the capital cost upfront, while the private developer invests the remaining 60% and handles operations, receiving annuity payments over 15 years. The model has seen increasing adoption, with notable projects in Mathura, Varanasi, and Meerut. In parallel, the "One City, One Operator" model is being used to improve accountability by bundling all STPs within a city under a single private operator, often in tandem with HAM contracts. These models aim to ensure sustained performance and better wastewater management outcomes in key urban centres.

D. Penalty for non-compliance:

State governments impose penalties under the Water (Prevention and Control of Pollution) Act, with maximum fines of INR 5 lakh—typically insufficient to deter violations. However, the National Green Tribunal (NGT) has taken stronger action by imposing environmental compensation for mismanagement of sewage and solid waste. As of May 2023, the NGT has collectively fined states approximately INR 79,234 Cr (~USD 10 billion). Within this, around INR 80,000 Cr was assigned specifically for sewage and waste mismanagement. Major penalties include.

Exhibit 5.8: Key Regulatory Requirements



Source: Frost & Sullivan analysis

Exhibit 5.9: Total fine levied for non-compliance, by State

STATE	FINE (INR BILLION)
Maharashtra	120
Telangana	38
West Bengal	35
Karnataka	34
Rajasthan	30
Punjab	21

5.6 Indian Government's vision and initiatives for sewage treatment infrastructure growth

While there isn't a single, overarching national target for sewage treatment capacity growth in India, the government acknowledges the critical need for improvement. The Governments vision focuses on achieving sustainable wastewater management and minimizing water pollution through strategic initiatives and programs.

A. Vision for sewage treatment infrastructure:

Environmental Sustainability: The goal is to establish a network of efficient Sewage Treatment Plants (STPs) to prevent untreated sewage discharge into water bodies, thereby enhancing environmental sustainability.

Public Health Improvement: Proper sewage treatment aims to reduce waterborne diseases and improve public health outcomes.

Resource Recovery: The government supports the reuse of treated wastewater for non-potable purposes such as irrigation and industrial processes to promote water conservation.

B. Key Government initiatives and potential targets:

National Mission for Clean Ganga (NMCG): Launched in 2011, this initiative aims to achieve complete sewage treatment for the Ganga by 2030, significantly boosting treatment capacity along the river.

Atal Mission for Rejuvenation and Urban Transformation (AMRUT): Initiated in 2015, AMRUT aims for universal sanitation access in cities by 2024, necessitating increased urban sewage treatment infrastructure.

Swachh Bharat Mission (SBM) Urban 2.0: In 2020, an updated program emphasized faecal sludge management and wastewater treatment, highlighting the urgent need for improved sewage treatment infrastructure. These initiatives also integrated sanitation, urban transformation, and river rejuvenation, all of which are critical components of India's broader infrastructural development plans.

5.7 Unique challenges in India's sewage treatment industry

The Indian government recognizes the critical need to improve sewage treatment infrastructure. However, the industry faces a multitude of challenges beyond the usual suspects of funding and infrastructure limitations. Here's a comprehensive analysis of 10 unique issues hindering growth:

Exhibit 5.10: Challenges in India's sewage treatment industry

Source: Frost & Sullivan analysis

5.8 Select upcoming sewage treatment plants in the country

Exhibit 5.11: Upcoming STP Plant * in India

CITY	PROJECT NAME / DESCRIPTION	CAPACITY (MLD)	ESTIMATED COST (INR CR)	EXPECTED YEAR	STATUS / NOTES
Ahmedabad, Gujarat	424 MLD STP at Pirana (AMC)	424	₹599 Cr	2025–26	Under AMC's infrastructure modernisation plan
Ahmedabad, Gujarat	375 MLD STP at Vasna	375	₹778 Cr	2025–26	Parallel project under the same AMC/World Bank effort
Hyderabad, Telangana	38 STPs under HMWSSB (Musi River Cleanup)	965 (combined)	₹1,565 Cr	2026–27	Approved; under Hybrid Annuity Model; work in progress
Bengaluru, Karnataka	9 STPs under Karnataka Water Security & Resilience Program	TBD	~₹3,500 Cr ($426M)	2027	Funded by World Bank; aimed at lake and aquifer restoration
Greater Noida (Yeida)	3 STPs (Sectors 18, 24, 29)	360 (combined)	₹160 Cr	End-2025	Work started; advanced stage
Greater Noida Authority	5 STPs in Sector 45 and others	~180+	₹120+ Cr	2025	Construction to begin
Nashik, Maharashtra	8 STPs + 1 upgrade (PPP model)	TBD	₹1,325 Cr	2025–26	Received Cabinet approval; tendering underway

**Includes projects under construction and upcoming projects at tender stage*
Sourced from data in the public domain and this may include the cost of construction of ancillary infrastructure facilities in addition to STP

5.9 Growth forecast of the Indian Sewage Treatment market

India's urbanisation and economic growth have led to increased wastewater generation, driving government and private sector efforts to improve sewage treatment infrastructure. This collaboration is advancing the sewage treatment market through new technologies that enhance treatment efficiency and support resource recovery, such as converting wastewater into reusable water or biogas.

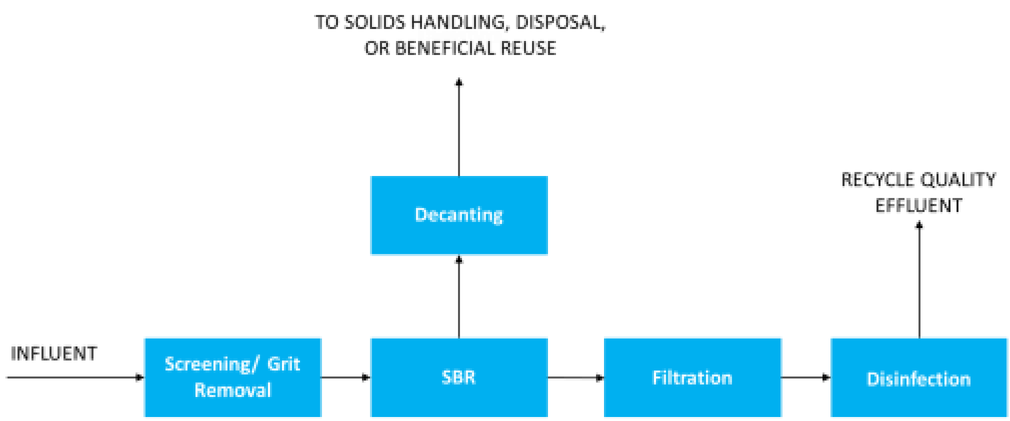
The Indian sewage water treatment market has grown at a CAGR of 5.4% between FY2020 and FY2025 and is projected to grow at a CAGR of 9.6% between FY2025 and FY2030E. A key factor driving this growth is India's population, which, while growing at a slower rate (approximately 0.9% annually as of FY2025), still results in a significant increase in sewage generation, particularly in urban and industrial areas. The pace of sewage generation, driven by both population growth and urbanization, is expected to outpace the growth in operational sewage treatment capacity.

Imbalance emphasizes the critical need for expansion and modernization of wastewater treatment infrastructure. As more people migrate to cities and industrial activity intensifies, the existing systems struggle to handle the volume of waste produced. Addressing this gap will be essential to meeting both environmental standards and public health needs.

5.10 Overview of SBR technology

The Sequencing Batch Reactor (SBR) is a key wastewater treatment technology in India, representing about 28% to 30% of installed capacity for municipal and industrial plants. It treats wastewater in a single batch reactor, combining equalisation, aeration, clarification and nutrient removal (nitrogen and phosphorus). Wastewater is screened and grit is removed before entering a partially filled reactor with acclimated biomass. The reactor operates in batches, performing aeration and mixing, then allowing biomass to settle before removing treated water. Excess biomass is periodically removed to maintain the proper influent-to-biomass ratio. In continuous flow systems, this ratio is maintained by adjusting return activated sludge flowrates. After SBR treatment, the wastewater may flow to an equalisation basin for controlled flow to additional processes. In some cases, it is further filtered and disinfected.

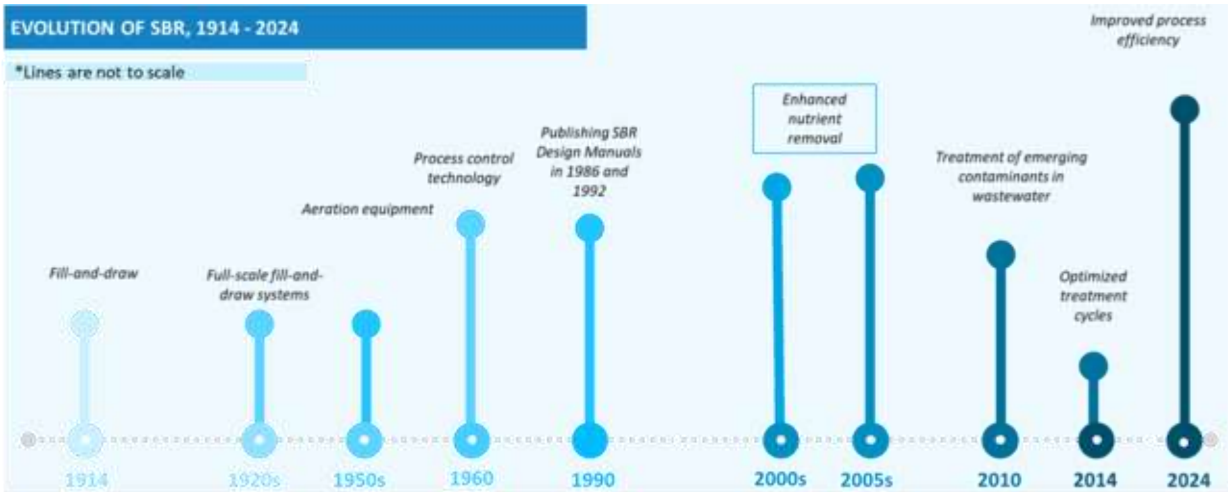
Exhibit 5.13: Process flow diagram for a typical SBR



Source: Frost & Sullivan analysis

The SBR technology, though not entirely new, has seen a resurgence in recent decades due to its flexibility and efficiency.

Exhibit 5.14: Evolution of SBR technology



Source: Frost & Sullivan analysis

5.11 Overview of C-Tech process

C-Tech is the latest generation SBR process, employed extensively for treating both domestic sewage and industrial effluents to achieve recyclable quality water with low life cycle cost, and has installations in many countries, including the UK, Germany, Poland, Austria, China, Russia, Australia, Vietnam and Malaysia. Unlike traditional SBR systems, C-TECH uses two or more batch tanks in parallel, with their sequences out of phase, allowing continuous flow without the need for an upstream buffer tank. This design reduces the site footprint by approximately 50%. C-TECH operates as a cyclic-activated sludge process and is fully automated through PLC and SCADA, requiring minimal operator intervention. C-Tech technology offers up to 40% savings in power consumption as compared to other conventional technologies, thereby reducing the overall O&M cost of the STP.

C-Tech is a versatile technology that effectively handles seasonal, diurnal and quality variations compared to conventional technologies by automatically adjusting water level, decanting rate and air supply, and has successfully been implemented to treat wastewater from refineries / pharmaceutical / petrochemical / textile industries.

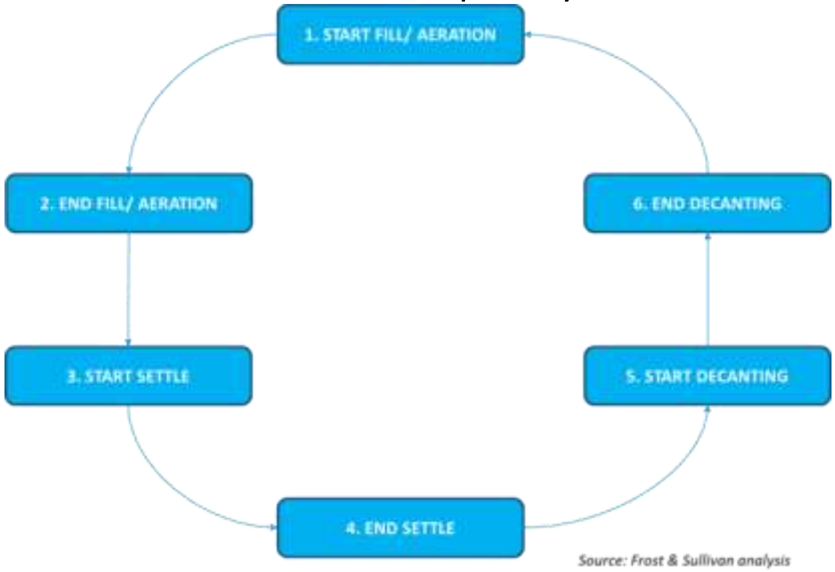
The C-TECH system features several circular or rectangular batch reactor basins, each with an anoxic-anaerobic selector zone, aeration zone, internal recycle, decant arm, and an oxygen uptake rate (OUR) based aeration control system. It operates with one equalization tank and one tank or with two or more batch tanks in parallel, with their cycles out of phase, enabling continuous flow and eliminating the need for an upstream buffer tank, thus reducing space requirements compared to traditional SBR systems. C-Tech is SFC's proprietary technology for wastewater treatment which is an advanced technology for treating sewage and effluents. The Company was the first technology provider in the SBR space, with the introduction of C-Tech in India in the WWT segment. A primary advantage of the C-Tech system, as compared to other conventional technologies, is that it offers an efficient method of a cyclic activated sludge treatment, that produces a recyclable quality effluent in a single step. This proprietary technology is not only superior to conventional systems but also drives significant cost, space, and environmental benefits. This technology stands out for its ability to handle large volumes of sewage, achieving superior treatment efficiency with a smaller footprint compared to traditional systems.

Exhibit 5.15: Summary of C-TECH Wastewater Treatment System

ASPECT	DETAILS
Process Flow	**Fill and Anoxic Mix:** Influent fills reactor; mixed with previous cycle effluent for microorganisms. Anoxic conditions favour PAOs for nutrient removal.
	Aeration: Dissolved oxygen increases, promoting aerobic bacteria growth.
	Settle: After aeration, solids settle; clarified supernatant is treated effluent.
	Decant: Clarified effluent removed from the top; sludge may be withdrawn.
Performance Parameters	**Effluent Quality:**
	BOD: ≤ 10 mg/l (typical 5-10 mg/l).
	SS: ≤ 10 mg/l (typical 5-10 mg/l).
	TN: ≤ 10 mg/l (typical 5-10 mg/l).
	TP: ≤ 1 mg/l (typical 0.5-1 mg/l).
	Process Efficiency:
	SVI: Target 40 mL/g – 60 mL/g
	Cycle Time: 3-6 hours.
	OUR: Oxygen Uptake Rate control for energy optimisation.
	Footprint: 30-50% reduction compared to conventional SBRs.
	Costs: 10-20% capital cost savings; 75-85% energy savings compared to ASPs.
Benefits	High efficiency, compact footprint, flexibility, low energy consumption.
Applications	Municipal and industrial wastewater treatment, small communities, remote locations.

C-Tech uses the latest automation technology, using the PLC / SCADA systems. The process automation is designed for operation without manual intervention and the performance of the STP is independent of the operators' skill. C-Tech technology introduced three path-breaking innovations, namely bacterial selection by using selectors prior to main treatment, concurrent nitrification and denitrification, and biological phosphorus removal by unique process designed based on simply switching air on and off, thereby facilitating the efficient removal of both carbon and nutrients (nitrogen and phosphorus) in a single treatment step, while also generating sludge with very low SVI, which results in excellent settling of suspended solids giving a crystal clear outlet with low suspended solids (<10 ppm) and BOD (< 5-10 ppm).

Exhibit 5.16: C-TECH process cycle



Source: Frost & Sullivan analysis

With 639 C-Tech installations commissioned in the wastewater treatment segment, particularly in STPs, SFC holds over 80% market share in SBR technology in India, as of March 31, 2025. This demonstrates their experience and leadership in this technology. SFC's C-Tech technology has been implemented in the large-scale SBR-based STPs in India, including one of the largest STP under development, which has a treatment capacity of 424 MLD wastewater, as of March 31, 2025. Over the years, the Company has successfully executed diverse portfolio of projects spanning various capacities and geographical locations. This underscores the Company's reliability, trustworthiness, and ability to consistently deliver value, solidifying its position as a preferred partner in the industry. The company's C-Tech technology generates sludge having one of the best sludge volume index ("SVI"), offering up to 98% biochemical oxygen demand ("BOD") removal efficiency in a single step.

These projects span diverse locations, including Germany, the UK, Austria, China, Iran, Saudi Arabia, Hungary, Mexico, and importantly, India. SFC's C-Tech technology has been implemented in the large-scale SBR-based STPs in India which has an impressive treatment capacity of 424 MLD (under construction) wastewater and even smaller plants handling 0.35 MLD. This demonstrates the company's ability to cater to diverse wastewater treatment needs across the country. This positions C-Tech as a promising technology for efficient and sustainable wastewater management in India.

5.12 The evolving landscape of sewage treatment: A comparative analysis of prominent technologies

Effective sewage treatment is crucial for public health and environmental protection. With rising urbanisation and industrial activity, the need for efficient wastewater treatment solutions has become increasingly critical. Key technologies in the global sewage treatment market, including C-Tech, are evaluated based on their performance across parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and capital investment costs. A structured comparison of these technologies is presented, highlighting their relative effectiveness and cost-efficiency. Notably, the SFC and broader wastewater treatment industry in India has not experienced any sudden instances of technological disruption in the recent past.

Exhibit 5.17: Performance Comparison of Sewage Treatment Technologies, India, for 1,000 MLD plant

TECHNOLOGY	BOD/COD REMOVAL EFFICIENCY (%)	TSS REMOVAL EFFICIENCY (%)	NUTRIENT REMOVAL	LAND FOOTPRINT (HECTARES)	ESTIMATED CAPITAL (₹ CRORE)	OPERATION-AL COST (₹ PER M3)
Activated Sludge Process (ASP)	BOD: 80-90 COD: 90-95	85-90	Moderate (Additional processes needed)	10-15	200-250	3-5
Membrane Bioreactors (MBRs)	BOD: 90-95 COD: 95-98	98-99	High (Nitrogen and Phosphorus removal possible)	5-8	300-400	4-6
Trickling Filters	BOD: 80-85 COD: 85-90	80-85	Low (Additional processes needed)	20-25	100-150	2-4
Lagoons	BOD: 60-70 COD: 70-80	60-70	Low (Natural processes)	40-50	50-80	1-2
C-Tech (SBR Variant)	BOD: 90-98 COD: 90-95	90-95	High (Nitrogen and Phosphorus removal possible)	8-12	250-300	3-5

Key considerations:

CRITERIA	HIGH	MEDIUM	LOW
BOD/COD Removal Efficiency	Excellent: Removes most organic pollutants effectively	Moderate: May require additional treatment steps for stricter regulations	-
TSS Removal Efficiency	Excellent: Removes most pollutants effectively	Moderate: May require additional treatment steps	-
Nutrient Removal	Efficiently removes nitrogen and phosphorus	May require additional processes for advanced nutrient removal	Limited nutrient removal capabilities
Land Footprint	Requires significant space	Moderate land needs	Minimal land area required
Capital Investment	Highest upfront costs	Moderate initial investment	Very low initial costs

Operational Cost	Requires significant ongoing maintenance and energy consumption	Moderate operational expenses	Low maintenance and energy requirements

5.13 Benchmarking SBR (Sequential Batch Reactor) technologies

SBR technology offers a flexible and efficient wastewater treatment approach. However, various configurations and operational modifications exist within the SBR umbrella. Here's a breakdown comparing some prominent versions:

Factors for Comparison:

- Treatment Efficiency: Measured by BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) removal rates.
- Nutrient Removal: The capability to remove nitrogen and phosphorus, increasingly crucial for stricter regulations.
- Footprint: Land area required for the treatment system.
- Operational Complexity: Level of automation and operator skill required.
- Sludge Management: Methods for handling and disposing of excess sludge produced.

Exhibit 5.18: Advanced Sequencing Batch Reactor (SBR) Technologies Comparison (1000 MLD Plant)

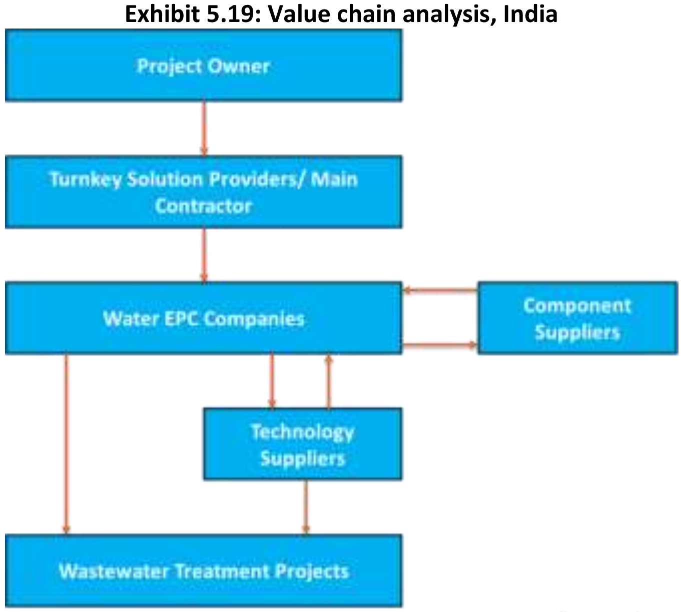
TECHNOLOGY	TREATMENT EFFICIENCY (BOD/COD) %	NUTRIENT REMOVAL	FOOTPRINT (Hectares)	OPERATIONAL COMPLEXITY	SLUDGE MANAGEMENT
Conventional SBR	BOD: 85-90 COD: 90-95	Moderate (Additional processes for N & P removal might be needed)	8-12	Moderate	Requires periodic wasting (around 5-10% of treated effluent)
Modified Ludzack-Ettinger (MLE)	BOD: 85-90 COD: 90-95	Moderate (Additional processes for N & P removal might be needed)	8-12	Moderate	Similar to conventional SBR (periodic wasting)
Intermittent Cycle Extended Aeration System (ICEAS)	BOD: 85-90 COD: 90-95	Moderate (Additional processes for N & P removal might be needed)	8-12	Moderate	Similar to conventional SBR (periodic wasting)
C-Tech (Cyclic Activated Sludge with biological selector)	BOD: 90-95 COD: 95-98	High (Nitrogen & Phosphorus removal)	5-8	High (Automated operation)	Requires periodic wasting (around 2-5% of treated effluent)

5.14 Value chain analysis of the Indian wastewater treatment sector: Key stakeholders

India's wastewater treatment sector is expanding due to rising water scarcity, stricter effluent discharge regulations, and government sanitation and infrastructure initiatives. The sector's value chain involves several key stakeholders:

- **Project Owners**: Government agencies, industries, or private developers who identify the need for treatment plants, define project requirements, secure financing, and obtain permits.

Exhibit 5.19: Value chain analysis, India



Source: Frost & Sullivan analysis

- **Turnkey Solution Providers/Water EPC Companies**: They handle project design, procurement, construction, and commissioning. Some also offer operation and maintenance services. They may focus on specific aspects of a project or technology.
- **Component Suppliers**: Manufacturers and distributors of essential equipment such as pumps, valves, and clarifiers, providing critical components for treatment plants.
- **Technology Suppliers**: Companies that develop and license wastewater treatment technologies (e.g., activated sludge, MBRs, SBRs), offering expertise in design and operation.
- **Wastewater Treatment Plants**: The facilities where wastewater is treated to meet discharge standards and enable resource recovery.

Project owners work with turnkey providers or EPC companies to define project scope and select appropriate technology. These companies collaborate with technology and component suppliers to procure equipment and ensure regulatory compliance.

5.15 Competitive landscape

The Indian sewage water treatment sector is witnessing significant growth, driven by stricter environmental regulations and increasing urbanization. This growth has fostered a diverse market with a range of companies offering various services.

Exhibit 5.20: Leading Sewage Technology and Equipment Suppliers, Revenue, FY2025

NAME OF COMPANY	FY2025 REVENUE IN INR MILLION
SFC Environmental Technologies	6,978.6
Thermax	1,03,886.9
Xylem Inc.	NA
Praj Industries	32,280.4
Alfa Laval	NA
Ion Exchange	27,371.1

Note: Va Tech Wabag is not a close peer to SFC Environmental Technologies, as a major portion of their revenue comes from EPC

5.16 Leading industrial wastewater treatment solution

Technology landscape:

- **Sequencing Batch Reactor (SBR):** This technology is widely used for the treatment of sewage due to its ability to achieve efficient treatment with lower sludge volume and potentially lower energy consumption compared to other technologies. The table given below offers ballpark estimates for the Indian sewage water treatment sector.

Exhibit 5.21: Market share of leading solutions with technology market share estimates

SEWAGE WATER TREATMENT TECHNOLOGY	ESTIMATED MARKET SHARE (%)	ESTIMATED MARKET SHARE IN INCREMENTAL TREATMENT CAPACITY FY2015 – FY2021 (%)
Sequencing Batch Reactor (SBR)	30-35%	60%
Others	65- 70%	40%

- Other Technologies include Activated Sludge Process (ASP), Membrane Bioreactor (MBR), Moving Bed Biofilm Reactor (MBBR), Upflow Anaerobic Sludge Blanket (UASB), Extended Aeration (EA), Fluidized Aerobic Bed Reactor (FAB), Oxidation Pond (OP), Waste Stabilization Pond (WSP), Aerated Lagoon (AL), Trickling Filter (TF), Bio-Tower, Electro Coagulation (EC), FMBR and Root Zone etc.

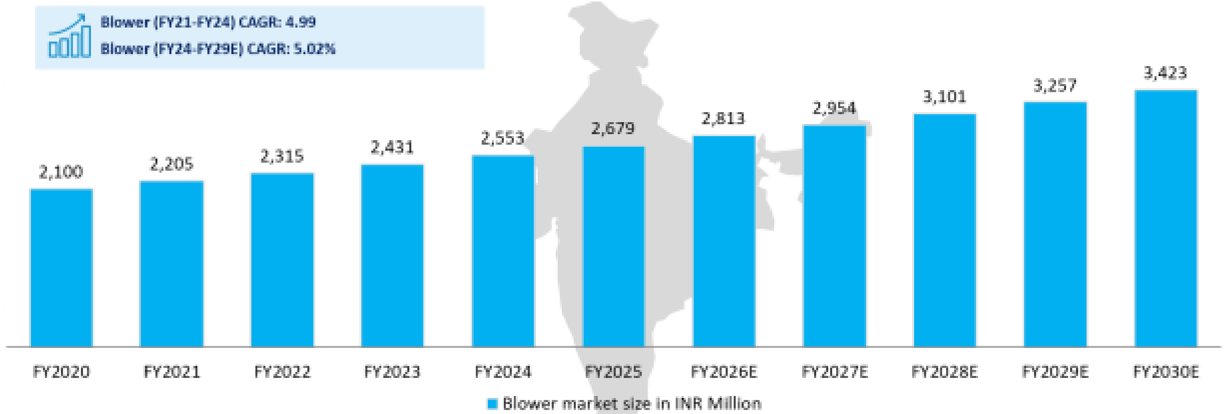
5.17 Overview of Blowers and Fibre Disc Filters

Efficient wastewater treatment is crucial for environmental protection and public health. Municipal STPs play a vital role in treating sewage before discharging it into water bodies. Blowers and disc filters are two key components of modern STPs, each contributing significantly to the treatment process.

Blowers:

- **Function:** Blowers provide the essential air supply for the biological treatment process in STPs. This aeration process allows bacteria to break down organic matter present in the sewage.
- **Types:** There are various types of blowers used in STPs, including positive displacement blowers and centrifugal blowers. The choice depends on factors like required airflow, pressure, and energy efficiency.
- **Benefits in STPs:** Efficient aeration is critical for maintaining healthy bacterial populations and optimising treatment. Blowers ensure adequate oxygen supply, leading to improved effluent quality and reduced odour problems.

Exhibit 5.22: Market size of blowers in India, in INR million, FY2020 – FY2030E



Source: Primary interactions, Frost & Sullivan knowledge repository and analysis

Note: In terms of cost breakdown, blowers are estimated to contribute approximately 5% to 8% of the total STP capital cost.

Disc Filters:

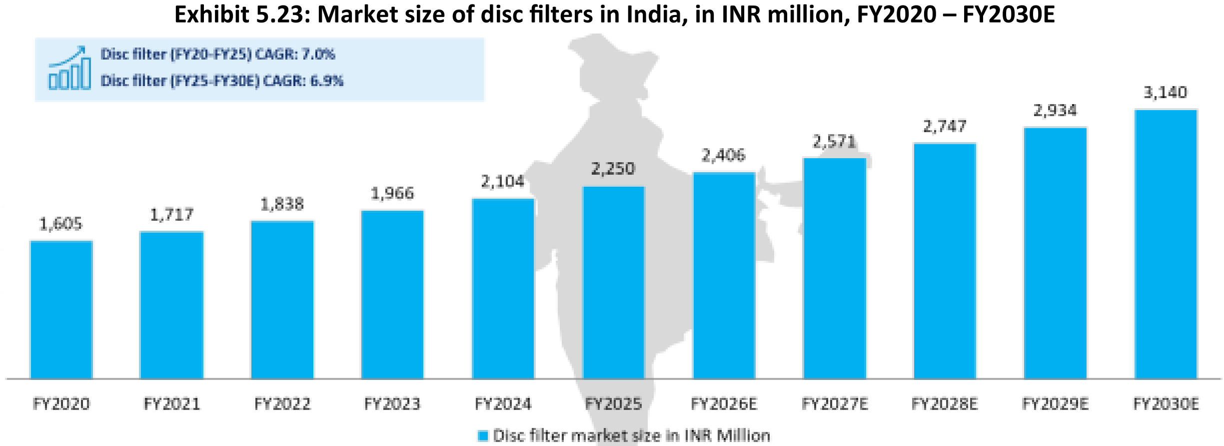
- **Function:** Disc filters are advanced filtration systems used in STPs for separating solids from the treated wastewater.
- **Components:** It consists of a series of discs that rotate partially submerged in the wastewater. Solids get captured between the discs, and the rotation helps remove them for further processing.
- **Benefits in STPs:** Disc filters offer several advantages over conventional filtration systems like sand filters. They have a smaller footprint, require less maintenance, and provide superior effluent quality with lower solids content.

Combined Application in Municipal STPs:

Blowers and disc filters work together in STPs to achieve efficient wastewater treatment:

- **Blowers provide aeration:** This creates an oxygen-rich environment for bacteria to break down organic pollutants in the sewage.

Exhibit 5.23: Market size of disc filters in India, in INR million, FY2020 – FY2030E



Source: Primary interactions, Frost & Sullivan knowledge repository and analysis

- **Disc filters remove solids:** After biological treatment, disc filters effectively remove any remaining solids from the treated wastewater, ensuring it meets the required discharge standards.

Note: In terms of cost breakdown, disc filters are estimated to contribute approximately 5% to 8% of the total STP capital cost.

A. Expanding the Reach: Applications of Blowers and Disc Filters Beyond Municipal STPs

While blowers and disc filters play a critical role in municipal Sewage Treatment Plants (STPs), their capabilities extend far beyond treating wastewater from households. These technologies offer efficient solutions for various other segments with similar treatment requirements.

- **Industrial Wastewater Treatment:** Industries like textiles, chemicals, and food processing use blowers for aeration and disc filters to remove pollutants and solids for compliant discharge.
- **Aquaculture:** Blowers maintain oxygen levels, and disc filters remove waste, ensuring a clean environment for aquatic life.
- **Food & Beverage Processing:** Blowers break down organic matter, while disc filters manage residual solids for wastewater treatment.
- **Other Applications:** These technologies support water reuse, environmental remediation, and wastewater treatment in pulp & paper processing.

5.18 Market presence and strategic focus of SFC Environmental Technologies

SFC has catered to a customer base across diverse end markets with footprints across various geographies, including Europe, the Middle East, Africa, and Southeast Asia. Contributing to this global growth, SFC has implemented many large-scale wastewater treatment plants utilizing SBR/C-TECH technology around the world, making it one of the leading integrated environmental companies.

The municipal wastewater treatment market features prominent players like SFC Environmental Technologies, which provides efficient technologies and comprehensive engineering solutions in the field of wastewater treatment. The Company mainly provides technology for wastewater treatment (predominantly STPs) plant projects. With 639 installations in the WWT segment, as of March 31, 2025, particularly in Sewage Treatment Plants (“STPs”), SFC hold over 80% market share in Sequencing Batch Reactor (“SBR”) technology, a key wastewater treatment method in India. SFC's technologies facilitate the treatment of 15,209.45 million litres per day (MLD) of wastewater as of March 31, 2025.

SFC's relevant industry experience, technical expertise, product portfolio driven by manufacturing capabilities and exclusive tie-ups, and market presence position the company well to capitalize on the upsurge in the tertiary wastewater treatment (TWW) market. The entire value chain is addressed, from upgrading existing wastewater treatment plants to meet stricter regulations and enhancing effluent quality, to building new treatment facilities, especially in areas experiencing rapid growth. The Company provides advanced treatment of sewage and effluents using C-Tech solutions.

SFC currently produces its ultrafiltration membrane, C-MEM™, at its Czech facility, which is used for tertiary wastewater treatment. The Company recently entered into an exclusive collaboration agreement with a leading ultrafiltration technology company for the distribution of its UF membranes in tertiary wastewater treatment projects in India. This forward integration enables the Company to offer a complete suite of water treatment solutions, from initial sewage treatment to advanced tertiary processes, thereby enhancing its value proposition and market reach.

Additionally, the Company markets and sells Fibre Disc Filters (FDF) in India, procured from a South Korean company through an exclusive agreement. FDF is an industrial filtration technology that enables the treatment of water for reuse purposes. SFC also provides equipment and solutions for sewage sludge management – a potential source of additional value through resource recovery.

This comprehensive approach, encompassing design, manufacturing, installation, and potential operation and maintenance, makes SFC a vital partner in unlocking the immense economic potential of treated wastewater reuse in India.

6. WASTEWATER RECYCLING & REUSE - TERTIARY TREATMENT

Tertiary treatment (Wastewater Recycling & Reuse), also known as advanced wastewater treatment, refers to the final stage in wastewater processing where remaining suspended solids, nutrients, pathogens, and dissolved contaminants are removed to produce high-quality effluent. This treated water can then be reused for irrigation, industrial processes, or even potable applications, depending on the treatment level.

6.1 Key Technologies India and Global – Filtration, Membrane based Ultra / Nano Filtration, RO (Reverse Osmosis)

A. Filtration Systems

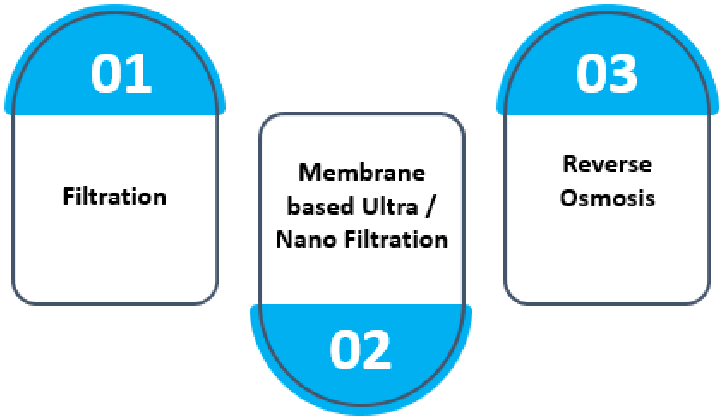
Global: Filtration is widely used in tertiary treatment for removing fine suspended solids and turbidity. Common technologies include:

- Sand filters
- Dual-media filters
- Disk filters
- Micro and ultra-fine screens

Filtration is often combined with coagulants or flocculants to enhance solids removal. In developed countries, especially in Europe and the U.S., filtration is integrated as a polishing step in municipal treatment plants before disinfection or reuse.

India: In India, filtration systems are commonly used in industrial ETPs and STPs (Sewage Treatment Plants), especially in Tier-1 cities. Compact filtration units are also gaining popularity in decentralized wastewater systems.

Exhibit 6.1: Key Technologies, Tertiary Treatment



Source: Frost and Sullivan Analysis

B. Membrane

Membrane-based technologies are central to modern tertiary treatment, offering high removal efficiency for solids, bacteria, and dissolved organics.

Global

- UF (Ultra Filtration): Used as a pre-treatment for reverse osmosis or final polishing.
- NF (Nano Filtration) and MF (Micro Filtration): Applied in nutrient and pathogen removal.
- MBRs (Membrane Bioreactors): Combine biological treatment with membrane filtration for compact, high-quality effluent.

These systems are widely used in municipal reuse schemes, industrial ZLD systems, and potable reuse in water-scarce regions like California, Singapore, and the Middle East.

India: In India, MBRs and UF systems are increasingly used in commercial and residential STPs, as well as for industrial wastewater recycling in sectors like textiles, pharmaceuticals, and food processing. Adoption is driven by regulatory ZLD mandates and rising freshwater costs.

C. Reverse Osmosis

Global: RO (Reverse Osmosis) systems are widely used for:

- Desalination
- High-purity water production
- ZLD applications (by recovering water and concentrating waste)

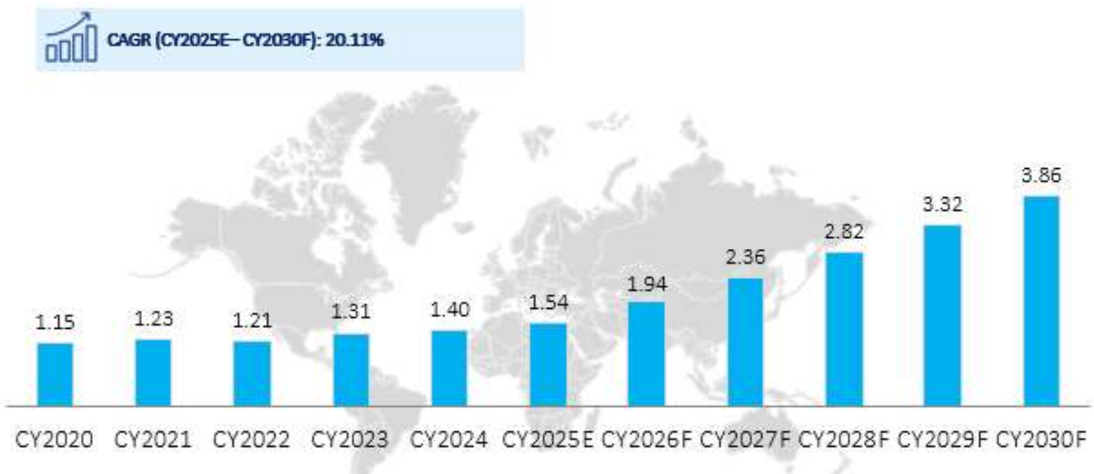
In tertiary treatment, RO is often the final step after filtration and UF to remove dissolved salts, heavy metals, and micropollutants. It is essential in water-scarce regions and industries with stringent discharge norms.

India: India has seen a significant rise in RO usage, particularly in industrial wastewater reuse and treated sewage reuse in cooling towers, with cities like Chennai and Bengaluru setting up large-scale RO tertiary treatment plants for reuse in industries.

6.2 Market Size in India and Global

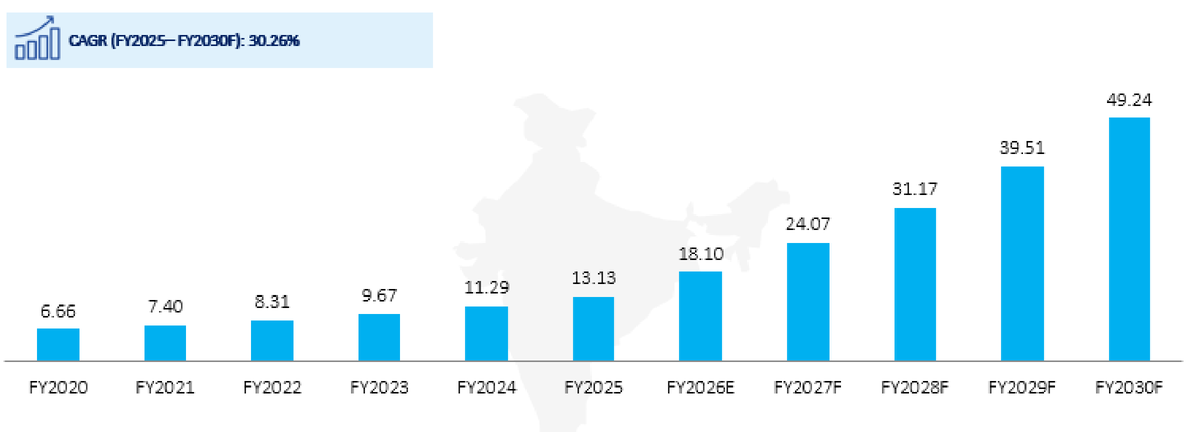
The global Tertiary Treatment market was valued at USD 1.15 Bn in CY2020 and grew to USD 1.40 Bn in CY2024. It is projected to reach USD 1.54 Bn in CY2025E and is forecasted to expand significantly to USD 3.86 Bn by CY2030F, registering a robust CAGR of 20.11% from CY2025E to CY2030F. This rapid growth is driven by increasing global focus on advanced wastewater treatment, stricter environmental regulations, and rising demand for high-quality reclaimed water across industries and municipalities. Technological advancements and sustainable water reuse initiatives are further accelerating market expansion, especially in water-stressed and rapidly urbanizing regions.

Exhibit 6.2: Tertiary Treatment Market (In USD Billion), Global, CY2020 – CY2030F



Source: Frost & Sullivan analysis

Exhibit 6.3: Tertiary Treatment Market (In INR Billion), India, FY2020 – FY2030F



Source: Frost and Sullivan Analysis

The Indian Tertiary Treatment market was valued at INR 6.66 Bn in FY2020 and grew to INR 11.29 Bn in FY2024. It is expected to reach INR 13.13 Bn in FY2025 and is projected to rise sharply to INR 49.24 Bn by FY2030F, registering a strong CAGR of 30.26% between FY2025 and FY2030F. This rapid growth is driven by increasing urbanization, water scarcity, and stricter government regulations on wastewater discharge. The push for sustainable water reuse in industrial and municipal sectors, along with investments in advanced treatment technologies, is propelling the demand for tertiary treatment solutions across the country.

A. Future growth prospects: Driven by urban water scarcity, regulatory mandates, and sustainability goals

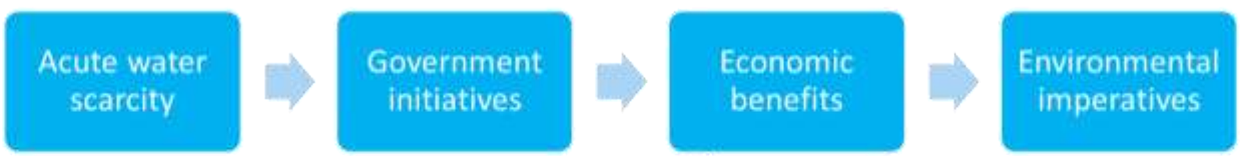
The WRR segment is expected to witness significant growth, driven by increasing water scarcity and government initiatives focused on water conservation in India.

Urban Water Scarcity: Rising urban populations and industrial growth have intensified water demand, leading to acute shortages in many cities. Traditional water sources are under stress, and climate change is compounding the problem through irregular rainfall and declining groundwater levels. Tertiary treatment allows wastewater to be safely reused for non-potable applications such as industrial cooling, landscaping, irrigation, and even groundwater recharge. Cities like Chennai, Bengaluru, Singapore, and Los Angeles have embraced tertiary treatment as a reliable strategy for water security and resilience.

Regulatory Mandates: Governments are enforcing stricter effluent discharge norms and encouraging water reuse. In India, the CPCB and NGT (National Green Tribunal) mandate tertiary treatment in STPs and industrial ETPs, particularly under ZLD regulations. Globally, agencies like the U.S. EPA and European Union are tightening standards for nutrient removal and water reuse, prompting widespread adoption of membrane, filtration, and UV technologies.

Sustainability and ESG (Sustainable Development Goals) Goals: Tertiary treatment supports UN SDGs, including clean water (SDG 6) and climate action (SDG 13). It helps organizations meet Environmental, Social, and Governance (ESG) commitments by reducing freshwater dependency, lowering pollution, and enabling circular water use.

Exhibit 6.4: Growth drivers for treated wastewater reuse in India



Source: Frost & Sullivan analysis

Exhibit 6.5: Enablers for Successful Treated Wastewater Reuse in India

Source: Frost & Sullivan analysis

6.3 Reuse of Sewage Water

Considering the growing volume of untreated sewage, it is essential to view sewage as a valuable resource that can be processed based on end-use requirements and utilized for non-potable applications and industrial operations. In recent years, several Urban Local Bodies (ULBs) across India have prioritized the reuse of treated wastewater, implementing initiatives that promote its use in horticulture, irrigation, non-contact water bodies, cleaning operations, and various industrial processes.

The following are notable examples of wastewater reuse in India:

I. The Government of Punjab introduced the *State Treated Wastewater Policy 2017* to encourage the recycling and non-potable reuse of treated sewage. To date, the Department of Soil and Water Conservation has completed 47 projects, utilizing approximately 243.3 MLD of treated wastewater from sewage treatment plants (STPs). These efforts involve the installation of underground pipelines for irrigation, covering 7,652 hectares (DECC, 2020).

ii. The Indian Agricultural Research Institute (IARI), Karnal, has conducted research on sewage-based agriculture and developed irrigation practices specifically for tree plantations irrigated with treated wastewater.

iii. The Government of Karnataka has mandated that only tertiary treated sewage should be used for non-potable activities such as landscaping in parks, resorts, and golf courses.

iv. In major metros like Delhi, Mumbai, Bengaluru, and Chennai, treated greywater is being reused for toilet flushing in several condominiums and high-rise residential buildings, primarily under pilot programs.

v. Since as early as 1991, industries in India have been purchasing and reprocessing secondary treated sewage for cooling water make-up, with examples including Madras Refineries, Madras Fertilizers, GMR Vasavi Power Plant in Chennai, as well as Rashtriya Chemicals and Fertilizers in Maharashtra, and more recently, the Indira Gandhi International Airport in Delhi and Mumbai International Airport.

Exhibit 6.6: Potential applications for TWW reuse in India

CATEGORY	APPLICATION	DETAILS
Rethinking Agriculture: Sustainable Irrigation	**Precision Irrigation**	Utilises drip irrigation and fertigation to deliver treated wastewater directly to roots, maximising water use efficiency and benefiting high-value crops like fruits and vegetables.
	Aquaponics	Integrates aquaculture and hydroponics; treated wastewater nourishes fish, and nutrient-rich water fertilizes plants, creating a sustainable, closed-loop system.
	Bioremediation & Phytoremediation	Utilises treated wastewater to irrigate tree plantations or constructed wetlands, acting as biofilters to remove pollutants and enhance biodiversity.
A Circular Water Economy	**Non-potable Urban Applications**	Applies treated wastewater for toilet flushing, street cleaning, and landscape irrigation, reducing freshwater reliance in cities.
	Industrial Process Water	Substitutes freshwater with treated wastewater for cooling and boiler feed in industries, especially in water-stressed zones.
	Urban Aquifer Recharge	Recharges groundwater by injecting advanced treated wastewater into aquifers, securing water resources for future use.
Embracing Innovation	**Construction Industry**	Uses treated wastewater for dust suppression, concrete curing, and mixing, reducing potable water usage in construction.
	Energy Production	Employs treated wastewater in cooling towers of thermal power plants, conserving freshwater resources.
	Sanitation and Hygiene	Provides treated wastewater for sanitation in urban slums and peri-urban areas, coupled with hygiene education to improve public health.

6.4 Administrative Reforms and Policy Guidelines

Niti Aayog has called for to consider Water as a commodity rather than as a public good due to the fact that market mechanisms would work best when it is considered as a commodity which can be purchased or sold WRC (Water Reuse Certificates) are conceptualized as market-based instruments that recognize and promote the reuse of treated wastewater for non-potable purposes. These certificates can be issued to utilities, municipalities, or industries that demonstrate measurable reuse of treated water, enabling them to trade or offset water usage within compliance frameworks. The aim is to encourage water-efficient practices, reduce freshwater withdrawal, and build a circular economy around urban water system. Though still in early stages of development, WRCs hold the potential to function similarly to Renewable Energy Certificates, facilitating a structured approach to incentivizing large-scale wastewater reuse.

The reuse of treated wastewater is increasingly being recognized as a reliable and sustainable solution to meet the high-water demand of thermal power plants. This approach not only reduces dependency on freshwater sources but also supports the circular economy and enhances water security in water-stressed regions. A notable example is the city of Nagpur, which is progressing towards becoming India's first city to reuse over 90% of its wastewater — a significant portion of which is being supplied to thermal power stations for cooling and other industrial purposes. This model demonstrates how treated water reuse is powering the operational success of thermal power plants, while also offering substantial growth potential for replication across the country as thermal plants seek cost-effective and sustainable water sources.

6.5 Policy-led Interventions

Policy frameworks at both global and national levels are increasingly emphasizing the need for sustainable wastewater management and reuse:

- Sustainable Development Goal (SDG) 6.3 specifically targets wastewater, aiming to halve the proportion of untreated wastewater and significantly increase recycling and safe reuse by 2030. This global mandate sets the direction for countries like India to adopt integrated wastewater reuse strategies as part of their water sustainability agenda.
- India is advancing toward this goal through initiatives promoting the Safe Reuse of Treated Wastewater (SRTW). These efforts focus on ensuring that reused water meets prescribed quality standards and is safely applied in sectors such as agriculture, landscaping, industrial processes, and non-potable urban uses. By embedding SRTW principles into urban water policies, states and urban local bodies are working toward enhancing water resilience, reducing freshwater dependency, and creating economic value from waste.

6.6 Policy and legal regulations framework for UWM (urban wastewater management)

- The vision expressed in the National Framework on the Safe Reuse of Treated Water, 2021 is – "*widespread and safe reuse of treated used water in India that reduces the pressure on scarce freshwater resources, reduces pollution of the environment and risks to public health, and achieves socio-economic benefits by adopting a sustainable circular economy approach*" (MoJS, 2020) and accordingly requisite recommendations are made in the framework.

- The National Water Mission promotes the recycling of wastewater for meeting water needs of urban areas. The Tariff Policy, 2016 by Ministry of Power mandates the thermal power plants located within 50 km radius of a sewage treatment plant of an urban local body to mandatorily use treated urban waste. The Service Level Benchmarks of the Ministry of Housing and Urban Affairs (MoHUA) mandate the extent of reuse and recycling of sewage in urban areas as 20%.
- The National Water Quality Monitoring Programme of India, through its network of SPCBs, advises central and State governments on prevention, control, and abatement of water pollution and sets standards on water quality in streams and wells. The Guidelines of National Building Code 2016, emphasise the reuse of treated sewage and sullage in commercial or residential multistoried complexes for flushing of toilets, horticulture and fire-fighting purposes. It also suggests separate storage tanks and separate distribution pipes.

Exhibit 6.7: Existing state-level and national policies for reuse of TWW

STATE/LEVEL	POLICY NAME	KEY HIGHLIGHTS
West Bengal	Treated Wastewater Reuse Policy of Urban West Bengal (June 2020)	Promotes sustainable water management by reducing freshwater dependence. Reforms span planning, finance, technology, and institutional frameworks. Remains in force and relevant.
Gujarat	Policy for Reuse of Treated Wastewater (May 2018)	Targets 70% reuse by 2025 and 100% by 2030. Focus on industrial and municipal reuse. Still active; recent state reviews reaffirm commitment.
Karnataka	Urban Wastewater Reuse Policy (Dec 2017)	Encourages reuse in agriculture and urban applications to address water scarcity. No significant revision but remains in effect.
Jharkhand	Wastewater Policy (2017)	Stresses role of ULBs in phased reuse; views treated water as a renewable resource. Still applicable, though no major implementation scale-up yet.
Madhya Pradesh	Wastewater Recycle & FSM Policy (2017)	Promotes reuse for parks and urban green belts. Policy remains in place with limited urban expansion updates.
Andhra Pradesh	Policy on Wastewater Reuse and Recycling for ULBs	Encourages treated wastewater in industrial and irrigation use. Still relevant and referenced in AMRUT-related guidelines.
Rajasthan	State Sewerage and Wastewater Policy (2016)	Supports reuse aligned with WHO guidelines for agriculture. Policy remains in place; PPP reuse projects underway.
Punjab	Treated Wastewater Policy (2017)	Prioritizes reuse in agriculture based on water quality and crop type. No major revisions but still officially valid.
Tamil Nadu	Treated Wastewater Reuse Policy	Encourages MoUs between ULBs and industries/agriculture users for secondary treated water. Implementation progressing via Chennai Smart City initiatives.
Jammu & Kashmir	Wastewater Reuse Policy (2017)	Drafted before reorganization into UTs; still serves as baseline. UT-level updates expected.
Chhattisgarh	Wastewater Recycle and Reuse Policy	Promotes non-potable reuse across sectors; focuses on balancing domestic, industrial, and agricultural needs. Active and integrated into state sanitation projects.

Haryana	Treated Wastewater Reuse Policy (2019)	Reuse hierarchy prioritizes high-demand users (power, industry). Agriculture only after all other uses. Policy is operational and actively tracked under Jal Jeevan Mission.
Maharashtra	State Water Policy (no separate reuse policy)	Mandates reuse of 80% of domestic water. MPCB standards apply. Implementation is patchy but policy remains valid. No separate TWW policy yet.
National	National Framework for Safe Reuse of TWW (Nov 2022)	Developed by NMCG & NITI Aayog. Provides guiding principles for safe, circular reuse. Still current and increasingly cited in Smart Cities and AMRUT 2.0 projects.

Exhibit 6.8: Key Major global and Indian solution providers and technology innovators

COMPANY NAME	HEAD QUARTERS	YEAR FOUND	TECHNOLOGY
Veolia	**Aubervilliers**, France	1853	physicochemical phosphate removal, activated carbon filtration, and ozone disinfection
Clean Water Technology	Gardena, USA	1996	Fully skid mounted systems, HMI – human mechanical interface panels
Mitawater Technologies	Siziano, Italy	1971	Free-fiber filtration systems, Sand Filtration, Cloth Filtration, Reverse Osmosis etc.
Acciona	Madrid, Spain	1931	Digitalization and Smart water management, Reverse Osmosis, Electrochemical technologies etc.
DUPONT	Wilmington, Delaware, United States	**1802**	Minimal liquid discharge (MLD) , DuPont™ AmberLite™ ion exchange resins, Nanofiltration (NF) membranes ultrafiltration (SUF), Close Circuit Reverse Osmosis (CCRO), Membrane Bioreactor Systems (MBR), Membrane Aerated Biofilm Reactor (MABR)
Ion Exchange	Mumbai, India	1964	Disinfection by chlorine or ozone followed by filtration through granular media or activated carbon filters.
Thermax	Pune, India	1966	Water recycling, Waste heat energy, Emission control, Cooling from heat waste etc.

With its portfolio of advanced membrane technologies, Dupont is well recognized global player in wastewater recycle and reuse sector.

7. OPPORTUNITY LANDSCAPE OF INDIA'S MUNICIPAL SOLID WASTE MANAGEMENT MARKET

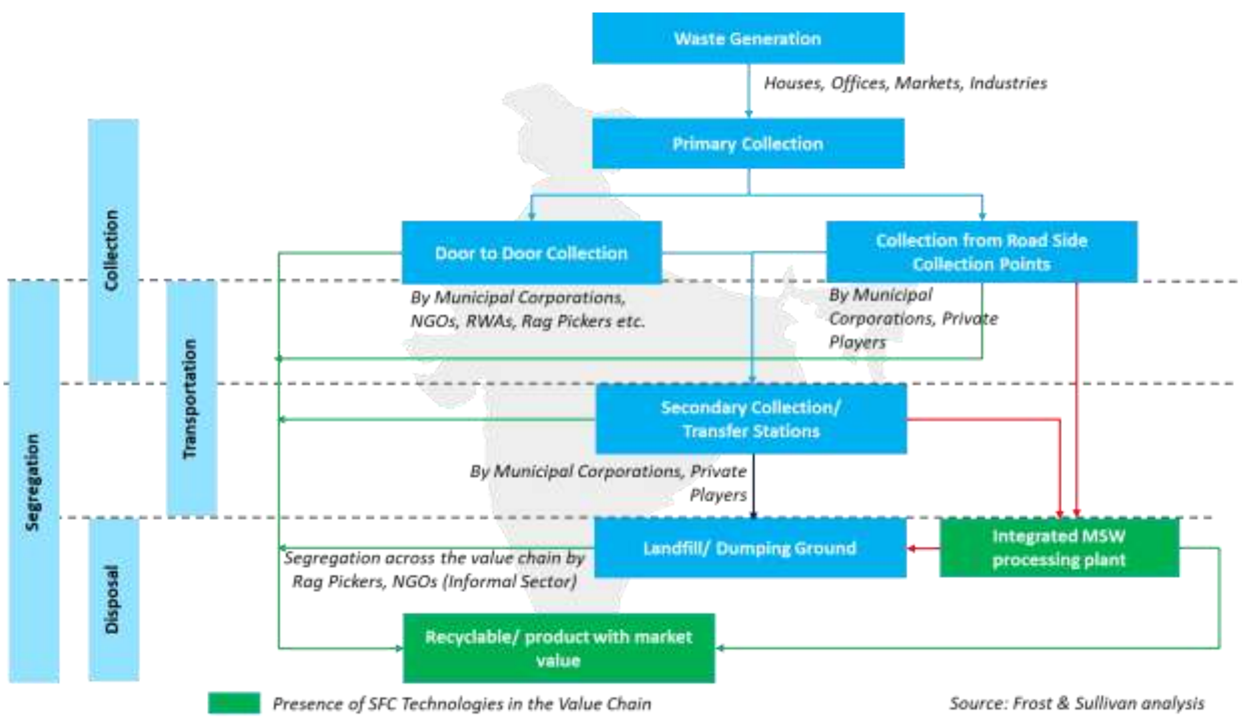
7.1 Overview of Indian Municipal Solid Waste management market

The solid waste management sector in India has experienced notable growth in recent years, primarily propelled by the government's emphasis on cleanliness and sanitation. The surge in population and rapid urbanization has led to a substantial rise in waste generation, necessitating efficient and sustainable waste management practices. The Swachh Bharat Abhiyan launched by the Government has significantly contributed to the sector's momentum, resulting in heightened demand for waste management solutions.

7.2 Municipal Solid Waste management value chain in India

The Municipal Solid Waste (MSW) management value chain begins with waste generation by households, industries, and institutions. This waste is collected by municipalities or private entities and transported to treatment facilities or landfills. At treatment facilities, organic waste is converted into compost or biogas, recyclables are processed, and non-recyclable waste is treated through incineration or landfilling. Government bodies, waste collectors, technology providers, and recycling companies are the key stakeholders in this value chain.

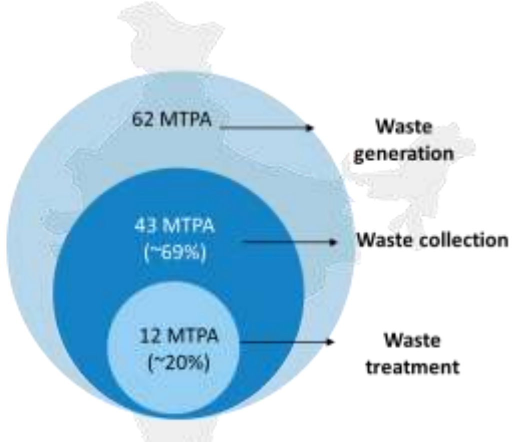
Exhibit 7.1: Municipal Solid Waste Management Value Chain in India



7.3 Solid waste generation and processing across various states in India

India generates over 62 million tons (MT) of waste annually with an average annual growth rate of 4%, of which 43 MT gets collected, with 12 MT (~20%) being treated before disposal and the remaining 31 MT (~50%) discarded in waste yards. The 62 MT of waste generated annually includes 7.9 MT of hazardous waste, 5.6 MT of plastic waste, 1.5 MT of e-waste, and 0.17 MT of biomedical waste.

Exhibit 7.2: Waste generation, collection, and treatment volume, Tons per Annum (TPA), India

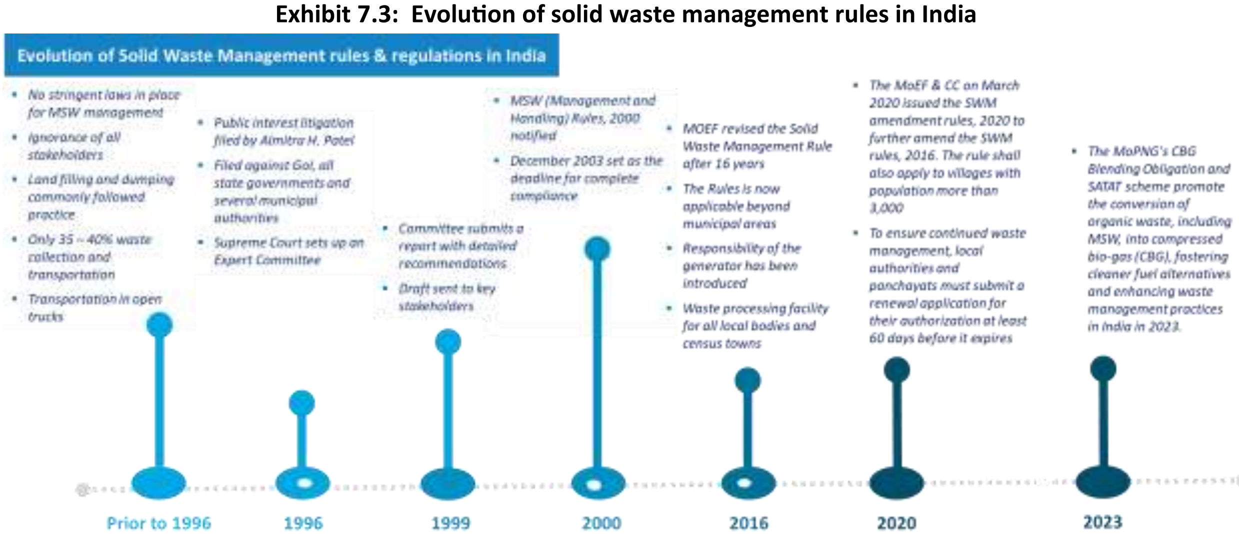


Note: Million Tonnes per Annum (MTPA)
Source: OGD Platform, ITA, Frost & Sullivan Analysis

The Swachh Bharat Mission-Urban (SBM-U), launched in October 2014, aims for a garbage-free India through 100% source segregation, door-to-door collection, and scientific waste management, including controlled landfill disposal and dumpsite remediation. The Central Pollution Control Board (CPCB) projects annual waste generation will reach 165 million tons by 2030. Indian cities are expected to generate an estimated 435 million tons of solid waste by 2050. The waste sector contributed around 1200 kilotons per year (Kt/yr) of PM2.5 emissions in India in 2020. These emissions are projected to almost double by 2050 due to rising waste generation.

7.4 Evolution of solid waste management rules and regulations in India

Exhibit 7.3: Evolution of solid waste management rules in India



Source: Frost and Sullivan Analysis

7.5 Salient features of Solid Waste Management Rules, 2016

FEATURES	DESCRIPTION	REASONS AND LIKELY IMPLICATION
SEGREGATION OF MUNICIPAL SOLID WASTE	• The SWM 2016 emphasizes source segregation, making it mandatory to separate municipal solid waste into wet and dry categories. This applies throughout the entire	• SWM companies need to collect segregated waste, add compartmented or separate vehicles for dry and wet waste as well as

	waste management value chain, including collection, transportation, storage, and ultimately, the treatment method used.	deploy bio- methanation/ composting for wet waste and **WTE only for dry waste, post recovery of recyclables**.
PROMOTION OF MARKETING AND UTILIZATION OF COMPOST	• The Department of Fertilizers shall ensure promotion of compost with chemical fertilizers in the ratio of 3 to 4 bags: 6 to 7 bags by the fertilizer companies to the extent compost is made available. • The Ministry of Agriculture shall also facilitate manufacturing and sale of compost for usage in farmlands and issue suitable usage guidelines.	• This will make the compost plants economically viable and improve the gainful utilization of waste.
PROMOTION OF WASTE TO ENERGY PLANT	• The Ministry of Power shall fix tariff or charges for the power generated from the WtE plants and ensure compulsory purchase of power by DISCOMs from these plants. • MNRE shall facilitate infrastructure creation for WtE plants and provide appropriate subsidy or incentives for such Plants. • All industrial units using fuel and located within 100 km from a RDF plant to replace at least 5% of their fuel requirement by RDF so produced. • Non-recyclable waste having calorific value of 1,500 Kcal / Kg or more shall not be disposed and to be utilized for energy generation. • High calorific wastes shall be used for co-processing in cement or thermal power plants.	• This will make the waste to energy plants economically viable. • Usage of RDF by nearby industries will support the WtE and reduce the consumption of fossil fuels. • WTE plants are however commercially viable for more than 600 TPD - most of the tier 2 cities would probably need to go for bio-methanation for the wet fraction and RDF disposal to Cement plants as RDF generation is 30% (500 TPD MSW plant will produce 150 TPD of RDF, which is not enough for a WTE plant).
CRITERIA AND STANDARDS FOR WASTE TREATMENT FACILITY AND POLLUTION CONTROL	• The SWM Rules 2016 provide for detailed criteria for setting up of solid waste processing and treatment facilities. • Emission standards are completely amended and include parameters for dioxins, furans, reduced limits for particulate matters from 150 to 100 and now 50. • Compost standards have been amended to align with Fertilizer Control Order.	• The criteria and buffer zone for waste treatment and landfill facility and stringent standards will facilitate smooth functioning of the facility without any pollution issues.
TIMEFRAME FOR IMPLEMENTATION	• The local bodies and other concerned authorities would be responsible for implementation of these rules. • Setting up solid waste processing facilities by all local bodies having 0.1 Mn or more population - within two years; local bodies and census towns below 0.1 Mn population – within 3 years. • Setting up of common or stand-alone sanitary landfills by or for all local bodies (0.5 million or more population) and census towns (under 0.5 million population) – within three years.	• This will ensure proper landfills and waste processing facilities across the country even in smaller towns.

	• Bioremediation or capping of old and abandoned dump sites - within five years.

7.6 Prominent technologies for energy generation from Municipal solid wastes

FEATURES	DESCRIPTION	EQUIPMENT USED FOR POWER GENERATION
Anaerobic Digestion/ Bio-methanation	• Organic fraction of the waste is processed through Biogas Digester. • Biogas Digester produces methane rich biogas and effluent. • Biogas can be used either for cooking / heating application, for power generation or for CBG/ Bio-CNG.	• Dual fuel / Gas Engine • LP Gas Turbine • Steam Turbine
Combustion / Incineration	• Waste is directly burned in presence of excess air (oxygen) at high temperatures (about 1,200° C), liberating heat energy, inert gases, and ash. Combustion results in transfer of 65% - 80% of heat content of organic matter. • The hot air thus produced is used to generate steam and power. Combustion / Incineration, however, is not suitable for all types of organic waste, especially when considering environmental and regulatory factors.	• Steam Turbine
Densification / Pelletization / Refused Derived Fuel (RDF)	• Segregating, crushing, and drying of inorganic material from MSW into fuel pellets is known as Refused Derived Fuel (RDF). The fuel is then used in Boilers for energy generation. • Balance waste in the dry fraction (after recovery of recyclables), often referred to as refused derived fuel ("RDF"), has a calorific value approximately between 3,000 to 3,500 Kcal/kg, making it a viable alternate fuel source for energy production or as a fuel (as replacement to coal) in cement plants.	• Steam Turbine

Based on discussions with the industry stakeholders, majority of the WtE plants in the country are based on incineration technology. There would be a handful of plants that are using Bio-methanation to generate energy from MSW. Pertinent to note that, the SWM Rules 2016, considering environmental impacts, provides for

- Bio-methanation, microbial composting, vermi-composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of biodegradable wastes
- Waste to energy processes including refused derived fuel for a combustible fraction of waste or supply as feedstock to solid waste-based power plants or cement kilns.

The SWM Rules 2016 highlights the need for and resultantly provides huge future potential for energy generation based on bio-methanation/anaerobic digestion of biodegradable wastes.

7.7 Overall potential of energy generation from Municipal Solid Waste in India

With its expanding population and rapid urbanisation, India has experienced a significant rise in municipal solid waste (MSW), posing notable environmental challenges. As per the Ministry of New and Renewable Energy, the total estimated energy generation potential from urban and industrial organic waste in India is approximately 5690 MW.

Exhibit 7.4: Energy generation potential from Urban and Industrial organic waste in India

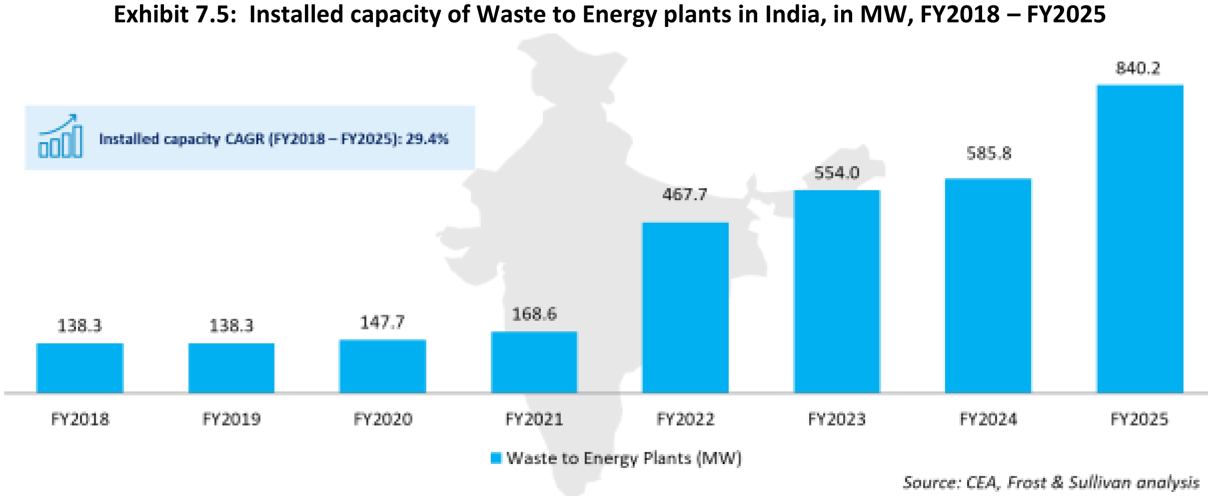
Sl No.	Sectors	Energy potential – MW
1	Urban Solid Waste	**1247**
2	Cattle farm (solid waste)	**862**
3	Distillery (liquid waste)	**781**
4	Vegetable Raw(solid waste)	**579**
5	Poultry (solid waste)	**462**
6	Urban Liquid waste	**375**
7	Slaughterhouse (liquid waste)	**263**
8	Paper (liquid waste)	**254**
9	Fruit Raw (solid waste)	**203**
10	Sugar press mud (solid waste)	**200**
11.a	Others (Solid Waste)*	**100**
11.b	Others (Liquid Waste)*	**364**
		5,690

Note: Million Tonnes per Annum (MTPA)
Source: MNRE and Frost and Sullivan Analysis

7.8 Installed capacity of Waste to Energy plants in India and historical growth

The WTE sector in India is in focus since last 7 – 8 years due to growing challenges related to waste management and need for energy through sustainable sources thereby ensuring the country's energy security. Installed capacity of WTE plants in the country has increased by 6 times between FY2018 and FY2025 – from 138.3 MW in FY2018 to 840.2 MW in FY2025. These WTE plants are both grid-connected and off-grid plants and they generate power from MSW and Industrial wastes. Based on discussions with the stakeholders, approximately 25 – 27 MSW based WTE plants were operational in the country at the end of FY2024 and installed capacity of these plants were approximately 250 MW.

Exhibit 7.5: Installed capacity of Waste to Energy plants in India, in MW, FY2018 – FY2025



Source: CEA, Frost & Sullivan analysis

Reviving India's Waste-to-Energy (WTE) sector presents numerous advantages, including diminished dependence on fossil fuels, a broader energy portfolio, and bolstered energy resilience. Additionally, WTE facilities skilfully handle solid waste by easing pressure on scarce landfill capacity and tackling the escalating waste production issue. These facilities also foster employment prospects, bolstering the regional economy and livelihoods. By harnessing latent waste resources, curbing greenhouse gas (GHG) emissions, mitigating health hazards, and combating climate change, WTE initiatives resonate with Sustainable Development Goals and promote a circular economy.

7.9 Leading developers of Waste to Energy plants in India and their portfolio

The Indian Waste-to-Energy (WtE) market is fragmented, with key players including SFC Environmental Technologies, RE Sustainability, JITF Urban Infrastructure, Abellon Clean Energy, and Antony Lara Renewable Energy. These companies do processing, and recycling of waste and few of them also does collection and transportation. Out of them, RE Sustainability, JITF, and Abellon focus solely on incineration. While majority of the companies use incineration to produce electricity from wastes, SFC Environmental Technologies is the only company to use bio-methanation technology to produce Biogas/ electricity, avoiding harmful emissions and ash. SFC Environmental Technologies is among the select few players who have leveraged global technology in the MSW space and transformed it to be suitable for Indian needs. The key features of its MSW plant at North Goa are as under:

- Ability to achieve biogas yield more than the industry average. The Company has achieved an average biogas yield of more than 150 Nm^3/ton of organic waste in the North Goa Plant in the last financial year, higher than the industry average of 80-100 Nm^3/ton.
- By converting the digestate formed after the fermentation of organic fraction into high-quality compost, the process improves the marketability and price realization of the compost produced.
- The Company has capability to recover higher proportion of recyclables than the industry average through its proprietary municipal solid waste processes
- Balance waste in the dry fraction (after recovery of recyclables), often referred to as refused derived fuel ("RDF"), has a calorific value approximately between 3,000 to 3,500 Kcal/kg, making it a viable alternate fuel source for energy production or as a fuel (as replacement to coal) in cement plants.

SFC is among the market leaders in the MSW space basis their operational results and comprehensive solutions. The company currently runs a 250 TPD Municipal Waste to Biogas plant in North Goa and a 125 TPD plant in South Goa. Operating continuously for over 8 years, SFC's plant at Saligao, North Goa holds the distinction of being one of the longest-operating integrated SWT-based biogas plants in India.

The plant deploys the Company's proprietary OREX technology. OREX is SFC's proprietary innovation, designed to efficiently separate biodegradable organics from inorganic materials and lignocellulosic fibres from mixed municipal waste. OREX automatically segregates mixed municipal waste into organic (wet) and inorganic (dry) fractions in a single step reducing the need for manual oversight, translating into lower ongoing operational costs and promotion of reuse.

OREX is a multi-stage system designed to extract maximum organics from the mixed waste and preparation of de-gritted organic slurry for downstream digesters resulting into homogenous pulped slurry having >98% biodegradable material, largely free of contaminants and non-biodegradable fractions which enhance the bio-methanization process inside digesters. This technology is particularly adept at processing the typical municipal solid waste found in India, which characteristically includes a diverse mix of bio-waste, inerts, textiles, glass, wood, metal, rubber, plastic, paper, and miscellaneous items.

Exhibit 7.6: Profile of leading Waste to Energy project developers in India, FY2025

			Waste Processing Technology					
Company Name	**Year of incorporation**	**Waste C&T**	**CBG/Bio-methanation**	**Incineration**	**Inorganic waste recycling**	**Waste Handling Capacity (TPD)**	**WTE Capacity (MW)**	**States where operational**
SFC Environmental Technologies	2005	✗	✓	✗	✓	350	2.17	South and North Goa
RE Sustainability	1994	✓	✗	✓	✓	13,500	48	19 locations across India
Ecogreen Energy	2011	✓	✗	✓	✓	4,500	55 (proposed)	MP, UP, Haryana
JITF Urban Infrastructure	2007	✓	✗	✓	✓	~2,000	16	Delhi, Punjab
Abellon CleanEnergy	2008	✓	✗	✓	✓	3,100	Current - 45 Upcoming - 65	Gujarat
Antony Lara Renewable Energy	2018	✓	✗	✓	✓	1,000	14	Maharashtra, UP

Note: (SFC Data - Waste Handling capacity - 350 TPD, with an additional handling capacity of 75 TPD resulting in our aggregate treatment capacity of up to 425 TPD)

Source: Annual Report, Frost & Sullivan Research and analysis

The organic fraction, high in biodegradable matter and moisture, enhances the bio-methanation process. The inorganic fraction, or refuse-derived fuel (RDF), includes materials like plastics and paper. After removing metals and heavy materials, RDF is refined into high-quality fuel with a calorific value of 3,000 to 3,500 Kcal/kg. This underscores the company's reliability, trustworthiness, and ability to consistently deliver value, solidifying the company's position as a preferred partner in the industry. The company benefits from a strong brand reputation that has been cultivated over more than 20 years of industry presence.

7.10 Key growth drivers of WTE sector in India

A. Increasing waste generation and waste management expected to drive the market

India's rapid urbanization is increasing waste generation, with organic waste making up over 50% of the total. Urban growth and high population densities are creating large landfills nearing capacity. Recycling occurs through formal and informal channels, causing environmental issues such as pollution from e-waste and improper dumping.

B. Government initiatives and policies to strengthen Waste to Energy Programme

The National Bioenergy Programme promotes waste-to-energy plants through the Waste to Energy (WTE) Programme, with a budget of INR 6,000 million from FY2022 to FY2026. The programme provides financial support for Biogas, Bio CNG, and power plants using urban, industrial, and agricultural waste.

The programme allows Viability Gap Funding (VGF) up to INR 2,000 million and include two sub-schemes:

- **Infrastructure Projects**: Supports water supply, solid waste management, and wastewater treatment, offering up to 30% of the total project cost as capital grant. Additional funding can cover up to 30% of the project cost, with projects required to recover 100% of operational costs.
- **Demonstration/Pilot Projects**: Provides up to 40% of the total project cost as capital grant and 25% of the net present value of O&M costs for the first five years. Additional funding can cover up to 40% of the project cost and 25% of O&M costs.

C. Only alternative to landfilling

Landfills are considered the least desirable option for waste management due to various issues, including the emission of greenhouse gases, the requirement for large areas of land, and the potential for pollutants to contaminate soil and groundwater.

D. Energy Demand and Renewable Goals

WTE supports India's target of 500 GW of non-fossil fuel-based capacity by 2030. Helps diversify the renewable energy mix beyond solar and wind.

E. Technological Advancements

Improved combustion, gasification, and biomethanation technologies have made WTE more efficient and viable for Indian waste characteristics.

F. Public-Private Partnerships (PPPs)

Increasing involvement of private players through PPP models, especially in large municipalities, boosts investment and operational efficiency.

7.11 List of notable, successful, and currently operating WTE plants in India

Waste-to-energy technologies transform waste materials into various forms of energy, such as electricity, heat, or fuel, through processes like combustion, gasification, or anaerobic digestion. These technologies provide a dual benefit: they process waste that would otherwise go unused, converting it into usable energy, and they significantly reduce the volume of waste sent to landfills, thereby mitigating environmental impact.

Furthermore, waste-to-energy plants offer the added advantage of recovering valuable resources, such as metals and plastics, during the treatment process. These materials can be extracted, recycled, and reintroduced into the economy, supporting circular economy initiatives and reducing the need for virgin resource extraction. By integrating energy production with resource recovery, waste-to-energy technologies present a sustainable solution for waste management and energy generation.

Exhibit 7.7: List of notable, successful, and currently operating WTE plants in India

City	Commencement Year	Location	Capacity (MW)	Developer
North + South Goa	2014	Saligoan and Cacora	1.37 MW + 0.8 MW	SFC Environmental Technologies
Delhi	2016	Narela-Bawana	24.0	Ramky Enviro Engineers
Hyderabad	2012	Jawaharnagar	19.8	Ramky Enviro Engineers
Delhi	2012	Okhla	~23.0	Jindal ITF
Delhi	2016	Gazipur	12.0	IL&FS - EverSource Capital will take over the Plant
Jabalpur	2018	Kathonda	11.5	Essel Infra; The plant will be taken over by Averda India
Hyderabad	2018	Bibinagar	11.0	RDF Power Projects Limited (IL&FS is yet to finalize the successor)
Solapur	2013	Not Known	4.0	Organic Recycling Systems
Shimla	2017	Bhariyal	1.7	Elephant Energy
Rajkot	2022	Gujarat	14.9	Abellon Clean Energy

Source: Frost & Sullivan research and analysis

7.12 Environmental issues and operational challenges

A. Low calorific value of solid waste in India due to improper segregation

In India, mixed waste has a calorific value of around 1,500 kcal/kg, insufficient for power generation compared to coal's 8,000 kcal/kg. Biodegradable waste, high in moisture, is more suited for composting. Segregated and dried non-recyclable waste has a higher calorific value of 2,800 to 3,500 kcal/kg, suitable for power generation. Proper segregation, ideally at the source, is crucial for meeting this calorific requirement.

B. High costs of energy production

Power generation from waste costs about INR 7-8 per unit, while traditional sources like coal and solar provide power at INR 3-4 per unit. To be competitive, waste-to-energy power prices need to be halved. Despite this, the primary goal of waste-to-energy plants is improving health, hygiene, and environmental conditions. Developers should receive adequate compensation through justified tariffs, and subsidies for capital expenditure could boost the sector. Operational costs can be offset by selling CBG and recyclables.

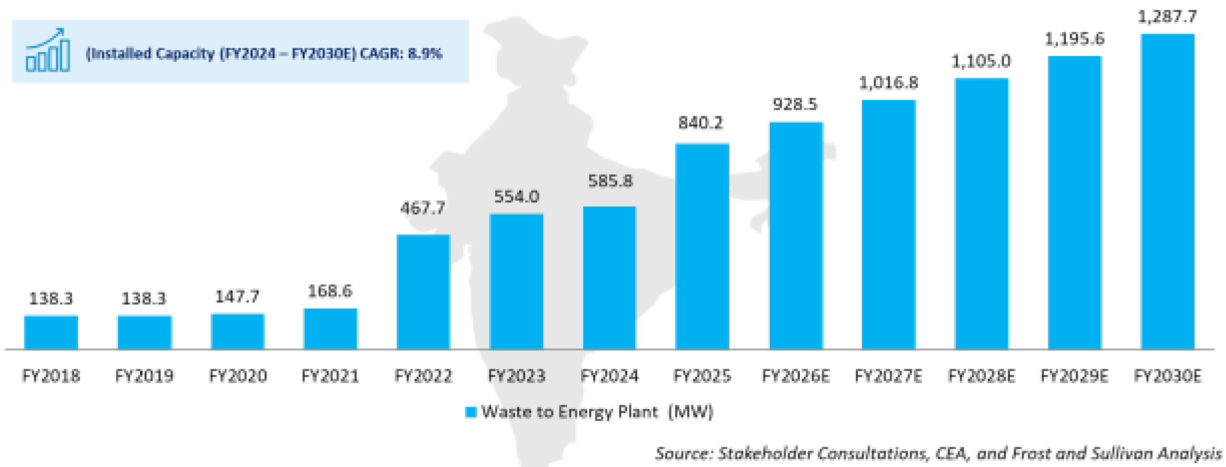
C. Improper assessments and unfavorable on-ground conditions

Many waste-to-energy projects face challenges due to poor assessments, unrealistic projections, and on-site issues. Waste volumes fluctuate due to seasonal changes, rainfall, and transient populations. These projects should use only non-recyclable dry waste, about 25% of total waste, which must be segregated to ensure effective energy generation. Successful operation depends on efficient waste collection, segregation, and processing. Issues at processing plants can increase moisture and reduce calorific value, affecting power generation efficiency.

7.13 Expected in installed capacity of WTE plants in the country

Based on discussions with the stakeholders and as per ongoing projects in the country, installed capacity of WTE projects in the country is expected to grow at approx. 8.9% CAGR to reach nearly 1287.7 MW by FY2030. MNRE projected that India's Waste-to-Energy capacity to reach 2,780 MW by 2050.

Exhibit 7.8: Growth forecast of WTE plants in India, MW, FY2018 – FY2030E



Source: Stakeholder Consultations, CEA, and Frost and Sullivan Analysis

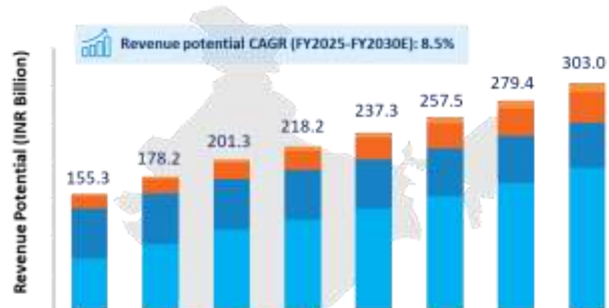
7.14 Revenue potential from MSW (CBG, Electricity, Compost, and Recyclables)

Municipal Solid Waste (MSW) has multiple revenue potentials from sales of Compressed Biogas, Electricity, Recyclables, and Compost. Based on solid waste generated in the country in FY2025 and subsequent collection and processing, revenue potential from the above-mentioned businesses were INR 201.3 billion. The potential is likely to increase to INR 303.0 billion by FY2030, growing at a CAGR of 8.5%.

Exhibit 7.9: Revenue potential from MSW related businesses, India, INR billion, FY2025-FY2030E

Key assumptions for calculation of potential revenue:

Parameters	FY25	FY30E
MSW Generation (TPD)	161,157	195,500
MSW collection %	96%	100%
MSW treatment %	78%	95%
Wet waste as % waste collected	50%	50%
CBG volume (Nm^3 per TPD)	100	120
CBG price including GST (Rs./Kg)	57	75
Compost as % of wet waste	6%	7%
Compost price (Rs./Kg)	2.0	3.0
Recyclables as % of dry waste	10%	15%
Recyclables price (Rs./kg)	6.0	8.0
MW / '100 TPD RDF	2	2
Electricity price (Rs./Kg)	7.5	7.5



	FY2023	FY2024	FY2025	FY2026E	FY2027E	FY2028E	FY2029E	FY2030E
Compost	3.2	3.6	4.7	5.5	7.2	8.6	10.2	12.0
Recyclables	16.2	18.7	21.8	25.3	29.0	32.8	36.8	40.9
Electricity	66.8	67.3	67.7	66.6	65.3	64.0	62.4	60.8
CBG	69.1	88.6	107.1	120.8	135.8	152.2	170.0	189.3

Source: Stakeholder Consultations, Frost and Sullivan Analysis

7.15 List of announced, planning, and under-construction projects

SL. NO.	MUNICIPAL CORPORATION	LOCATION	CAPACITY MSW (TPD)	CURRENT STATUS	DEVELOPER
1	Tinsukia Municipal Board	Tinsukia, Assam	125	Under Construction	Oil India Limited
2	Bhubaneswar Municipal Corporation	Bhubaneswar, Odisha	300	Under Construction	Oil India Limited
3	The Greater Noida Industrial Development Authority	Astauli, Uttar Pradesh	300	Under Construction	Reliance Bioenergy Limited
4	Pimpri-Chinchwad Municipal Corporation	Moshi, Pune, Maharashtra	375	Announced	Not Appointed
5	Brihanmumbai Municipal Corporation	Deonar, Mumbai, Maharashtra	1000	Announced	Mahanagar Gas Limited
6	Jorhat Municipal Board	Jorhat, Assam	125	Announced	Oil India Limited
7	Kochi Municipal Corporation	Kochi, Kerala	150	Under construction	Bharat Petroleum Corporation Ltd
8	Cuttack Municipal Corporation	Cuttack, Odisha	200	Announced	Oil India Limited

9	Agartala Municipal Corporation Solid Waste Management	Agartala, Tripura	160	Announced	Oil India Limited

The future of Waste-to-energy conversion looks promising with several factors such as integration with existing RE system, advancement in technology, and policy support are driving the growth of the sector. Generating energy from waste is a significant step in the quest for sustainability. By transforming waste into valuable energy, dual challenges of waste management and energy production can be addressed. Advances in chemical engineering have been instrumental in developing efficient and environmentally friendly WtE technologies. Innovative Waste-to-Energy Methods will play an increasingly important role in building a sustainable future as we continue to innovate and improve these processes.

8. OPPORTUNITY LANDSCAPE OF INDIA'S BIOGAS MARKET

8.1 Role of Biogas in India's CNG/PNG ecosystem

India's energy landscape is shifting towards cleaner alternatives, with biogas emerging as a key player in enhancing the CNG and PNG ecosystem. Once considered waste, biogas, rich in methane, is now valued as a renewable resource. By converting organic matter into clean fuel, biogas can be integrated into existing CNG and PNG infrastructure, reducing reliance on imported fossil fuels and supporting a sustainable energy future for India.

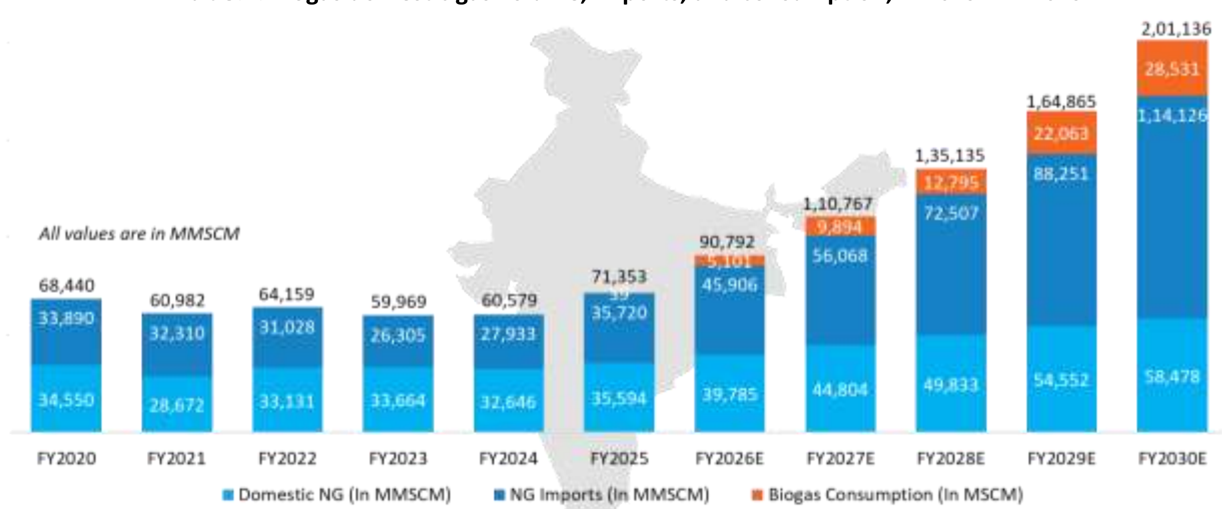
A. Biogas as a biofuel in India's decarbonization journey

India's shift towards renewable energy is critical for reducing carbon emissions. Biogas plays a key role with its potential to cut fossil fuel use by 6% by 2030. It contributes to emission reduction through methane mitigation, circular economy practices (using digestate as a natural fertilizer), clean energy substitution, and the use of biogenic CO2 for renewable processes.

B. Biogas can help in reducing India's LNG import

Biogas is set to significantly reduce India's reliance on imported LNG, with consumption projected to rise to 28,531 MMSCM by FY2030E, potentially saving substantial import costs. Compressed Biogas (CBG) could decrease natural gas consumption by 13.5–14% by FY2030E.

Exhibit 8.1: Biogas domestic gas volume, imports, and consumption, FY2019 – FY2029E



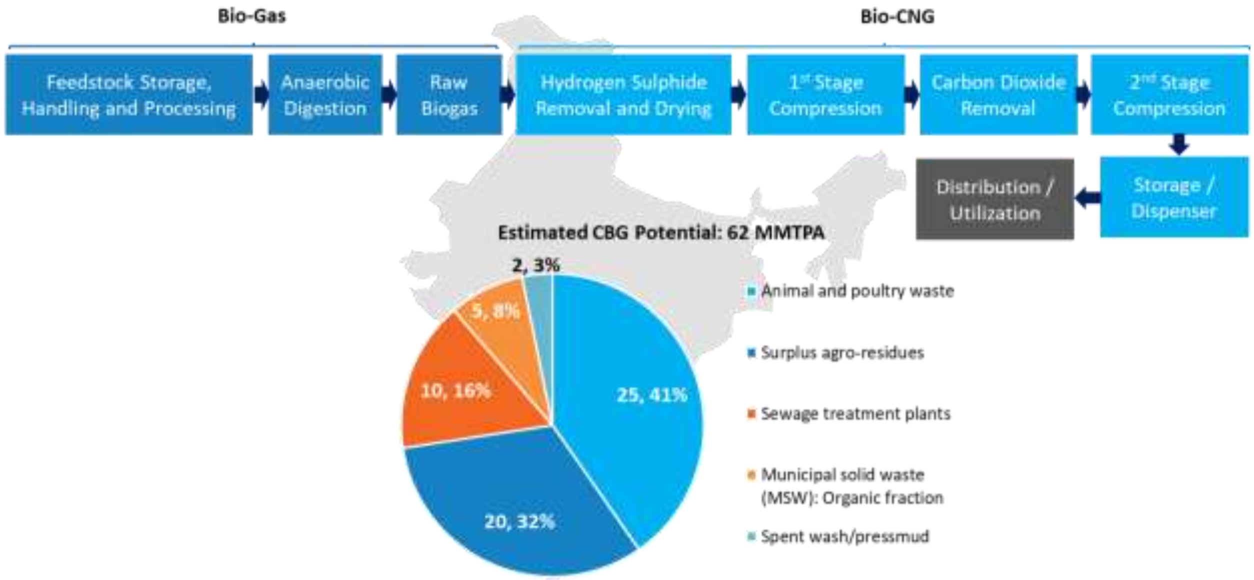
C. Reduce pollution and its effects that are generated from burning biomass

Biomass burning is a major source of air pollution and greenhouse gases, contributing to thousands of premature deaths annually, especially in North India. Converting crop residues into biogas can address this issue, and government initiatives like co-firing biomass in power plants have already reduced CO2 emissions by 1.2 Lakh Metric Tons.

8.2 Potential for Bio-CNG generation in the country from Agro-waste

India's diverse biogas feedstocks include animal waste, agricultural residue, municipal solid waste (MSW), and sewage sludge, with a total Compressed Biogas (CBG) potential of 62 MMTPA.

Exhibit 8.2: Bio-CNG generation potential from various feedstocks

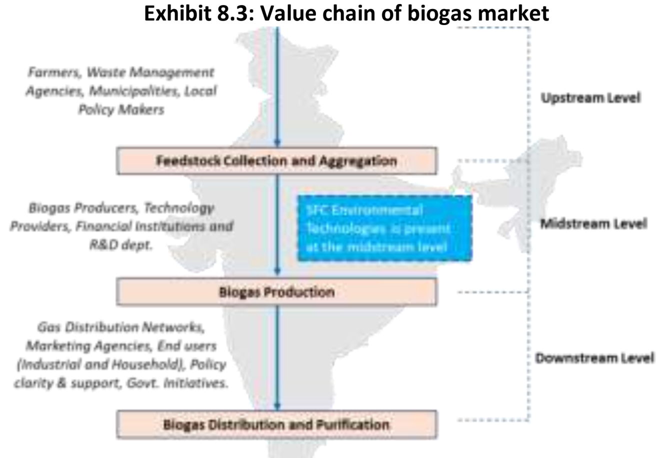


Source: Petroleum Research, Vol 7, Issue 3; Frost & Sullivan Analysis

8.3 Value Chain of Indian Biogas Market

The Indian biogas market includes feedstock collection, processing, production, and distribution. Key players are government bodies, state departments, cooperatives, private firms, and renewable energy agencies. Biogas is vital for energy security, entrepreneurship, and local economies.

Exhibit 8.3: Value chain of biogas market



Source: Frost & Sullivan research and analysis

The Indian government supports the sector with financial aid for biomass machinery and mandates CBG blending in City Gas Distribution pipelines from FY2026, driving demand for biogas production technologies.

SFC Environmental Technologies Ltd. being a provider of such technology used in midstream level of biogas production is one of the leading integrated municipal solid waste-based biogas developer in India and is poised to be a key beneficiary of government initiative of blending of biogas. Operating continuously for over 8 years, SFC's plant at Saligao, North Goa holds the unique distinction of longest operating integrated MSW based biogas plant in India.

Exhibit 8.4: Roles and responsibilities of key stakeholders

STAKEHOLDER	ROLES	RESPONSIBILITIES
Government Agencies (e.g., MNRE) and Policy Makers	Policy Formulation and Promotion	Formulate and implement policies, provide financial assistance, promote biogas use, and create a conducive environment for the biogas industry
Training and Development Centers (e.g., BDTCs) and Educational Institutions	Training and Development	Provide training, development programs, and research for biogas production
Promotional Bodies (e.g., KVIC, NDDB)	Promotion	Promote biogas plants among rural communities and the use of waste for biogas production
Biogas Producers and Companies	Production and Distribution	Involved in various stages of the biogas value chain, from feedstock collection, processing, production, to distribution
Distribution Entities (e.g., OMCs)	Distribution	Distribute biogas using their infrastructure and network
Technology Suppliers	Technical Support	Provide technical support, specialized equipment, and solutions for biogas production
Financial Agencies	Financial Support	Provide financial backing, approve loans for biogas projects, and invest in the biogas sector

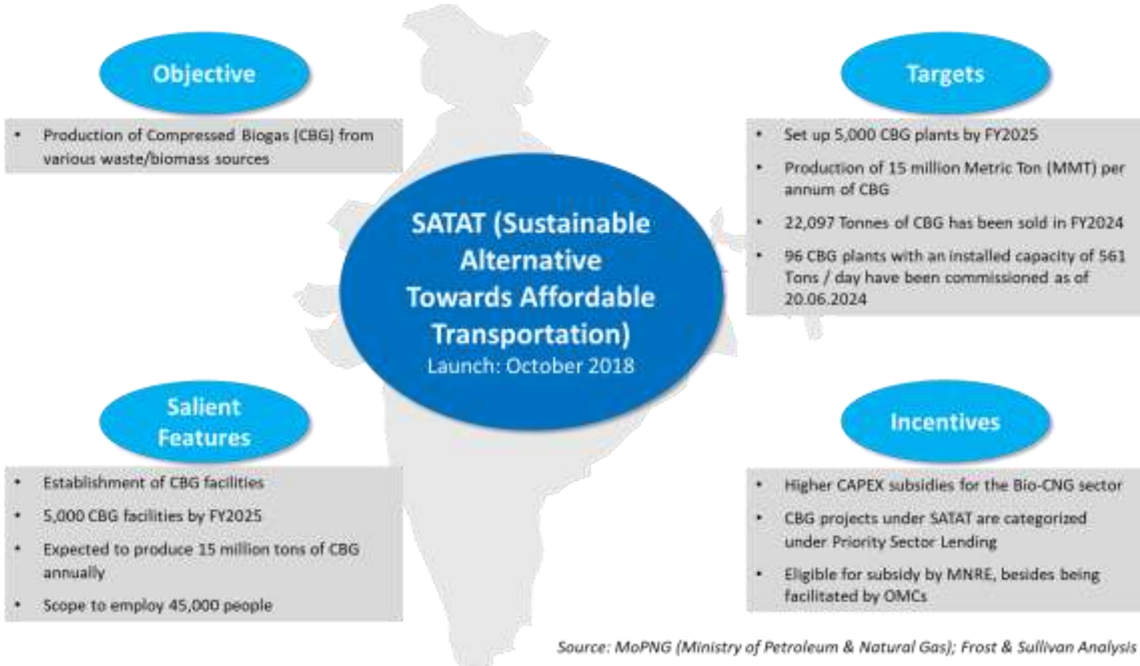
8.4 Government policies driving the growth of the Indian CBG sector

Following are various government initiatives to promote consumption of CBG in the country:

- **National Bio Energy Programme**: Launched by the MNRE on 2nd November 2022, this program aims to promote power, biogas/BioCNG, and briquette/pellet production with a budget of INR 17 billion (Phase 1: INR 8.6 billion). It supports the use of surplus biomass from rural areas, providing additional income for rural households.
- **Sustainable Alternative Towards Affordable Transportation (SATAT):** This initiative promotes the production of CBG from waste/biomass, aiming to reduce reliance on fossil fuels and air pollution from crop stubble burning. It is expected to produce 15 million tonnes of gas, reducing the CNG bill by 40%.

- **PM-PRANAM Scheme:** A proposed program to reduce chemical fertilizer use by promoting bio and organic fertilizers. It aims to reduce the subsidy burden on chemical fertilizers and encourage states to adopt alternatives.
- **Financial Assistance for Biomass Aggregation Machinery:** This scheme supports CBG producers in purchasing machinery for biomass aggregation, facilitating CBG production and overcoming funding challenges.
- **CBG Blending Obligation (CBO):** In India, the compressed biogas ("CBG") blending obligation mandates oil marketing companies to blend CBG into their fuel infrastructure. The mandatory blending obligation will begin in FY 2025-26, starting at 1% and gradually increasing to 5% from FY 2028-29 onwards. This initiative mandates OGMCs to set up projects for CBG production from organic waste and biomass.

Exhibit 8.5: SATAT Scheme, targets, salient features and incentives



Source: MoPNG (Ministry of Petroleum & Natural Gas); Frost & Sullivan Analysis

8.5 Revenue potential from Surplus Agro Residue and Press Mud (CBG and Briquettes)

Both Compressed Biogas and Briquettes can be produced from Surplus Agro Residue and Pressmud – the current availability of these two feedstocks has been estimated at approximately. 150 MT and 20 MT, respectively.

Exhibit 8.6: Revenue potential from Surplus Agro Residue and Press Mud, India, INR billion, FY2023-FY2030

Note / Assumptions:

1. *The revenue potential has been calculated based on only two feedstocks – Surplus Agro Residue and Pressmud.*
2. *Even though annual CBG potential of the above-mentioned feedstocks are 20 MMTPA & 2 MMTPA, considering realistic availability, the revenue has been calculated at 25%*
3. *CBG price is expected to increase from INR 57 / Kg in FY2023 to INR 70 / Kg in FY2030*
4. *Briquette's sale (quantity) has been considered as 10% of feedstock considering the mix of feedstock and marketability*
5. *Briquette price for FY2023 has been considered as INR 5 / Kg which is expected to increase to INR 8/ Kg by FY2030*

	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030
Briquette	21.2	22.0	27.5	28.6	34.6	36.0	40.1	44.5
CBG	313.5	326.0	356.9	371.2	418.2	435.0	487.1	506.6

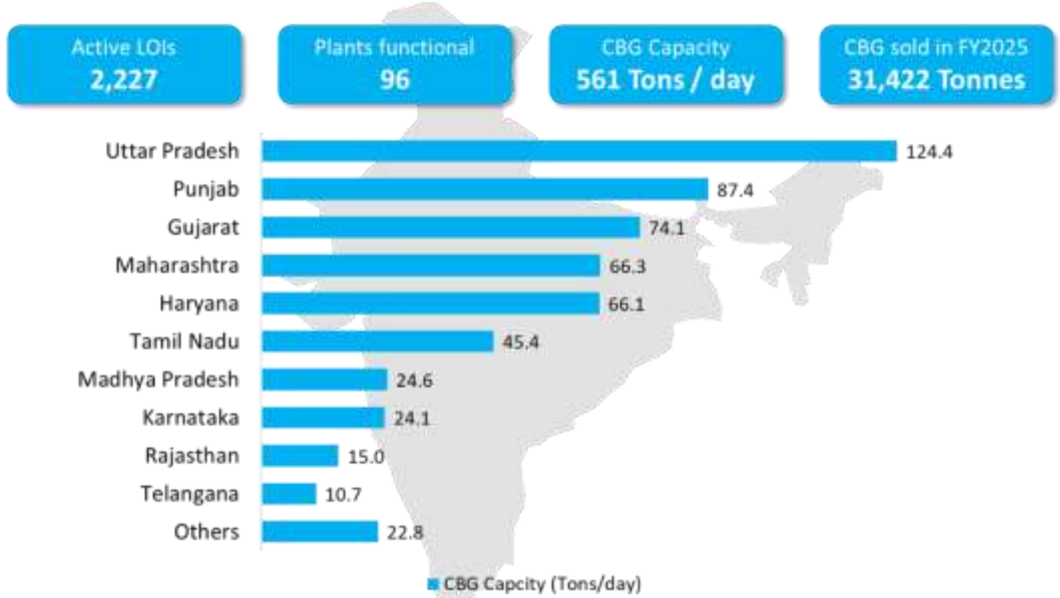
Source: Stakeholder Consultations, Frost and Sullivan Analysis

For the purpose of this calculation, it has been assumed that only 25% of the feedstock would realistically be available for CBG and Briquette production – this is in line with assumptions considered for the SATAT scheme. Basis these assumptions, revenue potential from the above-mentioned businesses in FY2023 were INR 313.5 billion. The potential is likely to increase to INR 506.6 billion by FY2030, growing at a CAGR of 7%.

8.6 Current state of CBG production in India

According to the information available on SATAT and GOBARdhan portal of Government of India, there are 96 functional CBG plants in India as on 08.05.2025 with a cumulate CBG production capacity of 561 Tons / day.

Exhibit 8.7: Status of CBG production, India

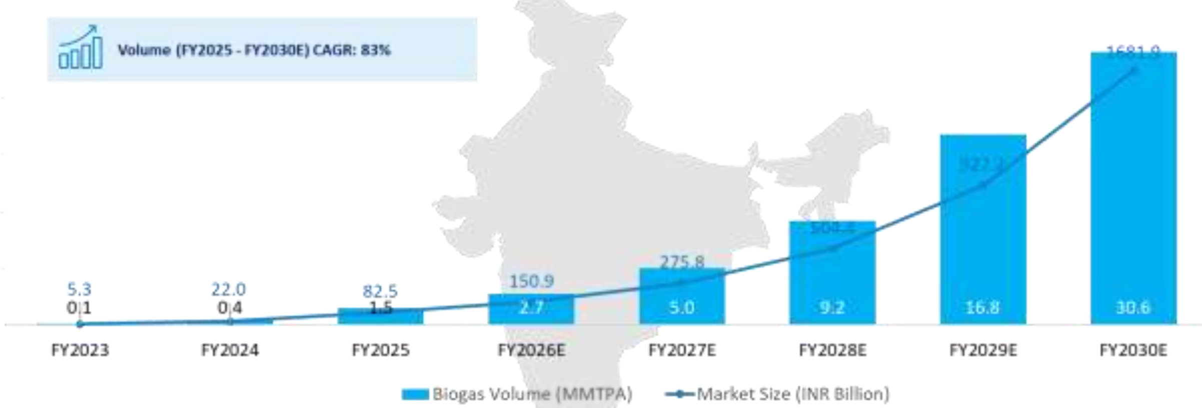


Besides, there are 2,227 active Letters of Intent (LOI) for setting up similar plants and in FY2025, 31,422 tonnes of CBG have been sold in the country. The above chart indicates approximately 2.5 times increase from 38 CBG plants, 225 Tons/day capacity at the end of October 2022. Advancements in technology have made the production of CBG more efficient and cost-effective, further boosting the market growth. Some of the renowned producers of CBG at present are Verbio India (33 TPD), Lakhimpur Kheri RNG (21.2 TPD), Jakraya Sugar (20 TPD), Reliance Bio Energy (20 TPD), Reliance Industries (20 TPD), Inodore Clean Energy (17 TPD), Sangrur RNG (14.8 TPD), Patiala RNG (14.8 TPD), Circle CBG India (14.6 TPD), HPCL (14.3 TPD), Bharat Biogas Energy (14.0 TPD) etc.

8.7 Current size of Indian Biogas Market and its growth

Government programs and policies are set to drive exponential growth in India's CBG sector. According to the 'Gobardhan' portal, there are 90 operational CBG plants, 8 completed, 161 under construction, and 372 in planning. These numbers are expected to increase significantly. Frost & Sullivan estimates that CBG production in India was 1.5 MMTPA in FY2025 and is projected to reach 30.6 MMTPA by FY2030. The market value is expected to grow from INR 82.5 billion in FY2025 to INR 1681.9 billion by FY2030, with a conservative CAGR of 80-85%. For example, HPCL has set up a plant in Budaun with an investment of INR 1,330 million, processing 100 MTPD of rice straw to produce 14 MTPD of CBG and 65 MTPD of solid manure. This plant will reduce stubble burning on 17,500-20,000 acres, cutting 55,000 tons of CO_2 emissions annually, and generating employment for 1,100 people. The government plans to establish 100 similar plants in Uttar Pradesh

Exhibit 8.8: Growth of Indian CBG market, in MMTPA and INR billion, FY2023 – FY2030E



Note:
1. *Density of CBG has been considered as 0.76 kg / SCM*
2. *Price of CBG considered as Rs. 55 / kg*

Source: Statista, Frost & Sullivan Research and Analysis

8.8 Growth drivers and restraints of the Indian CBG market

The growth of the Indian CBG sector is fueled by several factors that include supportive government, an abundant supply of organic waste, and a growing awareness about environmental sustainability. This could pave the way for a thriving CBG sector for the country.

Exhibit 8.9: Key drivers for the growth of Indian Biogas Market

SL. NO.	FACTORS	SHORT-TERM IMPACT	LONG-TERM IMPACT
1.	**Mandatory blending of 5% CBG from waste into the CGD network by FY2029**	This will stimulate demand for CBG in the CGD sector. It will promote production and consumption of CBG in the country.	The CBG Blending Obligation (CBO) will encourage significant investment and facilitate establishment of numerous CBG projects. It will lead to import substitution for Liquefied Natural Gas (LNG), saving in foreign exchange, and promoting circular economy.

2.	**Increasing awareness towards environmental sustainability**	Immediate increase in demand for biogas solutions.	Sustained growth as more people adopts renewable energy solutions.
3.	**Government initiatives promoting renewable energy**	Increased funding and support for biogas projects.	Creation of a favorable policy environment for renewable energy.
4.	**Rising adoption of renewable resources**	Increased market demand for biogas.	Shift towards renewable energy sources, reducing dependence on fossil fuels.
5.	**Increasing installation of energy sources**	Growth in the biogas industry due to increased installations.	Widespread adoption and normalization of biogas as a primary energy source.
6.	**Increasing utilization of wastes**	More efficient use of waste materials, boosting biogas production.	Establishment of waste-to-energy as a standard practice, contributing to a circular economy.

However, the sector is also affected with a few present-day challenges that have been listed below:

Exhibit 8.10: Restraints hindering the growth of the Indian CBG Market

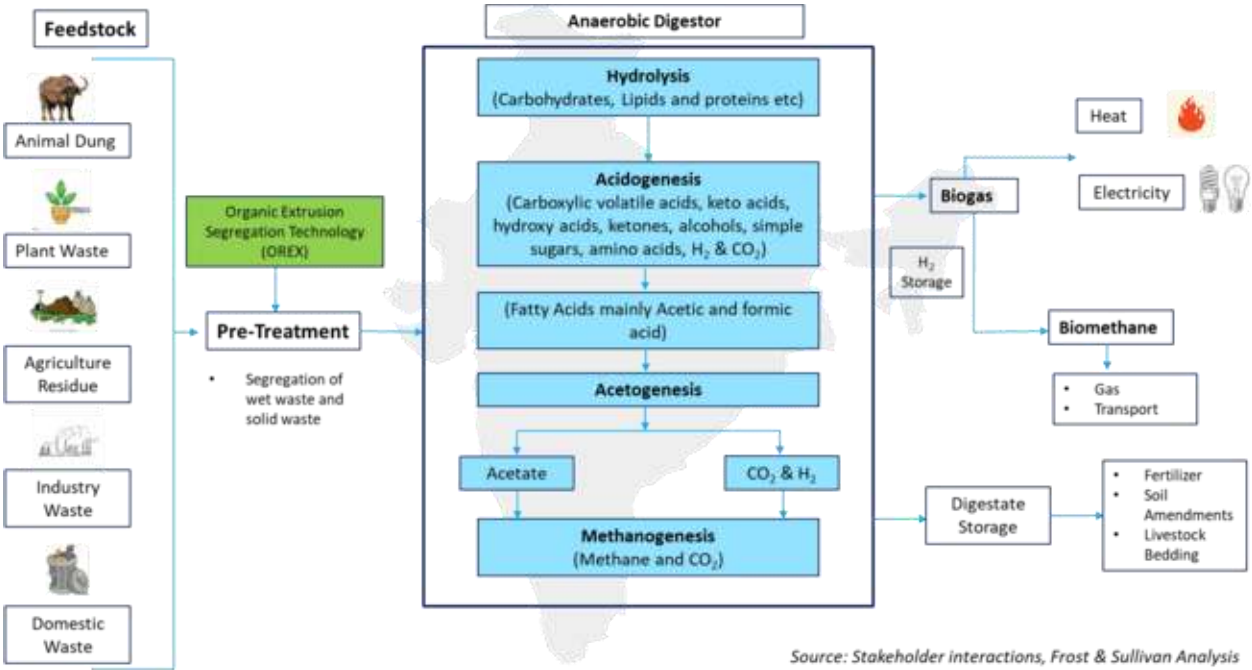
SL. NO.	FACTORS	SHORT-TERM IMPACT	LONG-TERM IMPACT
1.	**High capital expenditure**	Potential deterrent for new entrants due to high initial costs.	Consolidation of the market, with larger players dominating.
2.	**Supply chain related bottlenecks / availability of feedstocks**	Limited availability or fluctuations in the supply of feedstock could lead to delays or cancellations of ongoing projects and is a major operational challenge	Potential long-term disruptions in the supply chain, affecting future projects.

8.9 Bio-methanation process and OREX as an Organic waste pre-treatment technology

Bio-methanation is a process that converts hydrogen (H2) and carbon dioxide (CO2) into methane (CH4) through several key stages:

- **Hydrolysis**: Complex organic compounds are broken down into simpler molecules by bacteria, preparing them for further processing.
- **Acidogenic Fermentation**: These simpler molecules are further broken down, producing volatile fatty acids (VFAs) like acetic acid.
- **Hydrogen-Producing Acetogenesis**: VFAs are converted into hydrogen (H2) and carbon dioxide (CO2), essential for methane production.
- **Methanogenesis**: Methanogens use H2 and CO2 to produce methane (CH4).
- OREX technology enhances this process by efficiently segregating municipal waste into organic and inorganic fractions.

Exhibit 8.11: Bio-methanation process and OREX Technology



Source: Stakeholder interactions, Frost & Sullivan Analysis

The organic fraction, rich in moisture and organic matter, is used for bio-methanation, while the inorganic fraction is converted into high-quality Refuse Derived Fuel (RDF). This technology has capability to yield more than 150 Nm^3 of biogas per ton of organic waste, higher than the industry average of 80-100 Nm^3 per ton.

8.10 Plans of OMCs/CGD companies to enter Indian Biogas Market

Oil Marketing Companies (OMCs) and City Gas Distribution (CGD) Companies are entering the Indian biogas market, driven by the rising demand for clean energy and the government's biogas production targets. With their extensive infrastructure, OMCs and CGDCs are expected to boost the sector's growth, advancing India's energy security and sustainability goals.

In this evolving market, SFC Environmental Technologies Group have a clear edge over Original Equipment Manufacturers (OEMs). SFC's expertise in waste-to-energy solutions, strong regulatory relationships, and proven technologies make them well-suited to lead in biogas production and distribution. Collaborating with OMCs and CGD Companies, established players like SFC can accelerate market penetration and promote sustainable energy practices across India, reinforcing the nation's shift towards a greener future.

Exhibit 8.12: OMC (Oil Marketing Companies) and CGD Companies and their interest in Indian Compressed Biogas Market

OMC	PLAN
Oil India Ltd.	Oil India Ltd's Board has given in principle approval for formation of a joint venture with Hindustan Waste Treatment Pvt. Ltd. (HWTPL) a subsidiary of SFC to take up initiatives for establishment of CBG projects with equity holding in the ratio of 50:50, subject to approval of DIPAM and other authorities.
Oil and Natural Gas Corporation Ltd. (ONGC)	ONGC's Board has given in principle approval for formation of a joint venture to establish 15 waste-based compressed biogas (CBG) plants across

	India with two experienced companies: SFC and EverEnviro Resource Management Pvt. Ltd.
Indraprastha Gas Ltd. (IGL)	IGL has signed MOU with technology partners to establish Compressed Biogas (CBG) plants across four states: Delhi, Haryana, Rajasthan and Uttar Pradesh. Additionally, IGL has already empaneled two other partners for the same purpose. The biogas produced from these 19 plants shall be fed into IGL's City Gas Distribution network. This partnership aims to produce 0.45 MMSCMD (Million Metric Standard Cubic Meters per Day) of biogas from waste, equivalent to approximately 5% of IGL's daily requirements.
GAIL (India) Limited	GAIL (India) Ltd. plans to set up around 26 Bio CNG plants over the next two to three years, both as producers as well as joint venture partners with raw material suppliers or biogas producers. The company has issued an Expression of Interest across India, for companies qualifying with certain parameters to form joint ventures for raw materials such as paddy straw, municipal solid waste and sugar.
Mahanagar Gas Ltd. (MGL)	MGL is expected to invest over INR 600 Crores in constructing and operationalizing 1000 Ton per day segregated organic municipal solid waste (MSW) based compressed biogas plant at Deonar, Mumbai.
Indian Oil Corporation Limited (IOCL)	IOCL has shown interest in the SATAT initiative and is planning to procure CBG from potential entrepreneurs.
Bharat Petroleum Corporation Limited (BPCL)	BPCL is also part of the SATAT initiative and is planning to set up CBG plants across the country.
Hindustan Petroleum Corporation Limited (HPCL)	HPCL is planning to offer a delivered price for procurement of CBG, with additional incentives based on the delivery distance and current CNG market price.
Reliance Industries Limited (RIL)	RIL plans to set up more than 50 compressed biogas (CBG) plants in the next two years at a cost of over INR 50 billion. They have already set up two CBG demo units at its refinery facility in Jamnagar and commissioned the first commercial-scale CBG plant at Barabanki in Uttar Pradesh.
Essar Oil	Essar Oil has shown interest in the SATAT initiative and is planning to procure CBG from potential entrepreneurs.
Nayara Energy	Nayara Energy is also part of the SATAT initiative and is planning to set up CBG plants across the country.

Source: Frost & Sullivan research

8.11 Municipal Wet Waste to Biogas generation and selling as CNG/PNG

Municipal wet waste, such as food scraps and yard trimmings, can be converted into biogas through shredding, mixing with water, and anaerobic digestion, producing methane and carbon dioxide. This biogas can be purified to create Compressed Natural Gas (CNG) or Piped Natural Gas (PNG). The Ministry of New and Renewable Energy supports Waste to Energy projects for Biogas, Bio-CNG, and Power from various wastes. For example, a plant processing 20 tons of fruit and vegetable waste daily can yield about 2,400 m³ of Bio-CNG. Key factors for successful conversion include waste availability, collection costs, and digester facilities.

8.12 Leading Biogas Technology Suppliers

The Indian biogas market is dynamic, with key biogas technology suppliers shaping its trajectory. In the table above, we spotlight the leading biogas technology suppliers operating within India. These companies contribute significantly to the nation's sustainable energy objectives by advancing biogas adoption, waste-to-energy initiatives, and environmental stewardship.

Exhibit 8.13: Leading MSW treatment companies providing Waste to Energy (WTE) Solutions

COMPANY	PRODUCTS / SOLUTIONS	DESCRIPTION
SFC Environmental Technologies	Technology solutions for solid waste treatment comprising design, engineering, turnkey solutions and O&M	SFC provides solutions for Solid Waste Treatment, including project development, design and engineering, equipment supply, construction and commissioning, and long-term operation and maintenance. SFC also offer turnkey solutions through an engineering, procurement and construction ("EPC") model. SFC's principal technology is OREX, which is their proprietary technology, designed to separate biodegradable organics from inorganic materials and lignocellulosic fibres from mixed municipal wastes.
Ecogreen Energy	Waste Collection & Transportation, Waste Processing & Treatment, Waste to Energy, Construction & Demolition Waste Management	Ecogreen Energy is a waste management and waste-to-energy company in India. It provides door to door waste collection service, transportation of waste to plant sites where the waste is segregated and then converted into organic compost, electricity, and RDF (Refuse Derived Fuel).
Antony Lara Renewable Energy	Waste-to-Energy	The company focuses on comprehensive operations of collection, transportation, treatment and disposal of municipal solid waste.
Abellon Clean Energy	Waste to Energy, Extended Producer Responsibility, Biomass Heat & Transport, EPC3	Abellon Clean Energy is an integrated sustainable energy solutions provider. The company's primary business is energy generation from waste. The company has entered into a technical agreement with Germany's Agraferm Group for setting up biogas plants across India. In the first phase, the company will set up biogas plants in Gujarat and later, on a pan-India basis, with technical support from Agraferm Group.

8.13 Threats and challenges to SFC Technologies and its products and services

A. Challenges specific to the End user industry

Municipal Authorities: Ageing infrastructure, inadequate collection systems, and weak enforcement of industrial pre-treatment are major challenges, leading to pollution. Upgrading infrastructure, enhancing waste collection, and enforcing stricter regulations are needed.

Households and Residential Communities: Inefficient waste management stems from poor source segregation, mixing recyclables, food scraps, and non-biodegradables. Encouraging waste segregation and promoting composting are vital for improved management.

Industries: High installation and maintenance costs deter biogas adoption. Limited awareness of financial benefits and technology also hampers uptake. Government incentives and awareness programs can boost adoption.

Challenges specific to SFC Environmental Technologies

SFC Environmental Technologies faces standard industry risks, including competition from both established and new players, and economic fluctuations affecting project budgets and investment. Domestic market uncertainties and changes in government policies, such as levies or exemptions on imported materials, can impact sales and profit margins. For example, fluctuations in steel or plastic prices and changes in government subsidies may influence project costs and demand for SFC's solutions.

9. AGRO WASTE TO BIOGAS MARKET IN INDIA

9.1 Introduction

A. Agro-Waste (crop residues, husks, straw, stubble, sugarcane bagasse, press mud, etc.)

Agro-waste, or agricultural waste, refers to the by-products and residues generated from various agricultural activities, including crop cultivation, harvesting, and processing. It encompasses a wide range of organic materials that are typically not the main products but are left behind after harvesting or processing crops. Common types of Agro-waste include crop residues like stalks, stems, and leaves that remain in the field post-harvest; trash (such as sugarcane trash, soybean thrash and castor thrash) straw (especially from cereals like wheat, maize and rice); and stubble, the short stalks left after cutting crops.

Agro-industrial processing produces other forms of waste. Sugarcane bagasse, the fibrous residue left after extracting juice from sugarcane, and press mud, a by-product of sugar processing, corn cobs after taking out the corn, chikori shells are key examples. These materials are often underutilized or discarded, leading to environmental challenges such as open burning or improper dumping. Despite being considered waste, these materials are rich in cellulose and organic matter, making them valuable for bioenergy, composting, and other sustainable applications. Efficient management and recycling of Agro-waste not only reduce environmental pollution but also promote circular economy practices in agriculture, contributing to energy generation, soil health, and sustainable rural development.

B. Potential for energy generation - Compressed Biogas (CBG) and Biomethane:

Agro-waste holds significant potential for renewable energy generation, particularly in the form of CBG (Compressed Biogas) and biomethane. These gases are produced through anaerobic digestion, where microorganisms break down organic Agro-waste in the absence of oxygen, generating biogas that can be upgraded to biomethane or compressed into CBG for use as fuel. The CBG thus produced has similar properties to CNG (Compressed Natural Gas) and can be used in transport, industry, or reticulated system (piped gas for homes). Moreover, the digestate (by-product) serves as a nutrient-rich bio-fertilizer, closing the agricultural loop.

C. Although Market quantification is limited, policy interest and pilot-level activity are growing:

Although the quantification of the Agro-waste biogas market remains limited due to fragmented data and varying collection efficiencies, there is a growing policy interest and pilot-level activity in this sector. The diverse nature and seasonal availability of Agro-waste make it challenging to develop precise market estimates, but the untapped potential is widely acknowledged. Governments and stakeholders are increasingly recognizing Agro-waste as a strategic resource for clean energy, particularly for producing biogas, CBG, and biomethane. Initiatives such as India's SATAT (Sustainable Alternative Towards Affordable Transportation) scheme are encouraging public and private players to invest in CBG plants using agricultural residues like press mud, straw, and sugarcane bagasse.

Several pilot projects and decentralized biogas units are being set up across rural areas to demonstrate the viability of Agro-waste as feedstock. These efforts aim to create scalable models for waste-to-energy conversion, improve rural energy access, and reduce reliance on fossil fuels. While commercial deployment is still in its early stages, increased funding, technological support, and regulatory incentives are expected to drive the growth of the Agro-waste biogas sector in the coming years, aligning with broader climate and energy security goals.

9.2 Policy & Regulatory Support

India's government has implemented a series of forward-looking policies and programs to promote the conversion of agricultural waste into biogas and CBG. These efforts aim to address environmental issues like crop burning, improve rural energy access, create green jobs, and reduce dependence on imported fossil fuels. The following are the most significant schemes and mechanisms currently in place

A. SATAT initiative (Sustainable Alternative Towards Affordable Transportation) by MoPNG (Ministry of Petroleum and Natural Gas) (2018)

The SATAT initiative, launched in 2018 by the (MoPNG), is a flagship program aimed at boosting the production and usage of CBG in India. The initiative originally set a target of establishing 5,000 CBG plants by 2023–24, which has since been extended to allow for greater participation and execution. The goal is to utilize abundant agricultural residues and organic waste—such as crop stubble, cattle dung, and press mud—to produce CBG. The produced CBG is intended to be used as a cleaner, renewable automotive fuel and can also be injected into the existing CGD (City Gas Distribution) network as a substitute for natural gas. The SATAT initiative is market-driven and provides long-term offtake security through LOIs (Letters of Intent) from OMCs (Oil Marketing Companies) such as IOCL (Indian Oil corporation Limited), BPCL (Bharat Petroleum Corporation Limited), and HPCL (Hindustan Petroleum Corporation Limited), encouraging private investment in biogas infrastructure.

B. National Bio-Energy Programme (2022–2026) by MNRE (Ministry of New and Renewable Energy)

The National Bio-Energy Programme (2022–2026), introduced by the MNRE, serves as an umbrella scheme to promote energy generation from various biomass sources, including Agro-waste. This program provides financial and technical support for a wide range of waste-to-energy projects. It includes three major components: the Waste to Energy Programme, the Biogas Programme, and the Biomass Programme. Specifically, the scheme supports the construction of biogas and biomethanation plants that use agricultural residues such as sugarcane press mud, paddy straw, maize cobs, and cotton stalks. CFA (Central Financial Assistance) is offered to qualified developers based on project capacity and technology type. The program is designed to encourage both small-scale rural biogas plants and large-scale commercial CBG units, contributing to energy access, environmental sustainability, and rural economic development.

C. BPA (Biogas Purchase Agreements): Indian Oil, BPCL, HPCL inviting long-term offtake contracts

BPAs are being offered by major Oil Marketing Companies—IOCL, BPCL, and HPCL. These agreements provide long-term purchase commitments to biogas producers, ensuring a steady market for CBG. This procurement support reduces revenue uncertainty for plant operators and improves the bankability of projects. Under these agreements, CBG producers are assured offtake at pre-agreed prices, enabling them to secure financing more easily. The inclusion of biogas into the national fuel mix underlines the government's commitment to building a robust green gas infrastructure.

9.3 Drivers and Opportunities

A. Agro-residue burning and air pollution

One of the most critical environmental challenges in India is crop residue burning, particularly in the states of Punjab and Haryana. After harvesting paddy, farmers burn the leftover stubble in their fields to quickly prepare for the next crop (usually wheat). This practice contributes heavily to air pollution, including toxic smog that blankets the NCR (National Capital Region) each winter. Agro-waste biogas projects offer a practical solution by monetizing crop residues, such as paddy straw and wheat stubble, turning them into valuable fuel (CBG). This reduces the incentive to burn and offers farmers an alternative income stream, while helping to curb severe public health and environmental impacts.

B. Rural energy access and decentralized solutions:

Many rural and semi-urban regions in India still face energy access challenges, including irregular electricity and limited access to clean cooking fuel. Biogas and CBG units, especially decentralized and modular systems, can be installed near agricultural hubs or villages where Agro-waste is abundantly available. These systems provide localized energy solutions for cooking, heating, or even small-scale power generation.

C. Circular economy – converting farm waste to fuel, manure, and income:

Agro-waste biogas fits squarely within the principles of a circular economy, where waste streams are repurposed into useful resources. In this model:

Farm waste (such as sugarcane press mud, maize stalks, banana waste, and cotton residue) is converted into renewable fuel (CBG). The emerging technologies like dual fuel retro fitment (Diesel +CBG injection in the diesel CI engines) will enable farmers and sugar factories to drive their diesel driven tractors and vehicles to operate with 65% substitution of diesel marking an important initiative in circular economy.

The process also produces digestate, a by-product that serves as an organic fertilizer, enriching soil and reducing the need for synthetic chemicals.

Farmers can earn income by supplying crop residues to biogas plants or even participate as stakeholders in local projects.

This closed-loop system boosts agricultural productivity, improves soil health, and creates new rural business models, turning pollution sources into economic opportunities.

D. Government push for import substitution of CNG/LNG:

India imports a significant portion of its energy, including CNG and LNG (Liquefied Natural Gas), which impacts the country’s foreign exchange reserves and energy security. CBG is chemically similar to CNG and can be used interchangeably in transport and industrial applications. By promoting domestic production of CBG from Agro-waste, the government aims to reduce reliance on imported fuels.

E. Carbon credits and ESG commitments by large firms:

As the global focus on sustainability and decarbonization intensifies, large corporations in India are under increasing pressure to meet ESG criteria. Biogas and CBG projects help companies lower their carbon footprints, qualify for carbon credits, and fulfill net-zero goals. Under the Sustainable Alternative Towards Affordable Transportation (SATAT) initiative, India plans to establish 5,000 CBG plants by 2030, targeting an annual production capacity of 15 million tonnes. This expansion is expected to yield around 15,000 tonnes of CBG daily, displacing nearly 14,000 tonnes of fossil-based natural gas each day and reducing methane-equivalent carbon emissions by approximately 20 million tonnes CO_2e per year.[2]

[2] https://www.globalmethane.org/documents/CBG_Report_%20January%202025.pdf

F. **Potential integration with captive gas use in industries**:

Industries with continuous thermal energy or gas needs — such as distilleries, sugar mills, paper manufacturing, and food processing — can directly integrate CBG plants with their operations.

9.4 Project Activity and Early Commercial Examples

Several pilot and commercial projects have emerged, demonstrating the practical potential and growing interest in Agro-waste-based biogas and CBG production. These projects, often supported by government initiatives and private investments, highlight how diverse feedstocks and innovative business models are being harnessed to build a sustainable bioenergy sector.

- Leading OMCs like IOCL, BPCL, and HPCL have played a significant role by issuing LOIs to numerous developers and entrepreneurs for the purchase of CBG. These LOIs serve as long-term agreements ensuring offtake of CBG, providing financial certainty and encouraging investments in setting up CBG plants. This demand assurance has helped catalyze several pilot and commercial biogas projects across the country.
- Among the emerging players driving innovation and deployment in this space are startups like GPS Renewables and EverEnviro. These companies specialize in biogas technology, project development, and providing end-to-end solutions for Agro-waste to CBG conversion. Additionally, industry associations such as the Indian Biogas Association have been instrumental in fostering collaboration, knowledge-sharing, and advocacy for the biogas sector, helping startups and existing players navigate policy frameworks and market opportunities.
- Use cases:
  - **Sugarcane press mud to biogas**: In the sugar industry, press mud—a by-product from sugar extraction—is rich in organic material and well-suited for anaerobic digestion. Converting press mud into biogas helps sugar mills reduce waste disposal costs and generate renewable energy.
  - **Paddy straw and wheat stubble**: Common agricultural residues in northern states like Punjab, Haryana, and Uttar Pradesh, these materials are increasingly diverted from burning to biogas production, helping address air pollution while producing fuel.
  - **Cotton stalks in Maharashtra**: Cotton farming generates large volumes of stalks post-harvest, which are often underutilized. Biogas projects using cotton stalks offer farmers an additional revenue stream and reduce environmental impact.
  - **Maize cobs, banana peels, and other residues**: Various other crop residues and organic waste from horticulture and food processing are also being used as feedstock, showcasing the adaptability of biogas technology to diverse Agro-waste streams.

9.5 Challenges and Barriers

A. High capex and long payback periods:

One of the most significant hurdles is the high capital expenditure required to set up a CBG plant. Biogas projects—especially those using agricultural residues—require substantial investment in feedstock handling systems, anaerobic digesters, gas purification units, compression infrastructure, and storage. In addition, these projects often face long payback periods, particularly when operated at small or medium scales. Without concessional finance or performance-linked incentives, this can discourage private players, especially rural entrepreneurs or farmer cooperatives, from entering the market.

B. Challenges in the aggregation, storage, and logistics of Agro-waste:

Aggregation, storage, and logistics of Agro-waste, which is often decentralized, bulky, and seasonally available. Farmers produce different types of biomasses at different times of the year, and collecting enough uniform feedstock to ensure consistent plant operation is difficult. Transportation costs for low-density materials like straw or stalks are high, and spoilage during storage is common, especially during the monsoon season.

C. Inconsistent supply chain and feedstock moisture content:

Biogas production efficiency is sensitive to the composition and quality of the feedstock. Variations in organic content, high moisture levels, or contamination can reduce gas yields or damage equipment. Maintaining a stable supply chain of clean, appropriately processed Agro-waste is crucial for plant efficiency and reliability.

D. Limited awareness and skilled manpower in rural areas:

Biogas plants require regular monitoring, process control, and maintenance. However, many rural areas lack trained technicians or operators familiar with anaerobic digestion and gas purification processes. This results in suboptimal plant performance, operational downtime, and in some cases, project failure.

E. Delay in policy implementation, land acquisition, and regulatory clearances:

Although central government schemes like SATAT and the National Bio-Energy Programme are well-conceived, bureaucratic delays at the state and district levels often impede timely execution. Acquiring land for plant setup, securing environmental permissions, and connecting to grid or transport infrastructure can be time-consuming and unpredictable.

9.6 Outlook and Conclusion

Among the various bioenergy technologies in India—such as bioethanol, biodiesel, biomass gasification, and traditional biogas—CBG from Agro-waste stands out as a particularly fast-moving segment. This is primarily due to strong and sustained government policy support, particularly the SATAT initiative and the National Bio-Energy Programme, which provide a clear roadmap, financial incentives, and market linkages for project developers.

A promising medium-term opportunity lies in strategically co-locating CBG plants with Agro-processing zones such as sugar mills, rice mills, food processing hubs, and Agri-industrial parks. These facilities generate large volumes of consistent, localized Agro-waste such as sugarcane press mud, paddy husk, maize cobs, and fruit/vegetable residues, which can serve as ready feedstock for biogas plants. Co-locating reduces transportation costs and logistical complexity, while also ensuring year-round feedstock availability. Moreover, Agro-processing clusters typically require significant thermal or electrical energy, offering a built-in demand for the biogas or biomethane produced. Such captive consumption models can improve project economics and reduce the payback period.

While progress is accelerating, achieving nationwide scale in Agro-waste-based CBG will likely require 10 to 15 years, given the sector's complex value chain and infrastructure requirements. Large-scale deployment will depend on overcoming current challenges related to capital investment, feedstock logistics, technology standardization, and regulatory alignment across states. Crucially, the role of OMCs as anchor buyers under the SATAT scheme will remain vital. Their long-term offtake agreements provide price stability and commercial viability for CBG producers. As more CBG is blended into India's transport and industrial fuel mix, OMCs can facilitate grid integration and distribution. In parallel, carbon markets and sustainability-linked finance mechanisms—such as green bonds, ESG-linked loans, and carbon offset revenues—will become increasingly important. These tools will help unlock lower-cost capital and improve project returns, especially as corporate demand for green energy rises. As India's climate commitments intensify and energy demand grows, Agro-waste CBG is poised to become a key component of the national clean energy strategy. With the right policy, market, and financing frameworks in place, the sector is well-positioned to scale sustainably over the next decade and beyond.

10. SOLAR SLUDGE DRYING SYSTEM

10.1 Industry Overview India and Global - Historical evolution, adoption trends, and typical applications

A. Historical Evolution

Early Global Development (1980s–2000s)

Origin in Europe: The concept of using solar energy to dry sewage sludge emerged prominently in Europe during the late 1980s and early 1990s. Germany and Austria were at the forefront of this innovation, driven by increasingly stringent environmental regulations, including restrictions on landfilling untreated or minimally treated sludge.

Technology Pioneers: As technology evolved, systems became more sophisticated with the incorporation of:

- Green House: Transparent Green House made up of Polycarbonate sheets to entrap heat from solar radiations to facilitate evaporation of moisture from sludge.
- **Sludge tillers/ turners**: Mechanized devices that agitate the sludge periodically to improve airflow and evaporation.
- **Forced ventilation**: Fans to enhance air exchange and control humidity inside the structure.
- **Temperature regulation**: Basic sensors to monitor and optimize the drying environment.

This evolution helped overcome challenges such as uneven drying, odor management, and weather dependence.

Global Expansion and Technological Advancements (2000s–2010s)

Adoption Across Climates: By the early 2000s, successful European installations sparked interest globally. Countries in Southern Europe, North America, and eventually the Middle East and Asia began implementing solar sludge drying systems. Each region adapted the technology based on climatic conditions, sludge characteristics, and policy environments.

Hybrid Innovations: A significant innovation during this period was the development of hybrid systems—combining solar energy with auxiliary heating sources such as:

- Biogas from anaerobic digestion
- Waste heat from industrial processes
- Solar-thermal collectors

Evolution in India (2010s–Present)

Traditional Roots: India has a long tradition of using sun drying for agricultural products and organic waste, including sludge. In rural and semi-urban areas, sludge from septic tanks or small treatment units was often spread in open drying beds or fields, allowing natural evaporation. However, this method was labor-intensive, space-consuming, and often resulted in odor and hygiene issues.

-Modern Adoption

The 2010s saw a transformation in India's approach to sludge management, driven by major developments, as a result, solar sludge drying began to be integrated into FSTPs (Faecal Sludge Treatment Plants) and ETPs (Effluent Treatment Plants) across urban and peri-urban India. These systems offered a cost-effective and scalable solution for municipalities and industries seeking low-energy sludge treatment.

B. Adoption trends

Global Adoption Trends:

- Adoption is particularly strong in regions with abundant sunlight, such as Asia-Pacific (notably India and China), Africa, and South America. These regions benefit from both environmental conditions and government incentives promoting renewable energy.
- Commercial applications dominate the market due to higher volume requirements in industrial settings, but there is also rapid growth in the individual and small-scale user segments.
- Technological innovation is a key trend, including the integration of smart controls, hybrid systems (combining solar with other renewables), and improved design for efficiency and user-friendliness.
- The adoption is expanding in pharmaceuticals, and textiles due to the demand for controlled, cost-effective, and environmentally friendly drying processes.
- Regulatory support, rising energy costs, and increased awareness of sustainability are significant catalysts for adoption worldwide.

Indian Adoption Trends:

- India is one of the leading markets for solar sludge drying systems, supported by rapid industrialization, and strong government policies incentivizing renewable energy adoption.
- The commercial segment, including municipal wastewater treatment and industries, is particularly active, with businesses attracted by the low operational costs and environmental benefits of solar drying.
- Government initiatives and subsidies have significantly boosted adoption, making solar dryers a cost-effective alternative to traditional drying methods in regions with high solar irradiance. The Indian government, through MoHUA, has issued advisories promoting the use of solar greenhouse dryers for safe and efficient treatment and reuse of sewage sludge. These advisories include technical designs and cost details for solar sludge dryers, aiming to improve the quality of biosolids, reduce drying time, and promote safe disposal and reuse practices. The initiative is part of a broader push to achieve sustainable sanitation and environmental goals, including the Sustainable Development Goals (SDGs)[3]
- India's solar dryer market is also characterized by scalability, accommodating both small and large-scale operations, and by increasing sophistication in commercial installations, such as automated control systems and higher hygiene standards.
- The market is expected to continue expanding rapidly, fueled by the need for efficient post-harvest management, and the push for sustainable industrial practices.

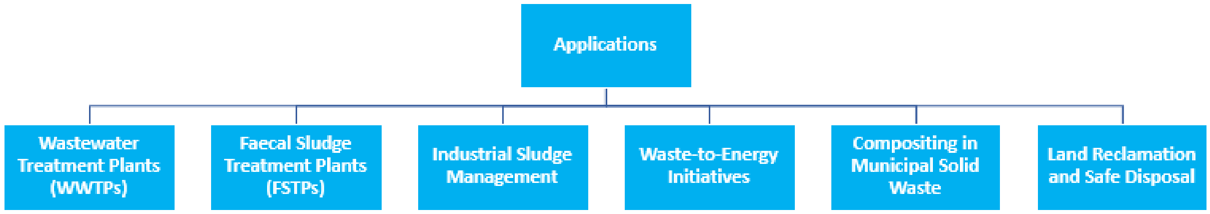
C. Applications

WWTPs (Wastewater Treatment Plants)

- Solar sludge drying is widely used to treat sludge generated from municipal and industrial wastewater treatment plants.
- The primary goals are to reduce sludge volume, lower disposal costs, and improve handling by converting wet sludge into a dry, stable product.
- The process also helps in pathogen reduction and stabilization of organic and inorganic contaminants, making the end product safer for further use or disposal.

[3]https://www.newindianexpress.com/nation/2025/Jan/27/government-suggests-ways-to-treat-reuse-sewage-sludge

Exhibit 10.1: Applications, Solar Sludge Dryer



Source: Frost and Sullivan Analysis

FSTPs (Faecal Sludge Treatment Plants)

- Solar drying is increasingly adopted for faecal sludge management, particularly in regions with high solar irradiance and limited access to conventional energy sources.
- The technology reduces the volume and pathogen content of faecal sludge, producing a dry material that can be safely disposed of or repurposed as fertilizer or fuel.

Industrial Sludge Management

- Solar drying systems are used for chemical and industrial sludge, including those from pharmaceuticals, and other manufacturing sectors.
- The process is especially valuable where contaminants (e.g., heavy metals, antibiotics) make traditional disposal methods problematic, and where energy efficiency is a priority.

Waste-to-Energy Initiatives

• Dried sludge with high calorific value (up to 9–12 MJ/kg) can serve as a renewable fuel source, supporting local energy production and reducing reliance on fossil fuels. This energy recovery is gaining traction as energy prices rise and the demand for CO_2-neutral fuels increases.

Compositing in Municipal Solid Waste Plant

• Sludge generated from the treatment of organic municipal solid waste can be processed into high-quality compost, contributing to sustainable soil management, reducing the burden on landfills and increase in circular economy practices.

Land Reclamation and Safe Disposal

- In cases where reuse is not feasible, solar-dried sludge is easier and safer to transport and dispose of in landfills or for land reclamation projects due to its reduced volume and stabilized nature.

10.2 Market Size India and Global - Current and projected market size

The global Solar Sludge Dryer market was valued at USD 230.40 Mn in CY2020 and grew to USD 240.70 million in CY2024. It is estimated to reach USD 254.44 Mn in CY2025E and is forecasted to grow to USD 376.93 Mn by CY2030F, registering a CAGR of 8.18% from CY2025E to CY2030F. This growth is driven by increasing environmental awareness, regulatory push for sustainable waste treatment, and rising adoption of energy-efficient drying technologies. Emerging markets, particularly in Asia-Pacific, are expected to contribute significantly to future demand due to infrastructure development and industrial expansion.

Exhibit 10.2: Solar Sludge Dryer Market (In USD Million), Global, CY2020 – CY2030F

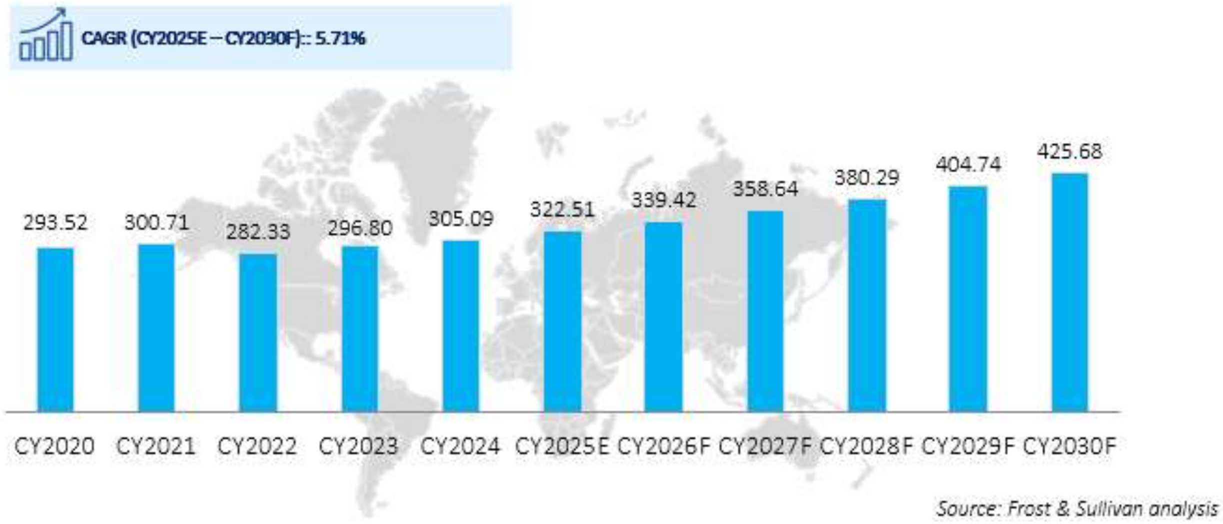
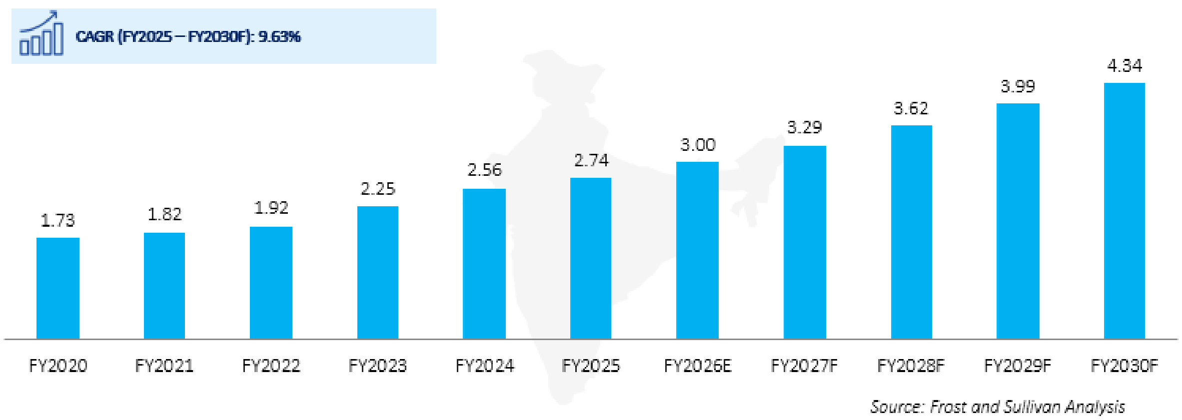


Exhibit 10.3: Solar Sludge Dryer Market (In INR Billion), India, FY2020 – FY2030F



The Indian Solar Sludge Dryer market was valued at INR 1.30 Bn in FY2020 and grew to INR 2.02 Bn by FY2024. It reached INR 2.16 Bn in FY2025 and is forecasted to grow to INR 3.84 Bn by FY2030F, registering a strong CAGR of 12.19% between FY2025 and FY2030F. This growth is fueled by rising environmental concerns, government initiatives promoting sustainable waste management, and increasing adoption of energy-efficient drying solutions by municipalities and industries. With rapid urbanisation and stricter regulations on sludge disposal, solar sludge dryers are emerging as a cost-effective and eco-friendly solution across India.

10.3 Future growth prospects - Regulatory support and environmental drivers

A. Regulatory Support

Global Regulatory Landscape: Regulatory frameworks worldwide are increasingly supporting sustainable wastewater and sludge management, creating a favorable environment for solar sludge drying systems. In the European Union, landmark regulations like the Urban Waste Water Treatment Directive (91/271/EEC) mandate stringent treatment and safe disposal of sewage sludge. Additionally, the EU Circular Economy Action Plan encourages resource recovery, including the reuse of treated sludge as soil conditioner or fuel—applications well-suited to solar-dried sludge.

In the United States, the EPA (Environmental Protection Agency) regulates biosolids under 40 CFR Part 503, encouraging environmentally sound practices such as land application, which require sludge to meet specific pathogen and solids content standards—achievable through solar drying.

In MENA and Southeast Asia, water reuse and zero-waste policies are pushing for decentralized sludge treatment options. National governments increasingly favor low-energy, low-emission technologies that align with climate goals and water resource management.

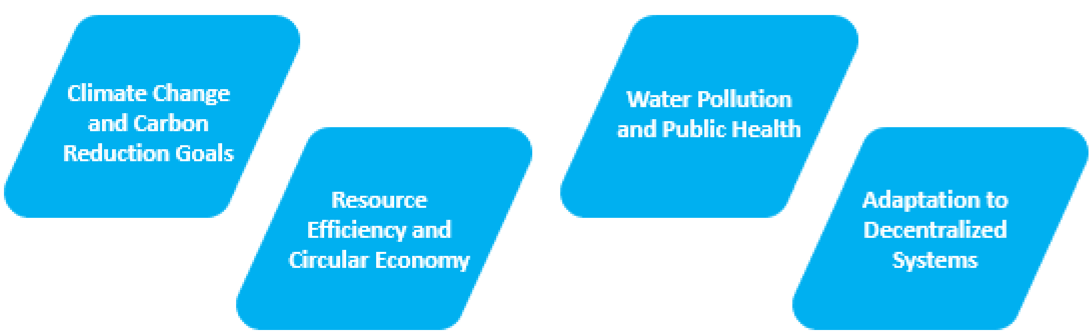
Regulatory Drivers in India: In India, solar sludge drying is being promoted through a combination of environmental regulations and sanitation missions:

- **Swachh Bharat Abhiyan (Urban & Rural)**: Emphasizes safe FSSM (Faecal Sludge and Septage management), especially in non-sewered areas.
- **NFSSM (National Faecal Sludge and Septage Management) Policy**: Encourages decentralized sludge treatment, were solar drying fits naturally.
- **ZLD (Zero Liquid Discharge) norms**: Mandated by the CPCB for industries like textiles, and chemicals, making sludge drying essential.
- **State-level Urban Development Policies**: Encourage cost-effective sludge treatment in small and medium towns through PPP models and infrastructure subsidies.

B. Environmental Drivers

Climate Change and Carbon Reduction Goals: One of the primary environmental drivers is the need to reduce GHG (Greenhouse Gas) emissions. Traditional sludge drying methods—such as thermal dryers and

Exhibit 10.4: Environmental Drivers, Solar Sludge Dryer



Source: Frost & Sullivan analysis

incineration—are energy-intensive and contribute significantly to carbon emissions. In contrast, solar sludge drying systems utilize renewable solar energy, significantly lowering operational carbon footprints. This aligns with national and international climate action plans and net-zero targets, particularly under the Paris Agreement and various NDCs (Nationally Determined Contributions).

Resource Efficiency and Circular Economy: Solar drying supports circular economy principles by converting wet sludge into a dry, stable product suitable for reuse. Dried sludge can be:

- Used as a soil conditioner in agriculture (kindly give potential market size (India or Globally) for use of dried sludge as soil conditioner)

- Co-processed in cement kilns or waste-to-energy plants (kindly give Potential market size (India or Globally) for use in cement industry
- Safely landfilled with reduced leachate generation

This resource recovery potential reduces dependence on chemical fertilizers, offsets fossil fuel use, and diverts waste from landfills.

Water Pollution and Public Health: Untreated or improperly disposed sludge poses serious risks to groundwater and surface water quality. Even under conservative estimates, India's Sewage Treatment Plants (STPs) are currently generating approximately 104,210 tonnes of sewage sludge per day. This volume is projected to rise significantly to around 186,347 tonnes per day if the country achieves 50% wastewater treatment coverage in the near future[4]. Solar drying reduces sludge volume and pathogens, supporting safe handling and disposal. This is especially important in developing countries, where wastewater infrastructure is often inadequate.

Adaptation to Decentralized Systems: As cities adopt decentralized wastewater treatment approaches, particularly in non-sewered or peri-urban areas, solar drying emerges as an ideal low-cost, low-maintenance solution with minimal environmental impact.

10.4 Key players/technologies - Leading companies, their offerings and Technology

Exhibit 10.5: Key Players and Technology

COMPANY NAME	HEAD QUARTERS	YEAR FOUND	TECHNOLOGY
Huber SE	Berching, Germany	1999	HUBER Sludge Turner SOLSTICE Sludge Drying and Sludge Disinfection and Reuse
Thermo-System	Esslingen, Germany	1997	Automation and Control, **Sludge Manager,** Sludge Tiller
Redco	Istanbul, Türkiye	2012	Solar Drying, BOBO sludge drying robot, PLC, Moving steel bridge and an adjustable rotary drum
Arges	Ankara, Turkey	1985	Solar sludge drying system, and sludge thickener
Solartiger	Gurten, Austria	2004	Hexagonal Rotating Drum, Air Scrubber and Biological filter. Biological and chemical processes

[4]https://www.indiawaterportal.org/health-and-sanitation/sanitation/sludge-food-food-thought#:~:text=This%20figure%20is%20expected%20to,biggest%20threats%20to%20the%20environment

IST-Anlagenbau GmbH	Neuenburg am Rhein Germany	1994	Turning and Conveying Machine, Technology of odor elimination (Zerodor)
Arvind Envisol Ltd	Ahmedabad, India	2008	Traveling bridge mixer, Advanced low-temperature drying and dehumidification technology, advanced automatic control technology and centralized monitoring of equipment.
Thermarex	Surat, India	2020	Electric Mole, speed-controlled wall fans, central PLC equipped with ClimaControl software.
ATR Solar	Madurai, India	2002	Solar Power Tower and Solar FSTP drying, and solar green house dryers,
Aadhi Solar	Tirupur, India	2009	Air heater, Electric heater etc.

IST-Anlagenbau GmbH, subsidiary of SFC Environmental Technologies Limited, is well recognised player in Solar Sludge Dryer market with more than 30 years of industry experience.

11. COMPETITIVE BENCHMARKING

Leading players in the waste management market are crucial to India's sustainability goals. Increased urbanization and industrial activities have led to higher wastewater generation, making its treatment and reuse vital for addressing water scarcity and preventing pollution. Companies specializing in wastewater treatment are advancing sustainable practices and addressing environmental challenges, paving the way for a more sustainable future.

11.1 Operational Benchmarking

A. Profile 1: SFC Environmental Technologies Pvt. Ltd.

Company Overview (Origin and Incorporation year must be included)	• **Established in 2005 and based in Navi Mumbai, India, SFC Environmental Technologies Ltd. is an environmental technology company offering technologies and engineering solutions in the field of wastewater treatment ("WWT") and solid waste treatment ("SWT")**	
Key Technologies	• C-Tech • OREX	
Solutions Offerings	• Waste water treatment	• Solid waste treatment • Agro waste treatment
Key Clients	• Enviro Infra Engineers Ltd. • EMS Ltd.	• Ramky Infrastructures

	• GVPR Engineers Ltd. • Gharpure Engineering & Constructions Pvt. Ltd.	• Toshiba Water Solutions Pvt. Ltd. • HNB Engineers Pvt. Ltd. • Goa Waste Municipal Corporation

B. Profile 2: Thermax

Company Overview (Origin and Incorporation year must be included)	• **Founded in 1966 and headquartered in Pune, India, Thermax is an engineering company providing sustainable solutions in the areas of energy and environment. The company's reach spans 86 countries, serving industrial and commercial clients with energy-efficient and eco-friendly operations.**	
Key Technologies	• Eco-friendly power • Water recycling • Waste heat energy	• Cooling from heat waste • Emission control
Product Offerings	• Waste Heat Recovery • Waste to Energy Conversion • Water and Waste Solutions	• Oil and Gas Sector Services • Energy Environment Solutions • Steam Accessories
Key Clients	• GAIL India • Daimler • Tata Communications	• ONGC Mangalore Refinery • JK Cement Works • Tata Sponge Iron

C. Profile 3: Praj Industries

Company Overview (Origin and Incorporation year must be included)	• **Established in 1983 and headquartered in Pune, India, the company specializes in biofuels, bioenergy, renewable energy, circular economy, green fuels, brewery, beer, alcohol, ethanol, water and wastewater treatment, process equipment, distillation, oil and gas, bio CNG, bio methanation, bio mobility, and renewable chemicals and materials.**	
Key Technologies	• EcoCool™ • MAXIMOL™ • PROFIIT™ (Process Optimized Flexible Integrated Incineration Technology)	• RenGas™ • efinity™ • Celluniti™ • BIOSYRUP™
Product Offerings	• Bio Energy- 1G Ethanol, Bio Ethanol and Compressed Biogas • Praj Hipurity Systems • Critical Process Equipment & Skids	• ZLD & resource recovery • Solvent recovery system • Total Water Management • VAS (value-added services)

Key Clients	• Incauca • Addax Petroleum • Bajaj Hindustan Ltd • Globus Spirits	• British Sugars • Seagrams • Vivergo Fuels • ThaiBev

D. Profile 4: Ion Exchange

Company Overview (Origin and Incorporation year must be included)	• **Established in 1964 and headquartered in Mumbai, India, Ion Exchange is a solution provider in water and environment management solutions. The company provides comprehensive solutions for water, wastewater, solid waste, and waste-to-energy sectors.**	
Key Technologies	• Complete Environmental Management Solutions	
Product Offerings	• Membranes • Instruments & Automation • Consumer Products • Zero Liquid Discharge (ZLD) Systems	• Activated Sludge Plants • Membrane Bioreactor (MBR) Systems • Sewage Treatment Plants (STPs)
Key Clients	• Emirates Steel • SAIL • Unilever	• Rockwool • Dabur • Ranbaxy

E. Profile 5: Xylem Water Solutions

Company Overview (Origin and Incorporation year must be included)	• **Established in 2011 and headquartered in Bengaluru, Karnataka, Xylem Water Solutions India Private Limited is a solution provider in the global water technology sector. Xylem offers a comprehensive range of solutions including water and wastewater transport, treatment, test, and efficient use.**	
Key Technologies	• Water Reuse Technology • Energy Efficient Pumping Solutions	
Product Offerings	• Analysis, Monitoring & Control Instruments and Equipment • Communications & Data Transfer • Gas Infusion Systems • Hydro Turbines	• Metrology for Utilities • Mixing & Mixing Equipment • Pumps & Packaged Pump Systems • Water and Wastewater Treatment Solutions
Key Clients	• AC Fire pump	• Godwin

	• Bell & Gossett • Flojet • Flygt	• Jabsco • Leopold • Lowara

F. Profile 6: Alfa Laval

Company Overview (Origin and Incorporation year must be included)	• **Alfa Laval, founded in 1883 and based in Lund, Sweden, is a leading global provider of first-rate products in the areas of heat transfer, separation, and fluid handling. Alfa Laval's innovative solutions are used to heat, cool, separate, and transport products such as oil, water, chemicals, beverages, foodstuffs, starch, and pharmaceuticals.**	
Key Technologies	• Heat Transfer • Separation • Fluid Handling	
Product Offerings	• Automatic back-flushing filters • Ballast Water Treatment Systems • Boilers • Brewery solutions • Bulk solutions	• Freshwater generation • Heat exchangers. • Heaters • Membranes • Pump control system.
Key Clients	• Arkema • Rhodia Brasil • BASF	• Lanxess • Dow Wolff Cellulosics • Balaji Amines

11.2 Financial benchmarking

Exhibit 11.1: Revenue from the operation, EBITDA, EBITDA Margin, PAT of key competitors, value in INR Million, FY2023 – FY2025

Financial Indicators	Years	SFC Environmental	Thermax	Praj Industries	Ion Exchange	Xylem India	Alfa Laval
Revenue from Operations INR Million	FY2023	5,194.47	80,898.10	35,280.37	19,896.09	4,927.93	16,873.28
	FY2024	6,574.95	93,234.60	34,662.78	23,478.49	5,924.35	NA
	FY2025	6,978.58	1,03,886.90	32,280.42	27,371.10	NA	NA
EBITDA in INR Million	FY2023	1,240.72	5,975.60	3,180.00	2,549.87	262.02	2,685.76
	FY2024	1,932.53	7,973.90	3,878.06	2,719.37	489.34	NA
	FY2025	2,074.79	9,077.80	3,248.32	2,939.00	NA	NA
EBITDA Margin in %	FY2023	23.89%	7.39%	9.01%	12.82%	5.32%	15.92%
	FY2024	29.39%	8.55%	11.19%	11.58%	8.26%	NA
	FY2025	29.73%	8.74%	10.06%	10.74%	NA	NA
PAT in INR Million	FY2023	948.09	4,507.00	2,398.18	1,949.66	105.43	2,101.81
	FY2024	1,441.73	6,431.90	2,833.91	1,953.52	213.24	NA
	FY2025	1,520.08	6,267.00	2,189.33	2083.00	NA	NA

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

Revenue from Operations Y-O-Y growth is calculated as (Current year revenue – previous year revenue)/ previous year revenue; EBITDA is calculated as profit before tax, depreciation and amortisation expense and finance costs less other income as per the Restated Consolidated Financial Information. EBITDA Margin is calculated as EBITDA/Revenue from Operations

Exhibit 11.2: PAT, PAT Margin, RoCE, RoE, Net Debt of key competitors, India, FY2023 – FY2025

Financial Indicators	Years	SFC Environmental	Thermax	Praj Industries	Ion Exchange	Xylem India	Alfa Laval
PAT Margin in %	FY2023	18.25%	5.57%	6.80%	9.80%	2.14%	12.46%
	FY2024	21.93%	6.90%	8.18%	8.32%	3.60%	NA
	FY2025	21.78%	6.00%	6.78%	7.61%	NA	NA
RoCE in %	FY2023	28.57%	15.00%	30.31%	30.00%	5.23%	39.83%
	FY2024	28.56%	17.00%	31.69%	26.90%	11.74%	NA
	FY2025	29.29%	16.00%	24.41%	22.00%	NA	NA
RoE in %	FY2023	25.44%	12.24%	24.06%	23.03%	3.19%	30.01%
	FY2024	29.80%	15.50%	24.09%	21.06%	6.78%	NA
	FY2025	24.84%	13.40%	16.48%	18.70%	NA	NA
Net Debt in INR million	FY2023	-783.14	-3,017.20	NA	-4,954.84	-1,841.44	-1,586.03
	FY2024	-494.49	3,015.00	NA	-4,503.16	-1,511.99	NA
	FY2025	-523.45	5,637.40	NA	-1,627.80	NA	NA

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

PAT Margin is calculated as PAT/Revenue from Operations. RoCE is calculated as a percentage of earnings before interest and taxes (EBIT) / total equity plus total borrowings plus deferred tax liabilities minus deferred tax assets as per the Restated Consolidated Financial Information. EBIT is calculated as profit before tax and share of profit of joint ventures / associate plus finance costs. RoE is calculated as total profit after tax for the year divided by average total equity. Net Debt is calculated as (Long-Term borrowings + Short-Term borrowings) – (Cash & Cash Equivalents + Bank Balance Other than Cash and Cash Equivalents).

Exhibit 11.3: Net worth, Debt to Equity, Fixed Asset Turnover Ratio, Cash Conversion Cycle, Total Order Book, FY2023 – FY2025

Financial Indicators	Years	SFC Environmental	Thermax	Praj Industries	Ion Exchange	Xylem India	Alfa Laval
Networth in INR million	FY2023	3,954.16	38,680.70	10,779.98	8,334.91	3,354.39	7,546.19
	FY2024	5,342.96	44,398.00	12,744.70	10,179.07	2,937.97	NA
	FY2025	6,486.82	49,370.00	13,817.67	12,078.80	NA	NA
Debt to Equity	FY2023	-0.19	-0.08	-0.10	-0.60	-0.55	-0.21
	FY2024	-0.09	0.07	-0.03	-0.40	-0.51	NA
	FY2025	-0.08	0.11	-0.13	-0.10	NA	NA
Fixed Asset Turnover Ratio	FY2023	15.06	4.78	15.85	12.62	5.07	7.91
	FY2024	13.25	3.80	10.77	9.94	4.61	NA
	FY2025	10.85	3.05	7.56	8.69	NA	NA
Cash Conversion Cycle in days	FY2023	105	NA	NA	NA	57	137
	FY2024	156	NA	NA	NA	105	NA
	FY2025	232	NA	NA	NA	NA	NA
Total Order Book in INR million	FY2023	6,432.52	NA	NA	NA	NA	NA
	FY2024	7,630.34	NA	NA	NA	NA	NA
	FY2025	5,603.86	NA	NA	NA	NA	NA

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

Net worth is calculated as total equity less non-controlling interest; Debt to Equity ratio is calculated as Net Debt/Total Equity; Fixed asset turnover ratio is calculated as revenue from operations divided by average property, plant and equipment; Cash conversion cycle is calculated as sum of inventory days and trade receivable days, subtracted by trade payable days.

ANNEXURE

Exhibit: Inventory of Sewage Treatment plants in the country, by States, FY2021[5]

SR.NO	STATE	SEWAGE GENERATION (IN MLD)	NUMBER OF STPs*	INSTALLED TREATMENT CAPACITY (IN MLD)
1	Andaman and Nicobar Island	23	-	0
2	Andhra Pradesh	2,882	37	833
3	Arunachal Pradesh	62	-	0
4	Assam	809	-	0
5	Bihar	2,276	0	10
6	Chandigarh	188	6	293
7	Chhattisgarh	1,203	3	73
8	Dadra & Nagar Haveli	67	3	24
9	Goa	176	9	66
10	Gujarat	5,013	68	3,378
11	Haryana	1,816	155	1,880
12	Himachal Pradesh	116	59	136
13	Jammu & Kashmir	665	12	218
14	Jharkhand	1,510	2	22
15	Karnataka	4,458	100	2,712
16	Kerala	4,256	5	120
17	Lakshadweep	13	-	0
18	Madhya Pradesh	3,646	45	1,839
19	Maharashtra	9,107	130	6,890
20	Manipur	168	0	0
21	Meghalaya	112	0	0
22	Mizoram	103	0	10
23	Nagaland	135	0	0
24	NCT of Delhi	3,330	35	2,896
25	Orissa	1,282	4	378
26	Pondicherry	161	3	56
27	Punjab	1,889	96	1,781
28	Rajasthan	3,185	56	1,086
29	Sikkim	52	6	20
30	Tamil Nadu	6,421	63	1,492
31	Telangana	2,660	27	901
32	Tripura	237	1	8
33	Uttar Pradesh	8,263	92	3,374
34	Uttarakhand	627	52	448
35	West Bengal	5,457	24	897
	Total	**72,368**	**1,093**	**31,841**

Note: This is the most recent, published, government and credible source available published in March 2021

**Includes functional STPs only*

5 https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==

Exhibit: Technology-wise Break-up of STPs in various States, by installed capacity in MLD, FY2021[6]

STATE	TECHNOLOGY								
	ASP	EA	FAB	MBBR	OP	SBR	UASB	WSP	OTHERS
Andhra Pradesh	321	20	3	39	57	17	130	31	235
Bihar	150	0	0	0	0	327	0	0	154
Chandigarh	5	0	0	136	0	107	45	0	0
Chhattisgarh	73	0	0	0	0	0	0	0	0
Dadra Nagar Haveli	0	0	0	0	0	24	0	0	0
Goa	0	0	0	0	0	103	0	0	1
Gujarat	1,254	60	0	175	46	1,285	491	0	67
Haryana	297	0	0	447	14	754	368	0	0
Himachal Pradesh	155	0	0	0	0	0	0	0	0
Jammu & Kashmir	9	0	3	3	0	10	1	0	0
Jharkhand	0	0	0	0	0	1	0	0	11
Karnataka	667	166	20	35	85	1,079	63	61	536
Kerala	112	0	0	0	0	0	0	0	8
Madhya Pradesh	120	0	0	0	0	358	0	178	1,268
Maharashtra	930	146	1	826	36	2,452	240	0	5,188
Mizoram	0	0	0	0	0	10	0	0	0
NCT Delhi	2,575	69	3	0	0	245	0	0	4
Odisha	100	0	0	0	0	183	0	35	60
Puducherry	0	0	0	0	0	20	36	0	3
Punjab	207	0	13	165	0	838	501	54	3
Rajasthan	445	0	0	10	30	428	33	137	112
Sikkim	0	0	20	2	0	2	0	0	6
Telangana	85	13	0	133	24	105	541	0	0
Tamil Nadu	1,011	0	6	0	6	319	9	112	29
Tripura	0	0	0	0	0	8	0	0	0
Uttar Pradesh	681	0	122	14	101	1,176	1,095	27	158
Uttarakhand	0	0	0	20	0	351	1	0	143
West Bengal	191	0	41	0	63	392	0	160	355
Total	**9,492**	**474**	**244**	**2,034**	**462**	**10,647**	**3,563**	**795**	**8,957**

Note: This is the most recent, published, government and credible source available published in March 2021

[6] *Source: https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==*

Exhibit: Technology-wise Break-up of STPs in various States, by operational number of STPs, FY2021

STATE	TECHNOLOGY								
	ASP	EA	FAB	MBBR	OP	SBR	UASB	WSP	OTHERS
Andhra Pradesh	7	2	2	10	2	2	5	3	4
Chandigarh	1	0	0	1	0	3	1	0	0
Chhattisgarh	3	0	0	0	0	0	0	0	0
Dadra Nagar Haveli	0	0	0	0	0	3	0	0	0
Goa	0	0	0	0	0	5	0	0	4
Gujarat	14	3	0	5	8	24	7	0	8
Haryana	7	0	0	83	4	49	10	0	0
Himachal Pradesh	59	0	0	0	0	0	0	0	0
Jammu & Kashmir	4	0	3	1	0	4	0	0	0
Jharkhand	0	0	0	0	0	1	0	0	1
Karnataka	12	9	1	1	10	24	2	8	30
Kerala	2	0	0	0	0	0	0	0	1
Madhya Pradesh	4	0	0	0	0	6	0	7	28
Maharashtra	18	2	1	24	2	52	6	0	25
NCT Delhi	25	4	1	0	0	4	0	0	1
Odisha	0	0	0	0	0	0	0	2	2
Puducherry	0	0	0	0	0	1	2	0	0
Punjab	4	0	1	24	0	42	7	16	1
Rajasthan	13	0		2	2	22	4	9	5
Sikkim	0	0	3	0	0	0	0	0	2
Telangana	10	3	0	8	0	3	3	0	0
Tamil Nadu	49	0	1	0	1	5	1	2	4
Tripura	0	0	0	0	0	1	0	0	0
Uttar Pradesh	19	0	3	3	11	31	24	2	6
Uttarakhand	0	0	0	6	0	32	1	0	13
West Bengal	8	0	2	0	6	1	0	2	5
Total	**259**	**23**	**18**	**168**	**46**	**315**	**73**	**51**	**140**

Note: This is the most recent, published, government and credible source available published in March 2021

Legend: ASP- Activated Sludge Process, EA- Electrocoagulation, FAB - Forward Activated Sludge, MBBR - Moving Bed Biofilm Reactor, OP - Oxidation Pond, SBR - Sequencing Batch Reactor, UASB - Upflow Anaerobic Sludge Blanket, WSP - Waste Stabilization Pond