ENERGY EFFICIENCY SERVICES LIMITED
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IIEC

MARKET ASSESSMENT OF ENERGY EFFICIENT TECHNOLOGIES FOR INDUSTRIAL UTILITIES

Market Assessment of Energy Efficient Technologies for Industrial Utilities

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FOREWORD

As India continues its trajectory of economic growth and infrastructure development, it becomes imperative to address the energy intensity and environmental impact of key industrial systems. India's pursuit of sustainable development hinges on enhancing energy efficiency and advancing decarbonization pathways to meet its growing energy demand while mitigating climate change. A key area of opportunity lies in improving energy efficiency in industrial utilities, covering equipment related to steam systems, motor driven system, compressed air systems, and HVAC systems, which account for up to 30-40% of industrial energy use. Upgrades in these systems can yield significant energy savings, cost reductions, and emissions cuts.

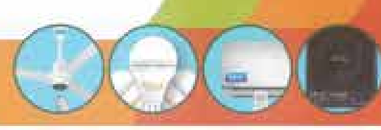
This report titled, "*Market Assessment of Energy Efficient Technology for Industrial Utilities*", was developed under the study funded from the GEF-6 project with technical support of UNEP through the collaborative efforts of the International Institute for Energy Conservation (IIEC) and Energy Efficiency Services Limited (EESL). The report presents an in-depth assessment of three industrial utility technologies namely Air Compressors, Water Pumping Systems, and Fans & Blowers, which evaluates not only the technical and economic potential of modern, energy-efficient alternatives for industries but also provides analysis of the prevailing market dynamics, barriers to adoption, and enabling policy environments. These three technologies are at the heart of industrial operations, including sectors under the Perform, Achieve and Trade (PAT) scheme of Bureau of Energy Efficiency (BEE), and offering untapped opportunities for efficiency improvements.

This report identifies actionable interventions and estimates substantial energy savings and carbon reduction potential through these three critical systems of industrial utilities in the PAT industries. The findings will help decision-makers, industries, manufacturers, energy service companies, and policymakers in tapping the energy saving potential through these three technologies. The analysis of market readiness and scalability framed through Total Addressable Market (TAM) and Serviceable Addressable Market (SAM) metrics further enhances the relevance of this work in shaping future strategies.

We hope this report will serve as a catalyst for accelerating the deployment of energy-efficient technologies across Indian industries. By aligning economic and environmental priorities, the recommendations herein can support India's broader goals of energy security, cost optimization, competitiveness and climate resilience.

We hope this report inspires informed action, sustained collaboration, and innovative solutions on the path to a greener industrial future.

(Vishal Kapoor)
Chief Executive Officer



Preface

Energy efficiency remains a cornerstone of India's strategy to balance rapid industrial growth with sustainable development. In this context, the efficient use of industrial utilities such as Air Compressors, Water Pumping Systems, and Fans & Blowers plays a vital role in reducing operational costs and carbon emissions across energy-intensive sectors.

The study focuses on the industrial use of these three industrial utilities technologies for the sectors under the Perform, Achieve, and Trade (PAT) scheme of Bureau of Energy Efficiency, aiming to evaluate their adoption potential, energy-saving benefits, and overall market landscape.

Through extensive data collection, analysis of current benchmarks, and stakeholder engagement, the study identifies key opportunities for enhancing system efficiencies. For each technology, the report offers targeted recommendations that address technical upgrades, cost-effectiveness, and carbon reduction potential. It also evaluates the Total Addressable Market (TAM) and Serviceable Addressable Market (SAM), helping to define the scale and scope of interventions needed to realize measurable benefits.

The report highlights not only the energy and environmental advantages of adopting efficient technologies but also the prevailing barriers, such as high capital costs, limited awareness, and fragmented policies. Overcoming these challenges requires a concerted effort through financial incentives, capacity-building, and policy coherence.

The three assessed industrial utility technologies namely, Air Compressors, Water Pumping Systems, and Fans & Blowers offer significant energy-saving and carbon reduction potential within the Indian industrial sector. Collectively, energy efficiency interventions in these technologies could yield estimated annual energy savings of over 3,000 million units (MU) and a reduction of approximately 2.16 million tonnes of CO_2 emissions. Specifically, air compressor upgrades and controls could save 1,239 MU, while water pumping system retrofits are projected to save 914 MU, and improvements in fan and blower systems could result in 864 MU of energy savings.

This work is intended to serve as a resource for policymakers, industry leaders, and implementation agencies seeking to accelerate the deployment of energy-efficient technologies. We hope it contributes meaningfully to India's energy transition by providing a clear pathway for cost-effective, scalable, and impactful energy efficiency interventions.

प्रशांत कुमार 22/5/2025

(Prashant Kumar)
CGM & Head CDP

Acknowledgment

The report titled *"Market Assessment of Energy Efficient Technology for Industrial Utilities in India"* marks an important step in recognizing the vital role of key industrial utilities such as air compressors, water pumping systems, and fans & blowers in shaping the decarbonization pathway for India's industrial sector. Developing a national program strategy to enable the widespread adoption of energy-efficient technologies in these utilities is essential. By unlocking the significant, yet underutilized, energy-saving potential across diverse industries, these technologies can play a pivotal role in advancing India's climate goals.

We express thanks to the International Institute for Energy Conservation (IIEC) for execution of the study and acknowledge the contribution provided by the experts, academia, consultants & other concerned stakeholders in shaping of this study.

We acknowledge the invaluable inputs and recommendations provided by Dr. Ashok Kumar, Deputy Director General, the Bureau of Energy Efficiency (BEE) and experts from State Designated Agencies (SDAs), whose insights have been instrumental in shaping this report.

We also thank ICF Consulting India Pvt. Ltd for their robust support and comprehensive market research, which significantly enriched our findings through both primary and secondary sources.

Additionally, we are grateful to the various industries of the Perform, Achieve, and Trade (PAT) scheme, and the technology manufacturers, suppliers, and OEMs across India for their unwavering support. Finally, we appreciate the efforts of all the reviewers and contributors whose expertise and collaboration have helped in preparing this report.

(Girja Shankar)
General Manager (Technical)

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LIST OF ABBREVIATIONS

AC	Alternating Current
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standard
CAGR	Compounded Annual Growth Rate
CFM	Cubic Feet per Minute
DC	Direct Current
DCs	Designated Consumers
EC	Electronically Commutated
EC Act	Energy Conservation Act
ESCO	Energy Services Company
EE	Energy Efficiency
FDF	Forced Draft Fan
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatts
GHG	Greenhouse Gases
HVAC	Heating, Ventilation, and Air Conditioning
IDF	Induced Draft Fan
IFC	Intelligent Flow Control
INR	Indian Rupees
IoT	Internet of Things
ISO	International Organization for Standardization
KPIs	Key Performance Indicators
kW	Kilowatts
kWh	Kilo Watt-hours
LPC	Lease Performance Contract
MSME	Micro, Small and Medium Enterprises
MU	Million Units
MW	Megawatts
PAT	Perform, Achieve and Trade
PMSM	Permanent Magnet Synchronous Motor
R&D	Research and Development
SAM	Serviceable Available Market
SEC	Specific Energy Consumption
SMEs	Small & Medium Enterprises
TAM	Total Addressable Market
tCO_2	Tonnes of CO_2
USD	United States Dollar
VFD	Variable Frequency Drive
VSD	Variable Speed Drive

EXECUTIVE SUMMARY

This report presents a comprehensive technology and market assessment of three (3) technologies namely Air Compressors, Water Pumping Systems and Fans & Blowers in the Indian Industrial Sector. ICF worked with IIEC and EESL to conduct this study.

The study aimed to evaluate the adoption potential, energy-saving & carbon reduction benefits, and market dynamics of these technologies used in industries within the PAT (Perform, Achieve, Trade) sectors. By analyzing current performance benchmarks, cost-effectiveness, and existing market barriers, the assessment provides actionable insights for scaling up energy efficiency interventions. The findings serve as a foundation for potential deployment strategies to drive energy conservation, reduce carbon emissions and optimize operational costs across industries.

Air Compressors

The Indian market is overwhelmingly dominated by screw and reciprocating air compressors with nearly 80% of the market share of more than 75 kW capacity. Larger capacity compressors, however, are often imported. This report provides an analysis of a wide range of air compressors, with a focus on units exceeding 75 kW, used in diverse applications and industries within the PAT sectors.

The Indian air compressor market, valued at nearly INR 10,380 Cr in 2024, is expected to grow at a CAGR of 6.6% through 2030, driven by industrial expansion and government policies promoting energy efficiency. This report analyzes the market potential for energy-efficient air compressors in India, exploring technological advancements, adoption trends, economic and environmental impacts, and barriers to implementation.

The key recommendations of this report as summarized in Table 1 include replacing reciprocating air compressors with Permanent Magnet Synchronous Motor (PMSM) screw compressors, retrofitting with Variable Frequency Drives (VFDs) in screw compressors, upgrading inefficient screw compressors to PMSM screw compressors, and implementing demand-based intelligent flow control in existing air compressor systems. These combined measures are estimated to achieve approximately 11% energy savings. A potential energy savings of 1,239 MU and a CO_2 emission reduction of 0.89 million tCO_2/year are projected in the year 2025.

Table 1: Projected Energy Savings and Carbon Emission Reduction Potential

Technology Recommendations	Baseline Energy Consumption (MU)	Post-intervention Energy Consumption (MU)	Energy saved (MU)	Carbon Emission Reduction (M-tCO2/Yr)
1. Replacement of Reciprocating Compressors with PMSM Compressors	1,171	970	201	0.14
2. VFD Retrofitting in Existing Screw Compressor	6,555	5,659	896	0.64

Technology Recommendations	Baseline Energy Consumption (MU)	Post-intervention Energy Consumption (MU)	Energy saved (MU)	Carbon Emission Reduction (M-tCO2/Yr)
3. Replacement of Screw Compressor with PMSM Screw Compressors	437	377	60	0.04
4. IFC Retrofitting in Existing Air Compressor System	2,746	2,663	82	0.06

However, high upfront costs, limited awareness, and regulatory complexities hinder the widespread adoption of these technologies. Institutional barriers and inconsistent policies further slow market transformation. Despite these challenges, opportunities exist through policy incentives, financing mechanisms, and stronger stakeholder collaboration as summarized in Table 2.

Table 2: Estimated Market Potential and Payback Period for technologies options

Technology Recommendations	Total Addressable Market (Rs in Cr)	Serviceable Addressable Market (Rs in Cr)	Monetary Saving Potential (Rs in Cr)	Estimated Payback Period (Years)
1. Replacement of Reciprocating Compressors with PMSM Compressors	3,136	314	90	3.5
2. VFD Retrofitting in Existing Screw Compressor	975	585	403	1.5
3. Replacement of Screw Compressor with PMSM Screw Compressors	780	117	27	4.4
4. IFC Retrofitting in Existing Air Compressor System	813	57	37	1.5

The cumulative estimated payback period for all technologies is 2 years, indicating the financial viability of investments.

Total Addressable Market (TAM): The potential of the current Total Addressable Market (TAM) is estimated at INR 5,705 Cr.in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6%. As a result, the market for these critical components is expected to reach approximately INR 7,854 Cr. by 2030.

Serviceable Addressable Market (SAM): The potential of the current Serviceable Addressable Market (SAM) is estimated at INR 1,073 Cr. in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6% and additional minimum service growth of CAGR of 6%. As a result, the market for these critical components is expected to reach approximately INR 1,942 Cr by 2030, as shown in Figure 1.

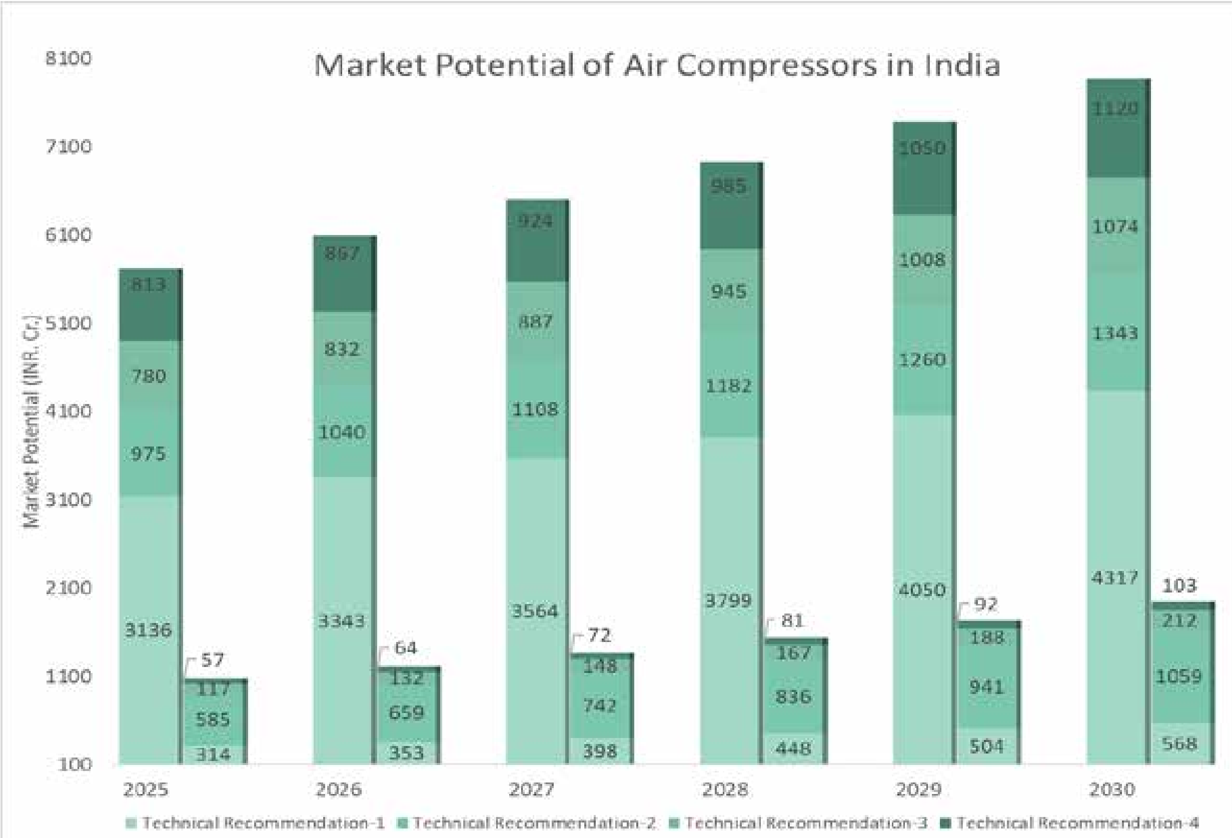

Figure 1: Market Potential of Air Compressors in India

Water Pumps

Water pumping systems are essential across diverse sectors, including agriculture, municipal water supply, and industry, relying on electricity or fuel to move water. Government initiatives focused on infrastructure development and water resource management are expected to drive significant growth in this sector. Consequently, water pumping systems offer a substantial opportunity for energy efficiency improvements and associated climate benefits.

Centrifugal pumps dominate the Indian industrial water pump market, accounting for over 90% of sales. This assessment examined specific applications, including condensate water pumps in a 210 MW power plant and pumps used in steel concast processes.

A key recommendation of this report is the retrofitting of existing water pumping systems with Variable Frequency Drives (VFDs) to enhance energy efficiency. A potential energy savings of 914 MU and a CO_2 emission reduction of 0.65 million tCO_2/year for the year 2026 are projected for water pumping systems through efficiency upgrades. This represents a decrease in energy consumption from 4,637 MU to 3,722 MU as summarized in Table 3.

Table 3: Projected Energy Savings and Carbon Emission Reduction

Technology	Baseline Energy consumption (MU)	Post Intervention Energy consumption (MU)	Energy Saved (MU)	Carbon Emission Reduction (M-tCO2/Yr)
Water Pumping System	4,637	3,722	914	0.65

Table 4: Market Potential and Estimated Payback Period

Technology	Total Addressable Market (Rs in Cr)	Serviceable Addressable Market (Rs in Cr)	Monetary Saving Potential (Rs in Cr)	Estimated Payback Period (Years)
Water Pumping System	1,062	425	411	1.03

The estimated payback period for the proposed VFD Retrofitting is nearly 1.03 years as summarized in Table 4, indicating the financial viability of investments.

Total Addressable Market (TAM) for these components is estimated at INR 1,062 crore and is projected to reach INR 1,324 crore by 2030, growing at a CAGR of 4.5%.

Serviceable Addressable Market (SAM) representing the realistically targetable portion of the TAM, is currently estimated at INR 425 crore, and is also expected to grow at a 4.5% CAGR and service growth of 6%, reaching INR 700 crore by 2030 as shown in Table 4 and Figure 2.

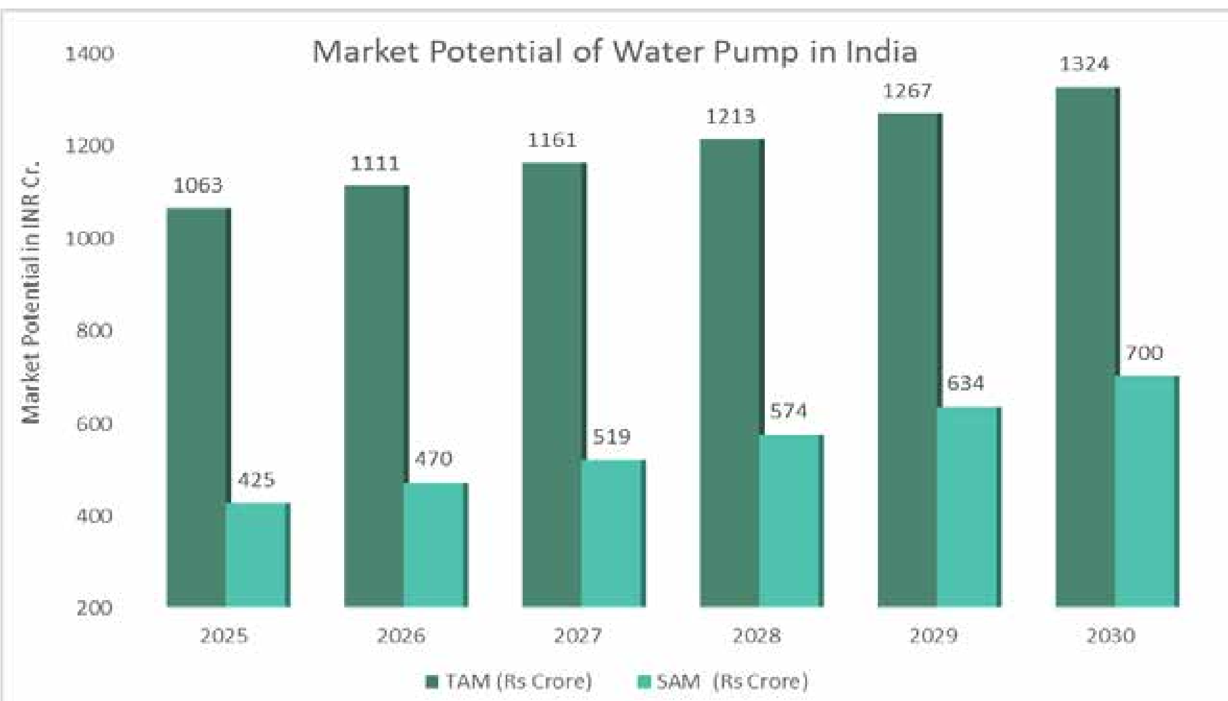

Figure 2: Market Potential of Water Pumps in India

Fans and Blowers

Fans and blowers are essential equipment across diverse sectors, including industry, building services, and infrastructure, relying on electricity to move air and gases. Government initiatives focused on industrial growth and infrastructure development are expected to drive increased demand for these systems. Consequently, fans and blowers represent a significant opportunity for energy efficiency policies and associated climate benefits.

While for it's widespread adoption is hindered by initial costs, lack of awareness, and a shortage of skilled labor. Additionally, industries are often reluctant to invest in solutions with long payback periods, especially when energy costs fluctuate. Further complicating the landscape, inconsistent policies and institutional challenges slow market transformation. However, strategic opportunities exist. Targeted policy incentives, accessible financing, and stronger collaboration among stakeholders can help overcome these barriers, accelerating market adoption and growth.

This report presents an analysis of Induced Draft Fans (IDFs), Forced Draft Fans (FDFs), and Primary Air Fans (PAFs) within the power generation sector.

Energy efficiency improvements in fan and blower systems are projected to yield substantial benefits. Baseline energy consumption is 5,890 MU, decreasing to 5,026 MU post-intervention, resulting in energy savings of 864 MU (17%). This improvement is achieved by increasing operational efficiency from 75% to 88% and translates to a reduction in CO_2 emissions of 0.62 million tCO2/year as summarized in Table 5.

Table 5: Projected savings and CO2 emission

Technology	Baseline Energy consumption (MU)	Post Intervention energy consumption (MU)	Energy Saved (MU)	Carbon Emission Reduction (M-tCO2/Yr)
Fan and Blower	5,890	5,026	864	0.62

This report highlights the need for a comprehensive approach combining policy support, technological advancements, and financial mechanisms to drive large-scale adoption of energy-efficient fans and blowers in Industries.

Table 6: Market Potential and Estimated Payback Period

Technology	Total Addressable Market (Rs in Cr)	Serviceable Addressable Market (Rs in Cr)	Monetary Saving Potential (Rs in Cr)	Estimated Payback Period (Years)
Fan and Blower	1,754	526	389	1.3

The estimated payback period for the proposed VFD Retrofitting is nearly 1.3 years, indicating the financial viability of investments.

Total Addressable Market (TAM) for these components is estimated at INR 1,753 crore and is projected to reach INR 2,436 crore by 2030, growing at a CAGR of 6.8%.

Serviceable Addressable Market (SAM) representing the realistically targetable portion of the TAM, is currently estimated at INR 526 crore and is also expected to grow at a 6.8% CAGR and service growth of 6%, reaching INR 772 crore by 2030 as shown in Figure 3.

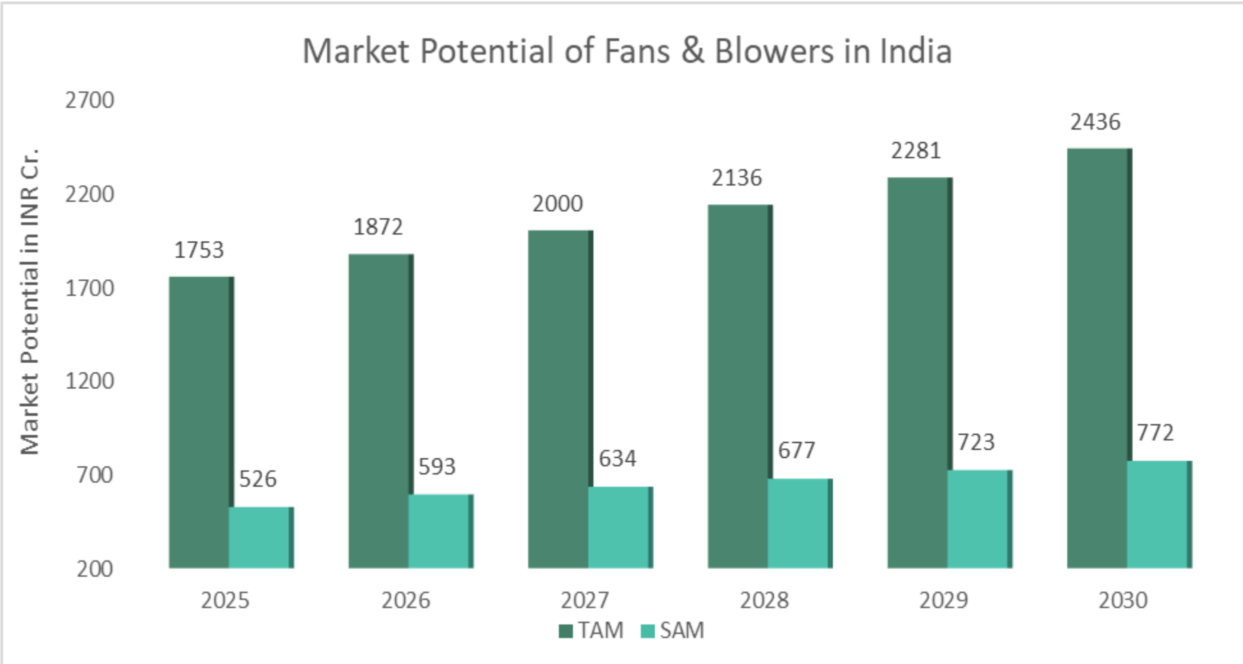

Figure 3: Market Potential of Fans and Blowers in India

Introduction

1. INTRODUCTION

India is the third-largest producer and consumer of electricity globally, with the industrial sector accounting for approximately 42% of the nation's total electricity consumption in 2021-22[1]. Within this sector, industrial utilities alone consume about 70% of the electricity used, underscoring their pivotal role in shaping the national energy landscape. These utilities, including air compressors, water pumps, fans, and blowers, are essential components in numerous industrial processes across different sectors. As the demand for energy continues to rise, there is a pressing need to enhance energy efficiency across industries. These utilities are often among the largest consumers of energy in industrial settings, making them critical targets for energy efficiency improvements.

The energy efficiency market in India is rapidly growing, with an estimated value of INR 1,60,025 Cr[2]. To address the challenges of energy consumption and carbon emissions, the Indian government has introduced several strategic policies. Among these is the Perform, Achieve and Trade (PAT) scheme, which targets energy-intensive industries by setting mandatory energy consumption reduction targets. Industries that exceed these targets are rewarded with tradable energy-saving certificates, incentivizing further improvements in energy efficiency. Additionally, the Standards & Labeling Program empowers consumers by providing information on the energy performance of appliances, encouraging the adoption of energy-efficient products.

These initiatives align with India's broader national objectives of promoting sustainable development, reducing carbon emissions, and fostering economic opportunities in the energy efficiency sector. Moreover, international organizations such as the International Institute for Energy Conservation (IIEC), UNEP, GEF, the World Bank, and GIZ, along with bilateral partnerships, play a crucial role by providing financial support, technical expertise, and capacity-building initiatives. Their efforts have been instrumental in facilitating the adoption of innovative energy-efficient technologies across various industrial sectors in India.

1.1 Objective

This report provides a comprehensive analysis of the market potential for air compressors, water pumps and fans & blowers in India's industrial utilities. It evaluates the status of available technologies, their operational efficiencies, and opportunities for improvement. Furthermore, it explores the market potential, manufacturing capabilities, and supply chains for these technologies. The study proposes strategic approaches, including business and financial models, to implement a comprehensive program targeting the identified technologies. All sectors under the PAT scheme are covered in the analysis, with the goal of fostering a more energy-efficient and sustainable industrial landscape in India.

[1] https://www.mospi.gov.in/sites/default/files/publication_reports/Energy_Statistics_2023/EnergyStatisticsIndia2023.pdf

[2] https://www.thehindubusinessline.com/economy/india-makes-strides-in-energy-efficiency-market-size-to-hit-20-billion-in-2024/article68844154.ece

1.2 Scope of Assessment

This report focuses on the findings of the Air Compressor System, Water Pumping system and Fans & Blowers study in the Indian Industrial sector. The project's scope involves a comprehensive evaluation of current and emerging trends in these three technologies. The objective is to deliver an in-depth examination of the adoption rates, market trends, technological innovations, and the economic and environmental effects of these technologies, thereby offering essential insights for industry stakeholders, policymakers, and technology providers. The project analyzes the growing adoption of energy-efficient solutions across different industrial sectors and regions, highlighting key drivers such as rising energy costs, environmental regulations, and the need for incorporating sustainable practices. An assessment is conducted on the factors influencing the decision-making process for industrial utilities, including initial investment costs and payback periods. Understanding the barriers to adoption, such as high upfront costs or lack of technical knowledge, will help to identify strategies for overcoming these challenges and accelerating the uptake of energy-efficient technologies.

The market analysis explores the most recent advancements in air compressors, pumps, and fans & blowers technology, emphasizing energy-efficient options. This part of the study will also explore innovations such as retrofitting with variable frequency drive (VFD) in existing systems and integration of smart technologies that enhance the operational efficiency of the utilities.

1.3 Methodology

The project's approach and methodology are outlined in Figure 4, which include four major tasks: Research, Data Collection, Stakeholder Consultation, and Analysis. Each of these tasks is described in detail in Figure 4.

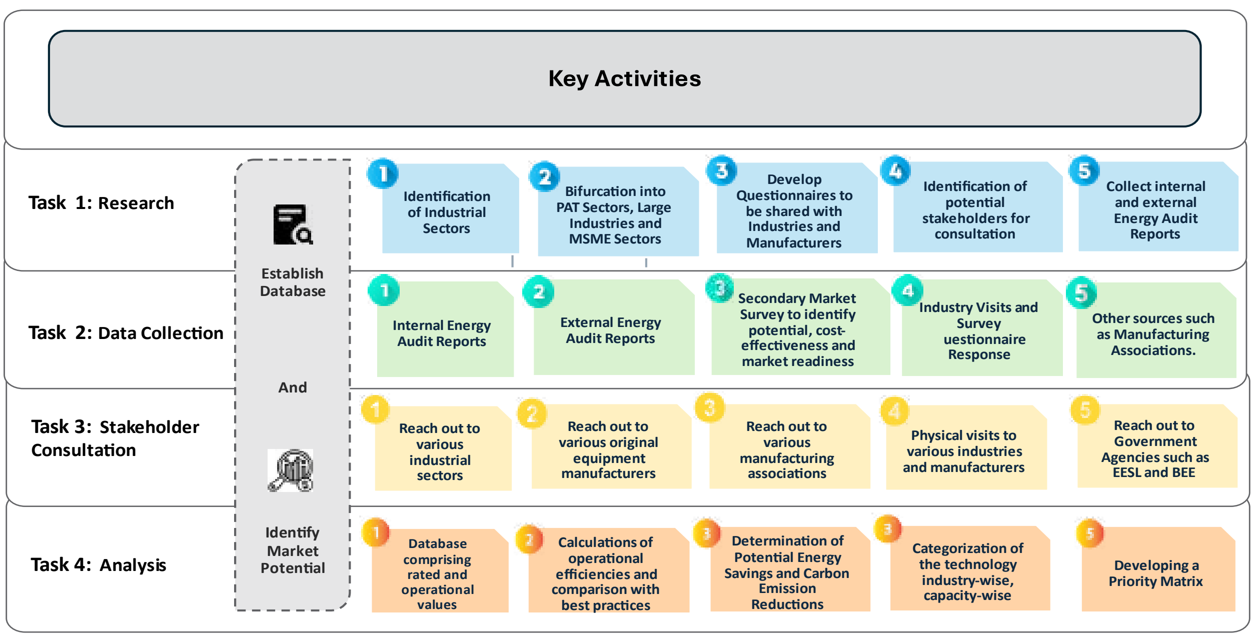

Figure 4: Methodology of the Study

Task-1: Research: The research gathered data from medium and large industries, including Designated Consumers (DCs) of PAT program, chemical & pharmaceutical, glass & ceramic, automobile, food processing, etc. Technology assessment is provided to assess current technology, capacity, and efficiency. Potential stakeholders such as industrial associations, government agencies, and manufacturers were identified. Data was collected from energy audit reports and stakeholder consultations through calls, emails, online meetings and visits.

Task-2: Data Collection: Data Collection emphasized gathering specific data from multiple sources such as internal and external reports on energy audits to analyze current efficiency levels, energy consumption patterns, and savings potential. A secondary survey data on market potential, cost-effectiveness, and market readiness was gathered from available market survey reports and stakeholder consultations. Stakeholder consultations provided valuable data inputs through survey questionnaires, industrial visits, and interaction with manufacturers and other trade associations.

Task 3: Stakeholder Consultation: Stakeholder consultation involved engaging with industries, industrial associations and regulatory bodies to gather insights and obtain data, which helped map the industries and their capacities. Various manufacturers of the three technologies were also contacted via emails, telephone and in-person communication to assess their capabilities and market. Mapping of the distribution network for the three technologies manufacturers was also done to identify their key players for sales, service, and logistics. Government agencies such as EESL, BEE and other key stakeholders were contacted as part of stakeholder consultations to obtain the necessary data. Manufacturer associations were also contacted to identify the typical demand for the three technologies.

Task 4: Analysis: The analysis focused on synthesizing data and deriving actionable insights by compiling a database obtained from energy audit reports, surveys, and site visits. Operational efficiencies, annual energy consumption and GHG emissions were calculated from the operational data and compared with the best practice values in the market. Further classification of the three technologies was done based on the industry type, range of operation, and energy consumption. An assessment of the policy and regulatory framework was conducted, which included a comprehensive review of regulations, policies, and institutional practices.

This review identified gaps in the current policies that may hinder technology adoption. Based on the data analyzed, a priority matrix was developed considering factors such as the potential for adoption, efficiency, market size, and policy support as shown in Figure 5.

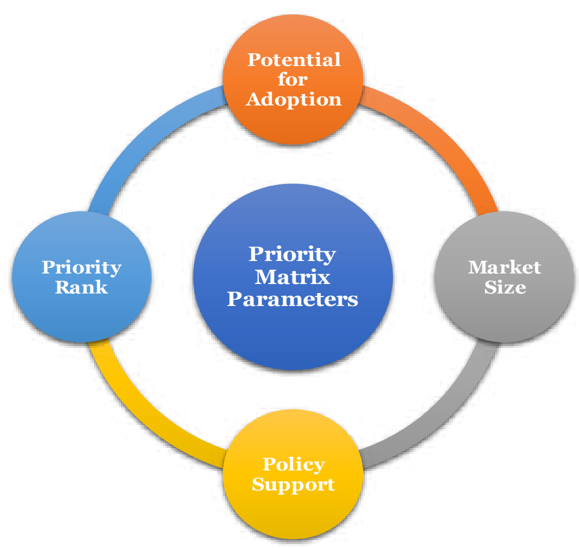

Figure 5: Priority Matrix Parameters for EE

Current Status and Trend

2. CURRENT STATUS AND TRENDS

2.1 Global Perspective

This section provides an overview of the global market, trends and technological advancement for the three technologies.

2.1.1 Air Compressor

The Global Air Compressor Market was valued at $28.4 billion in 2021 and is projected to reach $46.2 billion by 2031, growing at a CAGR of 4.9% from 2022 to 2031[3], as depicted in Figure 6. Increasingly stringent environmental regulations and a stronger focus on sustainability are driving industries to adopt more eco-friendly air compressors.

The growing adoption of variable-speed systems, low maintenance costs, and enhanced operational efficiency, along with the ability to retrofit existing systems are key factors driving the increasing demand for air compressors across major end-use industries. Energy-efficient compressors are gaining significant traction due to their cost-effective operations and long-term savings. Leading companies are creating environmentally sustainable and low-maintenance solutions to motivate consumers to choose advanced products. Firms such as Ingersoll Rand Plc and Atlas Copco Inc. have developed next-generation systems with high-performance capabilities to differentiate their products in a highly competitive market. Some of the key features offered by these air compressors include increased efficiency and reduced noise levels.

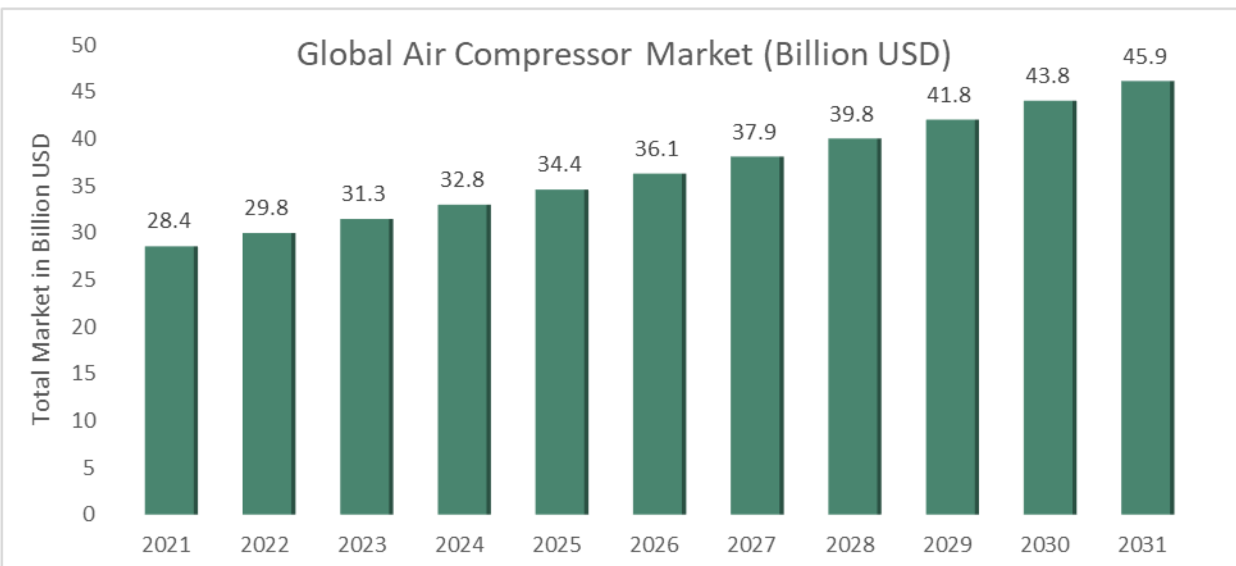

Figure 6: Global Market Trends for Air Compressor Technology

[3] https://www.alliedmarketresearch.com/air-compressor-market

2.1.2 Water Pumps

The global water pump market size reached a value of approximately USD 67 billion in 2024. The market is projected to grow at a CAGR of 4.4% between 2025 and 2034[4], reaching a value of USD 99 billion by 2034 as shown in Figure 7.

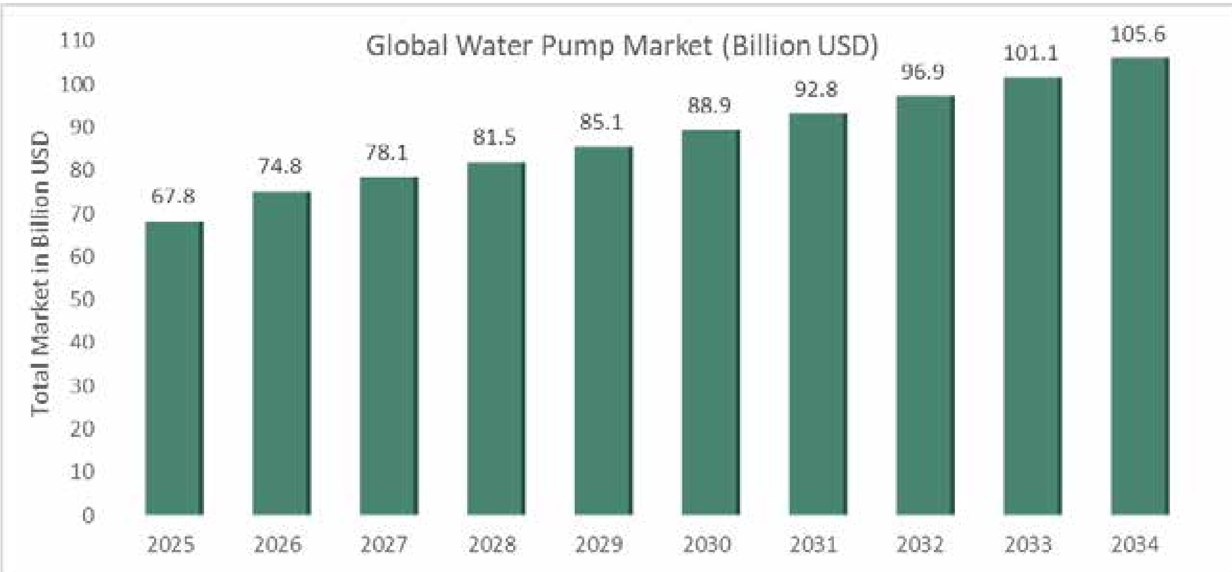

Figure 7: Global Market Trend for Water Pump Technology

Water Pumps play a critical role across diverse industries, including oil and gas, cement, textiles, infrastructure, pulp and paper, food and beverage, power generation, water and wastewater management, and chemicals. The integration of advanced technologies like automatic actuators and control systems with standard valves enhances the efficiency and versatility of water pumping systems, contributing to the overall growth of the market.

The global water pumping systems market is experiencing a dynamic transformation driven by converging factors: escalating water scarcity, rapid industrial growth, and a heightened emphasis on environmental sustainability. Key emerging trends include the integration of Internet of Things (IoT) technology into smart water pumps, facilitating remote monitoring, predictive maintenance, and optimized energy consumption. Advancements in variable frequency drives (VFDs) are revolutionizing energy efficiency by enabling precise pump speed adjustment based on real-time demand. Moreover, the development of high-efficiency pumps incorporating advanced materials and innovative designs is contributing to reduced energy consumption and lower operational costs.

2.1.3 Fans & Blowers

The global fans and blowers' market at USD 18.8 billion in 2022, is projected to reach USD 28.9 billion by 2032, with a CAGR of 4.41% during the forecast period 2024-2032[5], as shown in Figure 8. India, along with China, is a key contributor to the Asia Pacific market's growth, which is the fastest-growing region globally.

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[4] Water Pump Market Size, Share & Growth Analysis, 2034

[5] https://www.marketresearchfuture.com/reports/fans-and-blower-market-25093

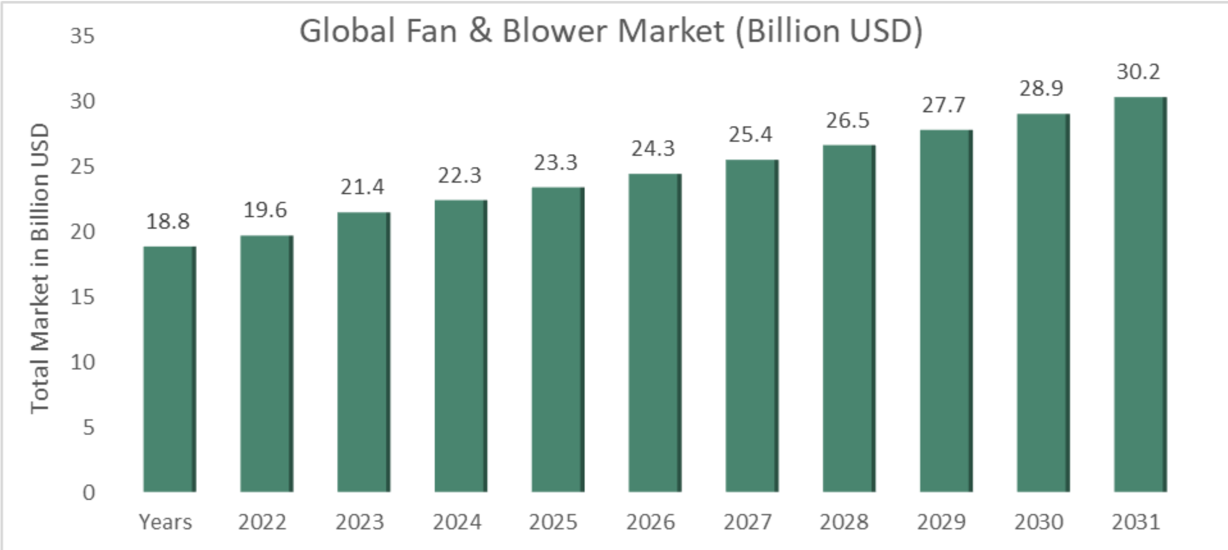


Figure 8: Global Market Trend for Fans and Blower Technology

The fan & blower market is highly competitive, featuring a mix of global and regional players. Prominent manufacturers, including Acme Engineering & Manufacturing Corp., Airmaster Fan Company Inc., DongKun Industrial Co. Ltd., Flakt Woods Group SA, Gardner Denver Inc., Greenheck Fan Corp., Howden Group Ltd., Loren Cook Company, Pollrich DLK, Nadi Airtechnics India, Aeppl, Techflow Enterprises and Twin City Fan Companies, Ltd., employ various business strategies to maintain and expand their market presence.

2.2 Technology Overview

This section provides broad summary or description of the key aspects, trends, and impact of these three technologies in various fields. It provides an understanding of how technology functions, how it has evolved, and how it influences industries, societies, and individuals. The overview typically highlights the major technological advancements and their applications.

2.2.1 Air Compressor

Air compressors are primarily classified into positive displacement and dynamic types. Positive displacement compressors, including reciprocating and rotary models, dominate the market and are used extensively. These compressors are favored for their energy efficiency and adaptability across various industrial applications. Dynamic compressors, such as centrifugal models, are the faster-growing segment due to their ability to handle large volumes of air efficiently.

India's air compressor market is primarily driven by stationary units, which are prevalent in industrial sectors that require continuous airflow, such as manufacturing, automotive, and construction. These compressors are essential for operations that demand uninterrupted performance.

Oil-lubricated compressors remain the preferred choice for heavy-duty applications, while oil-free models are gaining popularity in sectors like healthcare and food processing due to their clean air output. Major industries that utilize compressed air include oil and gas, cement, glass, power generation, chemicals and pharmaceuticals, steel, food and beverages, textiles, automotive manufacturing, and agriculture.

Air compressors in Indian industries consume a lot of electricity, mainly for process requirements, operating pneumatic tools, and instrumentation. However, only 10% to 30% of this energy is effectively used, while 70% to 90%[6] becomes unusable heat, with further losses from friction, misuse, and noise. Optimizing system design and using advanced technologies can lead to significant energy savings. Due to their widespread use and potential inefficiencies, compressed air systems offer substantial opportunities for energy conservation as shown in Figure 9.

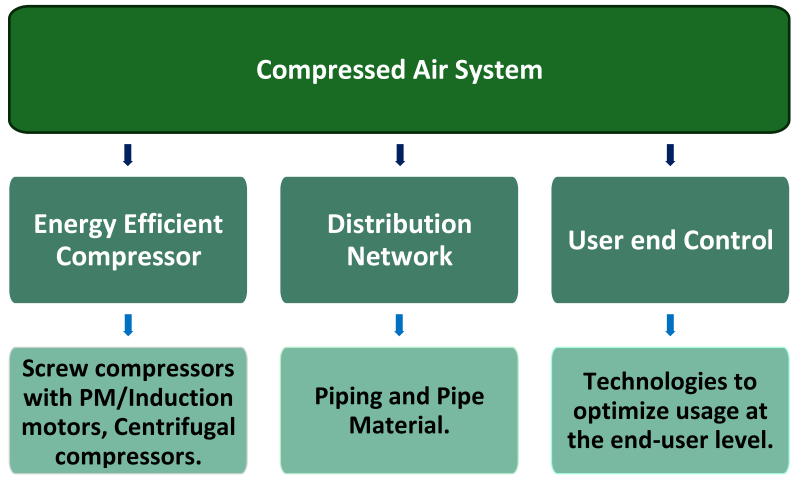


Figure 9: Classification of Air Compressors & Distribution System

Compressed air system consists of three main components: the compressor, the dryer, and the distribution network. The distribution network comprises dryers, distribution pipes and airflow control systems. Figure 10 illustrates a typical air compressor system, highlighting the key components and their interconnections. The various components starting from the compressor to the distribution network are depicted in the same.

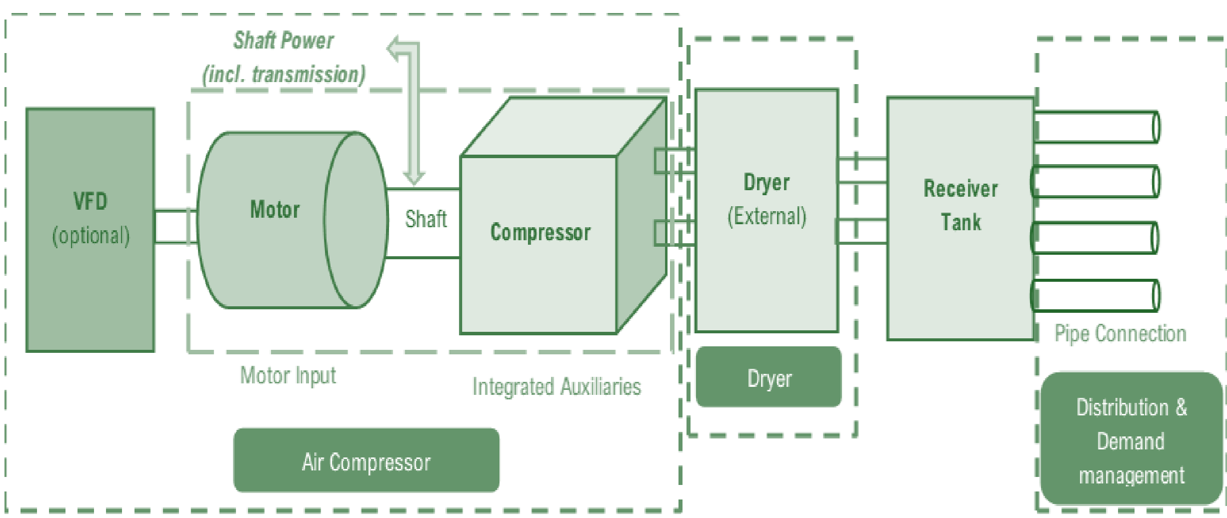


Figure 10: Air Compressor Network

Air compressors play a crucial role in various industrial sectors by supplying compressed air for multiple processes, including tool operation, material transport, and the functioning of pneumatic systems. These compressors come in various types, each designed to meet industrial requirements, based on factors like

[6] https://www.cementindusneed.com/compressor-performance-and-optimization/#:~:text=Compressed%20air%20is%20an%20essential,installation%20and%20original%20equipment%20cost.

pressure requirements, airflow capacity, and energy efficiency. They can be categorized according to their technology, cooling method, and drive speed, as illustrated in Figure 7.

Based on technology, the primary types of air compressors include positive displacement compressors, such as reciprocating and rotary screw compressors, and dynamic compressors, such as centrifugal compressors as shown in **Error! Reference source not found.**.

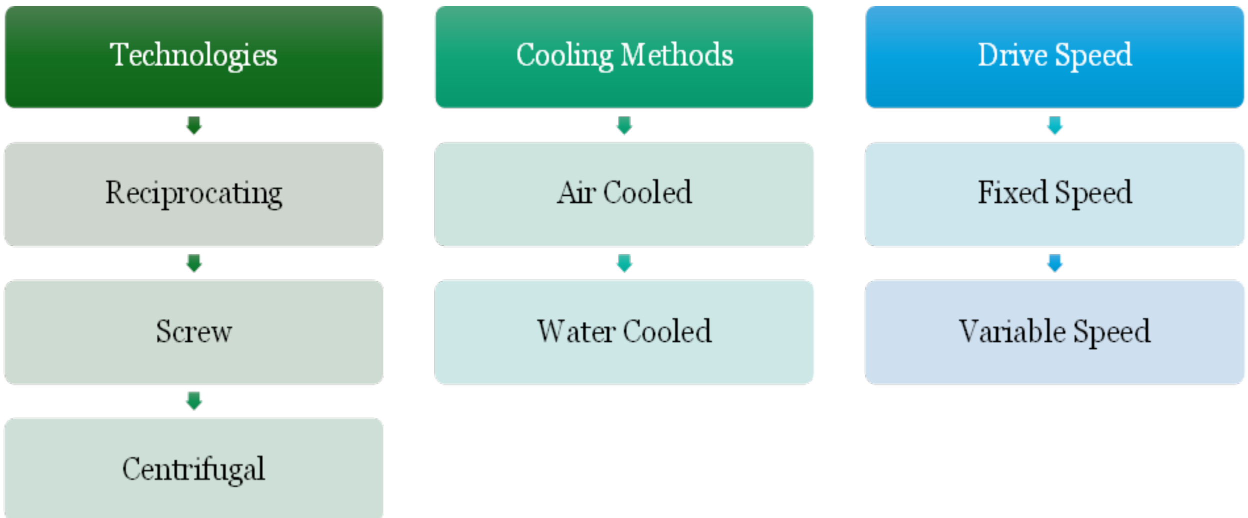


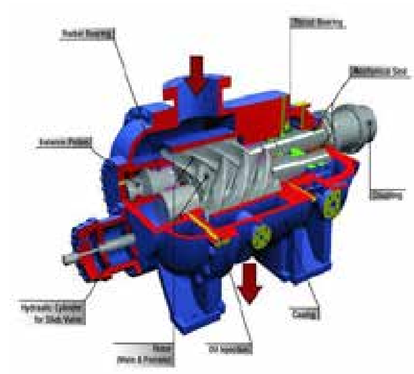
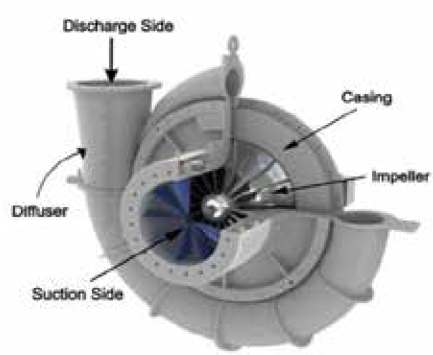
Figure 11: Classification of Air Compressors and its key components

Positive Displacement Compressor: provides consistent airflow by mechanically compressing a fixed volume of air, using mechanisms like pistons or rotary screws. These compressors are ideal for smaller, stable applications such as manufacturing and automotive industries, offering high-pressure ratios even at lower speeds, with a simple design that ensures reliability and ease of maintenance.

Dynamic Air Compressor: type of compressor that increases air pressure by using the kinetic energy of rotating blades or impellers. It works by accelerating air through a series of stages, where its velocity is converted into pressure. Common types of dynamic air compressors include centrifugal and axial compressors, which are widely used in applications like air conditioning, refrigeration, and industrial machinery. These compressors are particularly effective for high-flow, continuous operations, as they can handle large volumes of air efficiently.

A brief description of the categories of air compressors considered for the assessment is listed in Table 7.

Table 7: Categories of Air Compressors

Category of Compressor	Details	Illustrative Image
Screw Compressor	It is a type of positive displacement compressor that uses two interlocking helical screws to compress air by trapping air between the threads and reducing its volume, creating pressure. These compressors are known for their efficiency, reliability, and ability to provide a continuous supply of compressed air with minimal pulsation. **Applications:** Ideal for operations requiring consistent airflow and high reliability, such as manufacturing, construction, and automotive industries.	
Reciprocating Compressor	These compressors use a piston and cylinder mechanism to compress air. As the piston moves up and down within the cylinder, it draws in air on the intake stroke and compresses it on the discharge stroke. This process increases air pressure, which is then stored in a tank for use. **Applications:** widely used in applications requiring high-pressure air, such as in automotive repair shops, industrial machinery, and small-scale manufacturing. It is a low-capacity (low airflow) air compressor designed to operate at low, medium, or high operating pressure.	
Centrifugal Compressor	It is a type of dynamic compressor that increases air pressure through high-speed rotation. It uses a rapid spinning impeller to accelerate air, converting its velocity into pressure through a diffuser. **Applications:** power plants, refineries, and large HVAC systems. Known for their ability to handle high volumes of air with minimal pulsation, centrifugal compressors are commonly used where steady, high-capacity airflow is required. They are also typically more efficient at higher capacities compared to other compressor types.	

Cooling Methods

Air-cooled: Smaller capacity compressors generally utilize air cooling through a fan, an essential component of the belt-driven flywheel. This fan circulates cool air over the external finned surfaces of the compressor cylinder or casing.

Water-cooled: Two types of water-cooling systems are associated with compressors: external systems and those integrated within the compressor's packaging. The integrated system features cooling water jackets encircling the compressor's sealed cover, effectively dissipating the heat generated during operation.

Drive Speed

Variable Speed Drive (VSD) compressors adjust their motor speed based on air demand, offering energy efficiency by matching output to system requirements. This helps reduce energy consumption and operating costs, particularly in applications with fluctuating air flow needs. VSD compressors are ideal for industries where air demand is variable, such as in manufacturing and HVAC systems.

Fixed-speed drive compressors operate at a constant speed regardless of air demand, maintaining a steady flow of air. While they are generally simpler and more cost-effective upfront, they can lead to higher energy costs in applications where demand varies, as the compressor runs continuously at full capacity. Fixed-speed compressors are often used in applications with consistent, predictable air requirements.

2.2.2 Water Pumps

Industrial water pumps are essential across diverse sectors, including chemicals, petrochemicals, mining, textiles, pulp and paper, oil and gas, and food and beverage. These water pumps play a crucial role in various industrial processes, from cooling, heating, and wastewater treatment. In addition to their widespread use in industrial processes, water pumps play a crucial role in power plants, facilitating the circulation of water for cooling systems, boilers, and condensers.

These systems leverage a diverse array of technologies, including centrifugal pumps, positive displacement pumps, and submersible pumps, each tailored to specific demands. Key considerations in industrial applications include flow rate, head pressure, fluid properties (viscosity, temperature, abrasiveness), and energy efficiency. Advanced technologies like variable frequency drives (VFDs) and remote monitoring systems are increasingly integrated to optimize performance, reduce energy consumption, and enhance overall system reliability.

Table 8 below provides an overview of the specific water pumping systems considered for this assessment.

Table 8: Types of Water Pumps

Category	Types
Water Pumping System	Centrifugal Pumps, Reciprocating Pumps, Rotary Pumps

Figure 12 illustrates a water pumping system comprising a motor, a pump, and an optional Variable Frequency Drive (VFD). The core element, which is the water pump shaft, is driven by an electric motor, which provides the necessary power for operation. When integrated, the VFD enables precise control over the motor's speed, allowing for dynamic adjustments to the pump's flow rate and pressure.

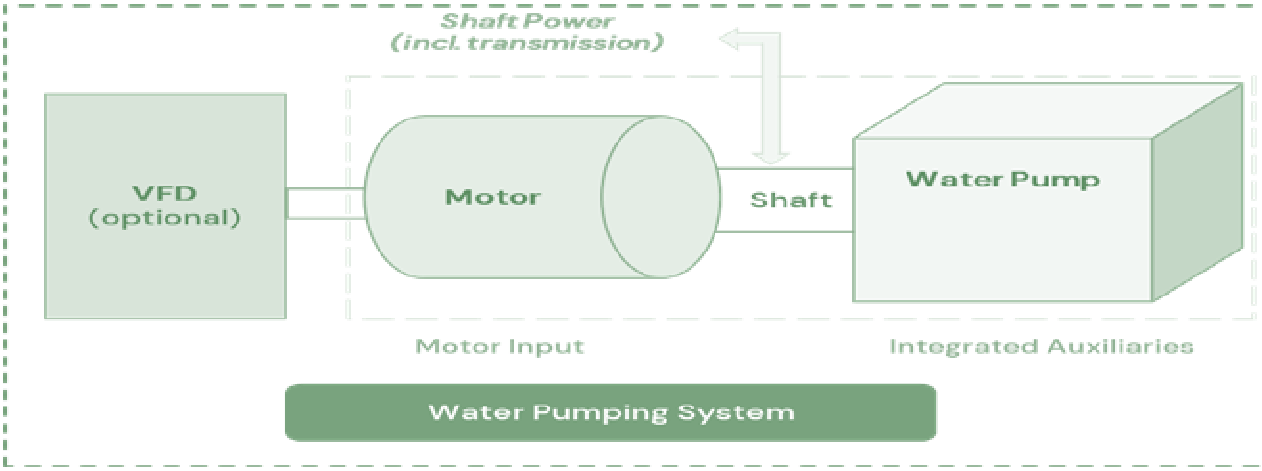


Figure 12: Water Pumping System

Technological advancements in pump design have resulted in highly reliable, energy-efficient, and durable solutions tailored to specific industrial needs. The diverse range of industrial water pumps encompasses centrifugal and positive displacement types, each optimally suited for applications based on factors such as flow rate, pressure requirements, and the characteristics of the fluid being pumped.

India's water pump industry is diverse and technologically advanced, catering to a wide range of industrial sectors with specific pump types tailored to different applications. A brief classification of water pumps based on technology types is given below in Table 9.

Table 9: Categories of Water pumps

Category of Pump	**Details**	**Illustrative Image**
Centrifugal Pump	They are the most used pumps in the industrial sector and use the principle of centrifugal force to move water or other fluids by converting the rotational energy from the motor through a system. **Application-** feed water supply, wastewater treatment, process cooling, and HVAC systems.	

Category of Pump	Details	Illustrative Image
Rotary Pump	They are designed to move water or other fluids by trapping a fixed amount of fluid and forcing it through the pump's discharge. **Application-** valuable in industrial, chemical, and manufacturing applications.	
Reciprocating Pump	They are powerful, versatile, and efficient for applications requiring high pressure and precise flow control. **Application-** Typically, these water pumps are used in high-pressure cleaning, boiler feed water, hydraulic systems, wastewater treatment and others.	
Vertical Pump	They are a key technology in many industries due to their versatility, efficiency, and ability to handle high-pressure, deep-well, and high-volume applications. **Application-** These pumps are commonly used for chemical processing, refineries, boiler feed water and process fluids.	

2.2.3 Fans & Blowers

Fans and blowers are critical components within various industrial sectors, serving essential functions such as ventilation, cooling, heating, and material handling. They are integral to processes requiring exhaust ventilation, drying, cooling, dust removal, and pneumatic conveying. Applications span a wide range of industries, including construction, metals, mining, power generation, food processing, petrochemicals, cement, automotive exhaust systems, and HVAC as shown in Figure 13. The continuous growth of industrialization, marked by the establishment of new factories, power plants, and manufacturing facilities, is

Figure 13: Sectors of Application

expected to lead to a substantial increase in the demand for fans and blowers.

Industries with the highest demand for air-handling equipment include iron and steel plants, chemical plants, and power plants, all of which have witnessed substantial growth in recent years. In response to this rising demand, key market players are strategically expanding their operations to meet the evolving needs for industrial fans and blowers effectively.

An overview of the fans and blowers evaluated in this assessment is provided in Table 10.

Table 10: Types of Fans and Blowers

Category	Subcategory	Details
Fans & Blowers	Types	EC blowers, Turbo blowers, Centrifugal blowers, Positive displacement blowers, Axial blowers

A typical fan and blower system as shown in Figure 14 is designed to efficiently move air within industrial processes. It comprises several key components that work together to achieve optimal performance. The core element is the fan or blower unit itself, which is responsible for generating airflow. This unit is driven by an electric motor, which provides the necessary power for operation. Many systems incorporate Variable Frequency Drives (VFDs) to optimize energy consumption and control airflow. VFDs adjust the motor's speed, allowing for precise control over airflow based on specific process requirements. This flexibility ensures efficient operation and reduces energy waste by only using the necessary power for the task at hand.

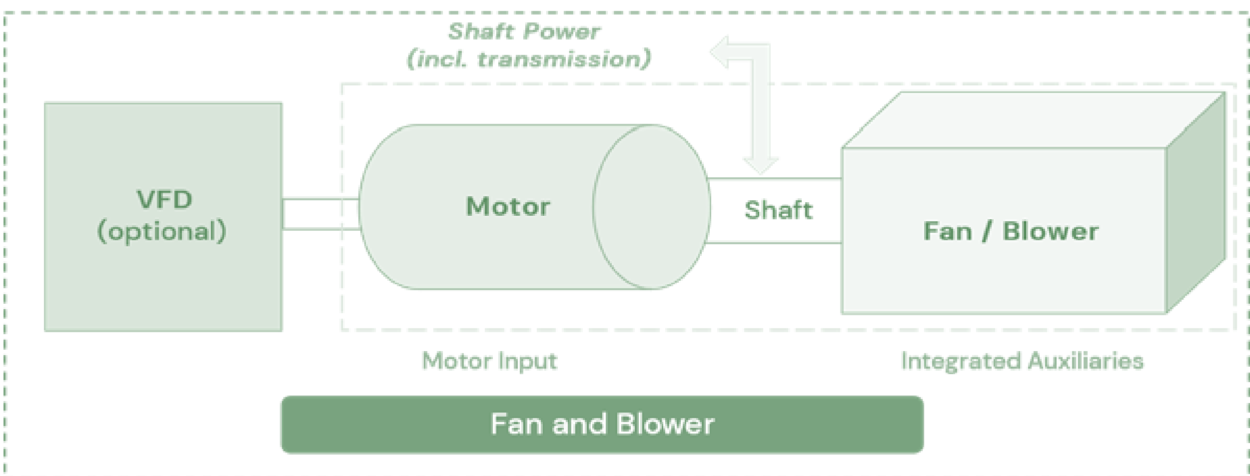


Figure 14: Fans and Blowers

Different types of fans and blowers, such as axial and centrifugal, are available, each optimized for specific applications based on factors like airflow capacity, pressure requirements, and energy efficiency. Based on the application, fans and blowers can be further classified into the types listed in table 11.

Table 11: Types of Fans and Blowers

Technology Name	Working and Application	Illustrative image
Centrifugal Blowers	These are mechanical devices that move air or gases by converting rotational energy into kinetic energy. **Applications**- widely used in various industrial applications for ventilation, air handling, exhaust systems, dust collection, and material handling.	
Axial Blowers	Axial fans and blowers are designed to move air or gases along the axis of the fan, meaning the air flows in a straight line parallel to the shaft around which the blades rotate. **Application-** commonly used in industrial, commercial, and residential applications where high airflow rates with relatively low pressure are needed, such as in ventilation, cooling, and exhaust systems.	
Turbo Blowers	They are high-efficiency blowers that utilize a rotating impeller (or turbine) to compress and move air or gases at high speeds. **Application-** Turbo blowers are designed for high airflow applications, offering energy efficiency, precise airflow control, and low maintenance. They are commonly used in wastewater treatment, industrial processes, and power generation.	
Electronically Commuted (EC) Blowers	They are high-efficiency fans and blowers that utilize electronically commutated motors (EC motors) to move air or gases. **Application-** These fans and blowers find extensive applications in scenarios that demand precise speed control, energy efficiency, and low noise, such as HVAC systems, refrigeration, and industrial ventilation.	

Technology Name	Working and Application	Illustrative image
Root Blowers	They are mechanical devices used to move large volumes of air or gas at relatively high pressures. They operate on a principle known as positive displacement, where two rotors rotate in opposite directions to trap air or gas and force it through the outlet. **Application-** Used in industrial applications such as wastewater treatment, pneumatic conveying, vacuum systems, and chemical processing	

2.3 Comparative Analysis

Compared to the global market for industrial utilities, the Indian market is significantly smaller in terms of size but is considered one of the fastest-growing regions. The projected CAGR indicates a rapidly expanding market within the larger global landscape; while the global market might be valued at tens of billions of dollars, the Indian market is currently valued in the billions, with substantial potential for further growth due to increasing infrastructure development and industrial activity in India. However, the key difference lies in the overall technological advancement and market maturity, with global technological solutions generally offering more advanced features like higher energy efficiency, a wider range of capacity options, and often incorporating newer technologies for noise reduction and environmental sustainability, while Indian technological solutions tend to focus on cost-effective options suitable for smaller-scale industrial applications, driven by the rapidly growing manufacturing sector in India.

The major KPIs and their impact on the Global and Indian Scenarios are elaborated in Table 12 and Table 13.

Table 12: Technology KPIs between Indian and Global Scenario

KPIs	Global Scenario	Indian Scenario
Technology & Features	• The rapid adoption of IoT-enabled monitoring and control for predictive maintenance and remote operations. • Emphasis on energy-efficient designs such as high-speed motors, VFD integration, and aerodynamic improvements to meet global standards. • Compliance with stringent energy standards like ISO 50001 and initiatives promoting green manufacturing are prevalent.	• Adopting energy-efficient technologies is seen, however, the penetration of advanced technologies like IoT-based monitoring systems and high-efficiency motors is still growing. • Focus on durable and robust systems as a cost-effective solution, while compromising efficiency. • Many industries continue to use older, less efficient models due to cost constraints.
Demand Drivers	• A variety of industries, such as power generation, mining, manufacturing and HVAC drive the global market. • Global manufacturers focus on high customization to cater to diverse applications, including specialized industries like aerospace and renewable energy. • Developed markets prioritize long-term operational efficiency and sustainability over initial costs, supporting the adoption of premium technologies.	• Rapid expansion due to infrastructure development and industry growth driven by manufacturing sectors such as cement, steel, textiles, and pharmaceuticals. • The Indian market often demands robust, low-maintenance, and cost-effective solutions tailored to local industrial and environmental conditions. • Indian industries are highly cost-sensitive, often balancing upfront investment with operational savings. This leads to slower adoption of advanced technologies compared to global markets.
Market Challenges	• Increased cost of production due to the integration of smart and IoT-enabled monitoring systems. • Regulatory pressures for energy efficiency, emission reduction, high initial costs of advanced technology and slow replacement cycles in developed markets are some of the global challenges. • Global reliance on diversified supply chains can cause vulnerabilities due to geopolitical tensions.	• Lack of awareness and expertise on energy-efficient technologies. • High dependence on imports for advanced technology increases equipment costs, leading to a lack of adoption of the technology. • A fragmented market with competition from unauthorized manufacturers limits the adoption of premium products. • Lack of enforcement of energy efficient regulations is not helping the adoption of the technology.

Table 13: ***Financial KPIs between Indian and Global Scenario***

KPIs	Global Scenario	Indian Scenario
Price Point	• Generally higher due to advanced technology and better efficiency. • Opted by large industries due to better energy savings and longer lifespan.	• Often more cost-effective due to the focus on basic designs and compromised efficiencies • Local resistance to adopting better technological solutions due to the high investment costs.
Maintenance Costs	• Sensor-based monitoring technologies reduce annual energy consumption and reduce maintenance costs. • Use of smart monitoring with IoT enables predictive maintenance and reduces unplanned downtime. • Spare parts and services are typically more expensive but high in quality and longevity.	• As the technologies opted for are less efficient compared to the global standards, energy consumption is significantly high. • Limited adoption of predictive maintenance due to cost and technological barriers. • Advanced systems require imported parts, increasing costs and lead times. • Inadequate infrastructure and inconsistent energy supply affect the installation and operation of high-performance systems.

Technology Identification and Analysis

3. TECHNOLOGY IDENTIFICATION AND ANALYSIS

3.1 Literature Review

This section provides a comprehensive summary and analysis of the existing scenario, market potential, regulatory landscape etc. for the three technologies.

3.1.1 Air Compressor

The India Air Compressor Market size was valued at USD 1.9 billion in 2023 and is projected at a CAGR of 6.6% during 2024-2030 to reach USD 2.9 billion by 2030[7], as shown in Figure 15. India's robust industrial sector, with its heavy reliance on compressed air, presents substantial opportunities for energy conservation. Air compressors find widespread application across diverse industries, including automotive, textiles, pharmaceuticals, pulp and paper, cement, refineries, and others.

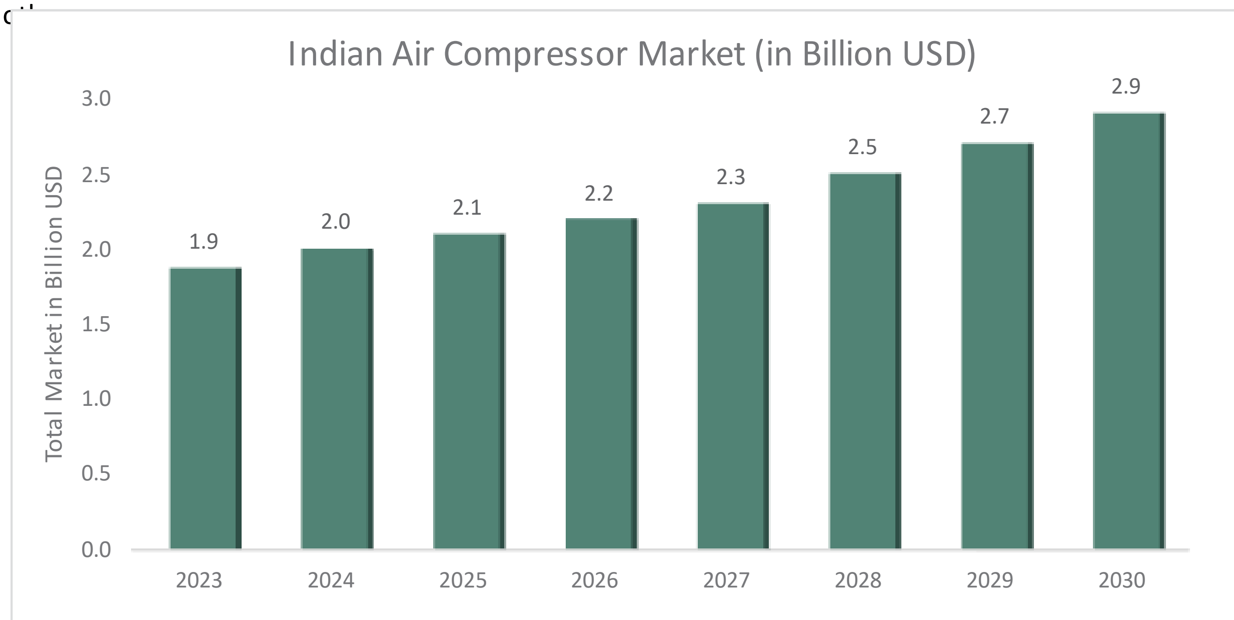


Figure 15: Market Potential of Air Compressors in India in Billion USD

Despite the market's promising growth trajectory, several challenges may impede the progress of the Indian air compressor market during the forecast period. Moreover, stringent environmental regulations, particularly those pertaining to emissions and noise pollution, necessitate substantial investments in research and development for manufacturers to develop efficient compressors. Furthermore, the high initial investment costs associated with air compressor acquisition, coupled with ongoing maintenance requirements (e.g., filter replacements, lubrication, and inspections), can deter widespread adoption within the Indian industrial landscape.

The Indian air compressor market is a competitive landscape with a diverse range of players, including global giants like Atlas Copco, Ingersoll Rand, and Kaeser Kompressoren, as well as prominent domestic

[7] https://www.psmarketresearch.com/market-analysis/india-compressor-market

players such as ELGI Equipment's, Godrej & Boyce, and Kirloskar Pneumatics. These companies are actively engaged in research and development initiatives, focusing on innovations such as energy-efficient technologies, advanced controls, and compact designs to enhance product performance and expand their market share. Atlas Copco currently holds a leading position in the market.

The Indian air compressor market operates within a framework of both national and international standards and regulations. Internationally, standards like ISO 1217 provide crucial guidelines for evaluating the performance of displacement compressors, enabling accurate assessments of energy efficiency.

Domestically, the Indian government has taken significant steps to promote energy efficiency and safety within the sector. The Bureau of Energy Efficiency (BEE) has established a voluntary energy efficiency standard for air compressors, setting benchmarks for energy consumption. While voluntary, this initiative has significantly influenced the market, driving manufacturers to develop and introduce more energy-efficient compressor models.

The Indian air compressor market is experiencing robust growth, driven by a confluence of factors. The burgeoning industrial sector, with its expanding manufacturing base, necessitates a significant demand for air compressors across various applications, from process air to service air. Moreover, government initiatives aimed at promoting "Make in India" and fostering sustainable industrial practices are creating a favorable environment for market expansion.

The increasing demand for portable and oil-free air compressors is a noteworthy trend. These compressors are favored for their ease of use, low maintenance requirements, and environmental friendliness, aligning with the growing emphasis on sustainability.

3.1.2 Water Pumps

The Indian industrial pump market is poised for substantial growth, with projections indicating a valuation of USD 2.8 billion by 2032, up from USD 1.9 billion in 2023. This represents a steady CAGR of 4.5% over the forecast period (2024-2032)[8] as shown in Figure 15. Industrial pumps are critical in various sectors, serving as the backbone of countless industrial processes. These essential machines facilitate the efficient transportation of fluids, including water and other liquids, over significant distances and to considerable heights.

[8] https://www.imarcgroup.com/india-water-pumpsmarket#:~:
text=Market%20Overview%3A,4.5%25%20during%202024%2D2032.

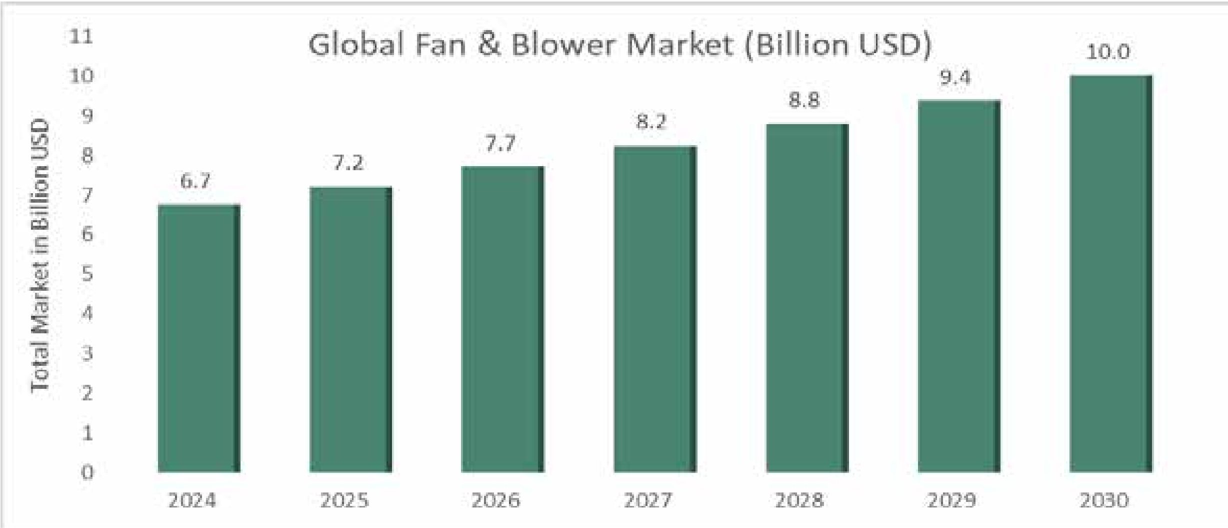


Figure 16: Market Potential for Water Pumps in India in Billion USD

The Indian market for industrial pumps is a competitive landscape, with key players including Kirloskar Brothers Limited, CRI Pumps, Grundfos, Shakti Pumps, Kishor Pumps, Sulzer Pumps, Andritz Pumps, Wilo Pumps, and numerous others. These industry leaders are actively engaged in research and development initiatives to drive innovation. This includes developing energy-efficient, high-performance pumps, exploring advanced materials, and implementing cutting-edge technologies to enhance product reliability and expand their market reach.

3.1.3 Fans & Blowers

The global fans and blowers market is experiencing robust growth, projected to expand from $6.7 billion in 2024 to nearly $10 billion by 2030 at a CAGR of 6.8%[9] as shown in **Error! Reference source not found.**. T his growth is primarily driven by factors such as industrialization and manufacturing expansion,

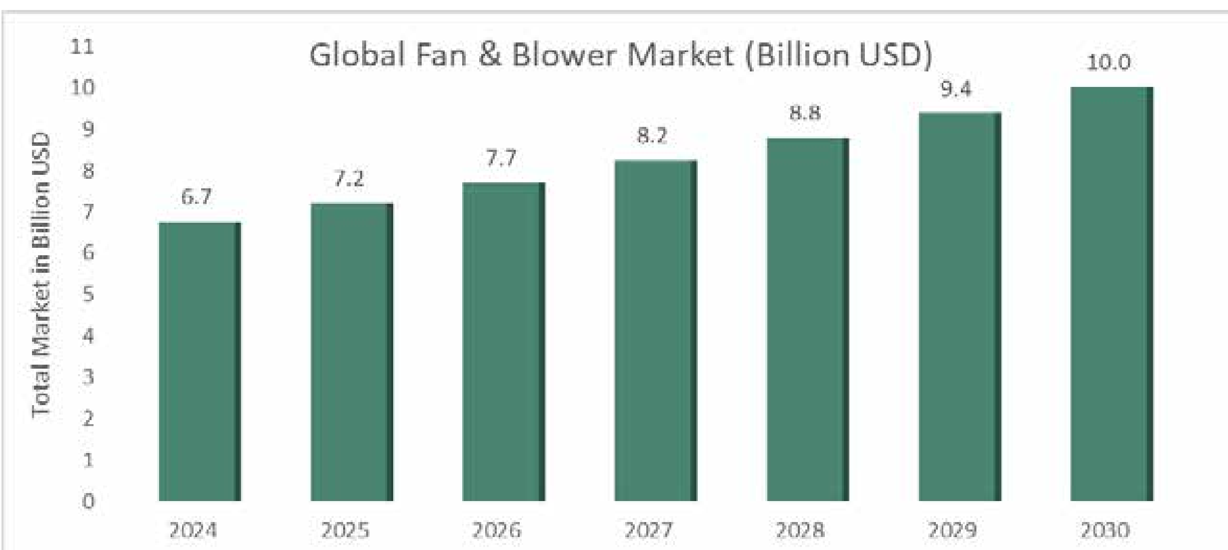


Figure 17: Market Potential of Fans and Blowers in India in Billion USD

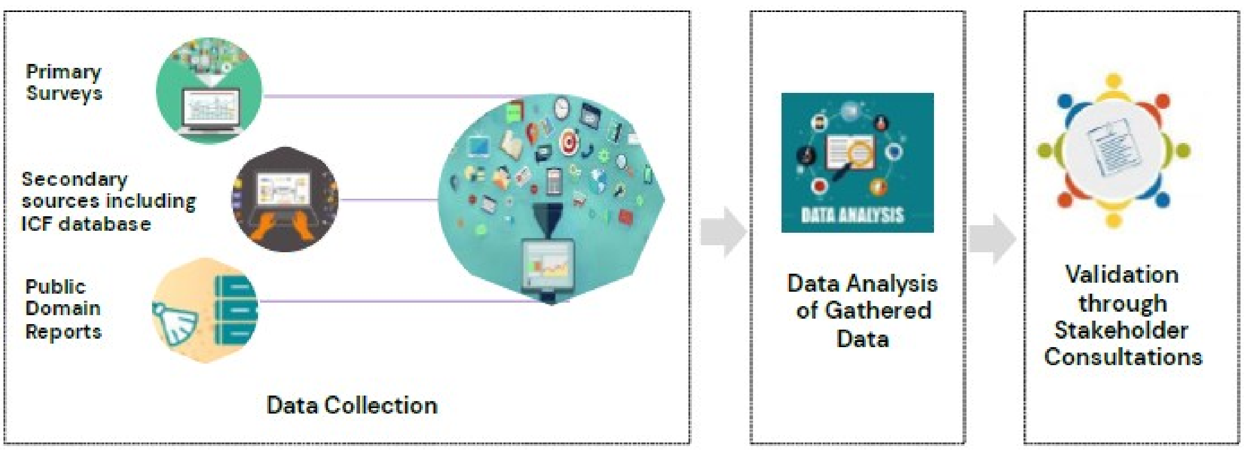
[9] https://www.thebusinessresearchcompany.com/report/fans-and-blowers-global-market-report

construction and infrastructure development, increasing demand for energy-efficient solutions, stricter air quality regulations, and the ongoing upgrade of HVAC systems.

A comprehensive literature review and market analysis of fans and blowers involved examining existing research, industry reports, and market data. This analysis encompassed historical trends, current market dynamics, and future projections. Key areas included market size and growth, segmentation by type (centrifugal, axial, etc.), application (industrial, commercial, residential), and region. Moreover, the analysis delved into technological advancements, key players, competitive landscape, and emerging trends such as energy efficiency, IoT integration, and advanced materials.

3.2 Data Collection

The ICF team conducted an extensive primary survey aimed at gaining in-depth insights into the industrial utilities (air compressors, fans & blowers and water pumps) market in India. This comprehensive survey involved the use of structured questionnaires to gather detailed data from a wide range of stakeholders within the supply chain of manufacturers. The data gathered from this primary research encompassed several critical aspects, including the various make and models, their rated specifications, current market demand, anticipated growth trends, and emerging technological advancements that have the potential to be adopted by the industrial sector. The ICF team also conducted several cross-sectoral industrial visits to gather on-site data and evaluate the operational efficiencies in real-world settings. These visits provided valuable insights into the on-field performance of the technology, enabling the team to validate its effectiveness, identify potential areas for improvement, and recommend best practices for enhancing operational efficiency.



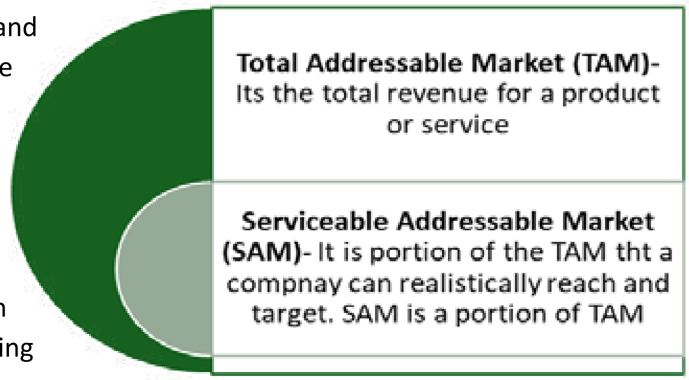
Secondary data on the technologies employed in Indian industries was collected through an extensive review of diverse sources. These included energy audit reports, market studies from the Bureau of Energy Efficiency (BEE), databases and research from ICF, reports from Energy Efficiency Services Limited (EESL), research institutes, and other publicly available resources from online platforms. These reports offered valuable insights into the types of technologies used, their adoption rates, operational efficiencies, and best practices associated with the selected technologies.

By carrying out the primary and secondary surveys, ICF developed a comprehensive database for the three technologies, including technical specifications and performance metrics. This assisted the ICF team in assessing potential energy savings and carbon emission reduction. The priority matrix was developed based on energy efficiency, cost-effectiveness, ease of implementation, market readiness, and scalability potential.

3.3 Market Analysis

The methodology developed by ICF for this market assessment study segments market potential into two distinct components: Total Addressable Market (TAM) and Serviceable Available Market (SAM).

Our comprehensive market research and extensive stakeholder engagement have identified significant opportunities for innovation within industrial utilities. These findings highlight a strong potential for advancing and enhancing existing technologies. To leverage this opportunity, distinct and promising approaches have been identified, which are outlined in the following utility sections.



3.3.1 Air Compressor

In air compressor systems, four strategic and innovative approaches have been identified, each providing a distinct pathway to optimizing the air compressor system and enhancing its efficiency.

Technology Recommendation -1: Replacement of Reciprocating Compressors with PMSM Compressors

Our market analysis indicates that approximately 25% of the air compressor market comprises reciprocating air compressors. To enhance energy efficiency, we propose replacing these with energy-efficient PMSM (Permanent Magnet Synchronous Motor) Screw Air Compressors equipped with Variable Frequency Drives (VFDs). We estimate the potential for this solution to cover approximately 10% of the overall air compressor market.

Total Addressable Market (TAM): The potential of the current Total Addressable Market (TAM) is estimated at INR 3,136 Cr. in 2025 This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6%. As a result, the market for this is expected to reach approximately INR 4,317 Cr. by 2030.

Serviceable Addressable Market (SAM): The potential of the current Serviceable Addressable Market (SAM) is estimated at INR 314 Cr. in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6% and additional minimum service growth of CAGR of 6%. As a result, the market for this is expected to reach approximately INR 568 Cr by 2030 as shown in Figure 18.

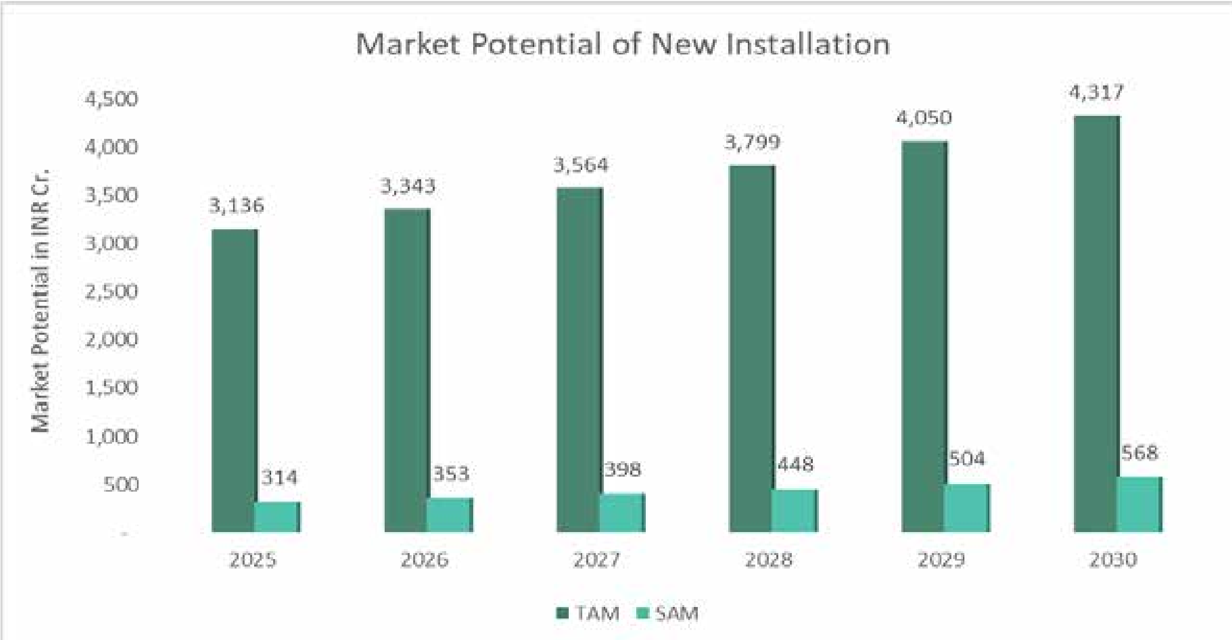


Figure 18: Market Potential of New Installations

Technology Recommendation -2: VFD Retrofitting in Existing Screw Compressor

Our market analysis indicates that screw air compressors dominate the Indian market, constituting nearly 59% of the total market share. Furthermore, our primary and secondary research reveals that approximately 27% of these air compressors are already equipped with Variable Frequency Drives (VFDs). This suggests a significant untapped market for VFD retrofits. Focusing specifically on the remaining 73% of screw air compressors, we estimate the retrofitting potential for VFDs to be approximately 60% of the remaining non-VFDs screw compressor.

Total Addressable Market (TAM): The potential of the current Total Addressable Market (TAM) is estimated at INR 975 Cr. In 2025 This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6%. As a result, the market for this is expected to reach approximately INR 1,343 Cr. by 2030.

Serviceable Addressable Market (SAM): The potential of the current Serviceable Addressable Market (SAM) is estimated at INR 585 Cr. in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6% and additional minimum service growth of CAGR of 6%. As a result, the market for this is expected to reach approximately INR 1,059 Cr by 2030 as shown in Figure 19.

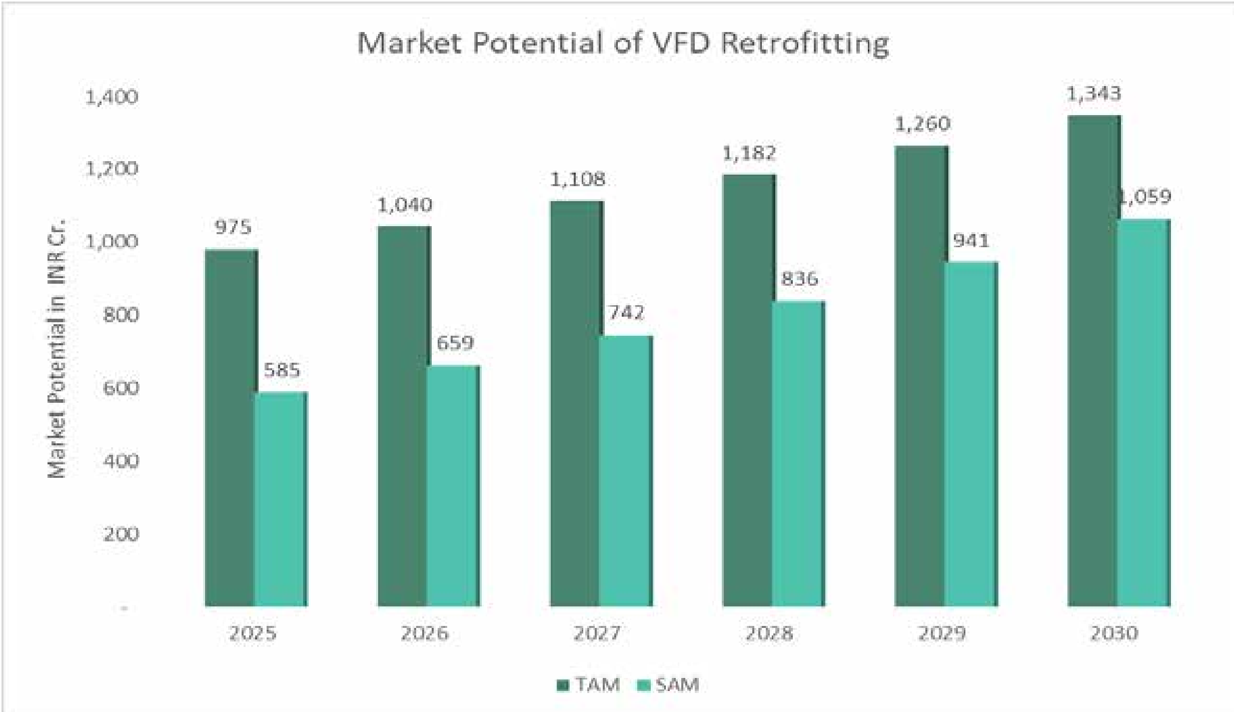


Figure 19: Market Potential of VFD retrofitting

Technology Recommendation -3: Replacement of Screw Compressor with PMSM Screw Compressors

Our market analysis indicates that screw air compressors dominate the Indian market, constituting nearly 59% of the total market share. Furthermore, our primary and secondary research reveals that approximately 27% of these air compressors are already equipped with Variable Frequency Drives (VFDs), also we already covered the remaining 44% compressor for VFDs retrofitting. This suggests a significant market for PMSM screw compressors which can replace in-efficient existing screw compressors, focusing specifically on the remaining 29% of screw air compressors, we estimate the potential for PMSM Screw Compressors to be approximately 40% of remaining screw compressors.

Total Addressable Market (TAM): The potential of the current Total Addressable Market (TAM) is estimated at INR 780 Cr. In 2025 This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6%. As a result, the market for this is expected to reach approximately INR 1,074 Cr. by 2030.

Serviceable Addressable Market (SAM): The potential of the current Serviceable Addressable Market (SAM) is estimated at INR 117 Cr. in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6% and additional minimum service growth of

CAGR of 6%. As a result, the market for this is expected to reach approximately INR 212 Cr by 2030 as shown in Figure 20.

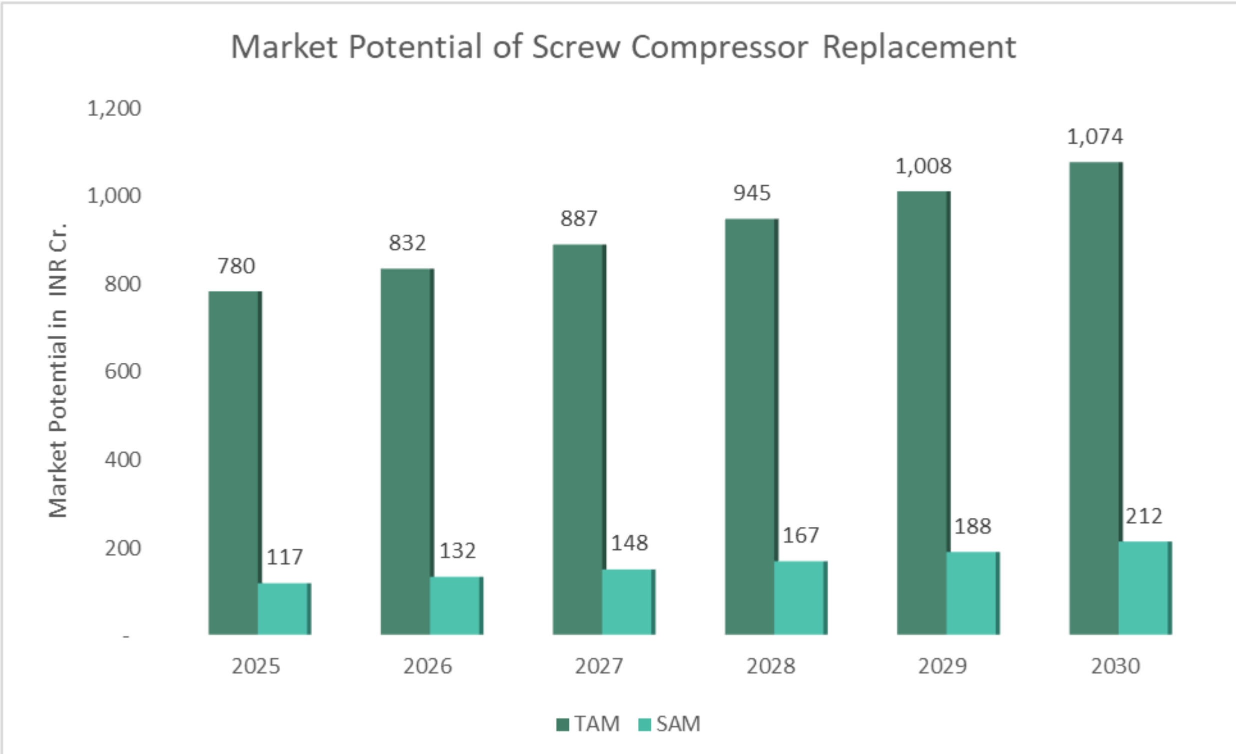


Figure 20: Market Potential of Screw Compressor Replacement

Technology Recommendation – 4: IFC Retrofitting in Existing Air Compressor System

Our market analysis indicates that screw air compressors, reciprocating air compressors, and centrifugal air compressors account for 59%, 25%, and 16% respectively of the Indian market. Additionally, our primary and secondary research reveals that intelligent flow control (IFC) in air compressor systems remains largely untapped in the Indian market, presenting a significant opportunity for IFC retrofitting. We estimate the retrofitting potential for IFCs to be approximately 60% of the total air compressor market.

Total Addressable Market (TAM): The potential of current Total Addressable Market (TAM) is estimated at INR 813 Cr. in 2025 This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6%. As a result, the market for this is expected to reach approximately INR 1,120 Cr. by 2030.

Serviceable Addressable Market (SAM): The potential of the current Serviceable Addressable Market (SAM) is estimated at INR 57 Cr. in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6% and additional minimum service growth of CAGR of 6%. As a result, the market for this is expected to reach approximately INR 103 Cr by 2030 as shown in Figure 21.

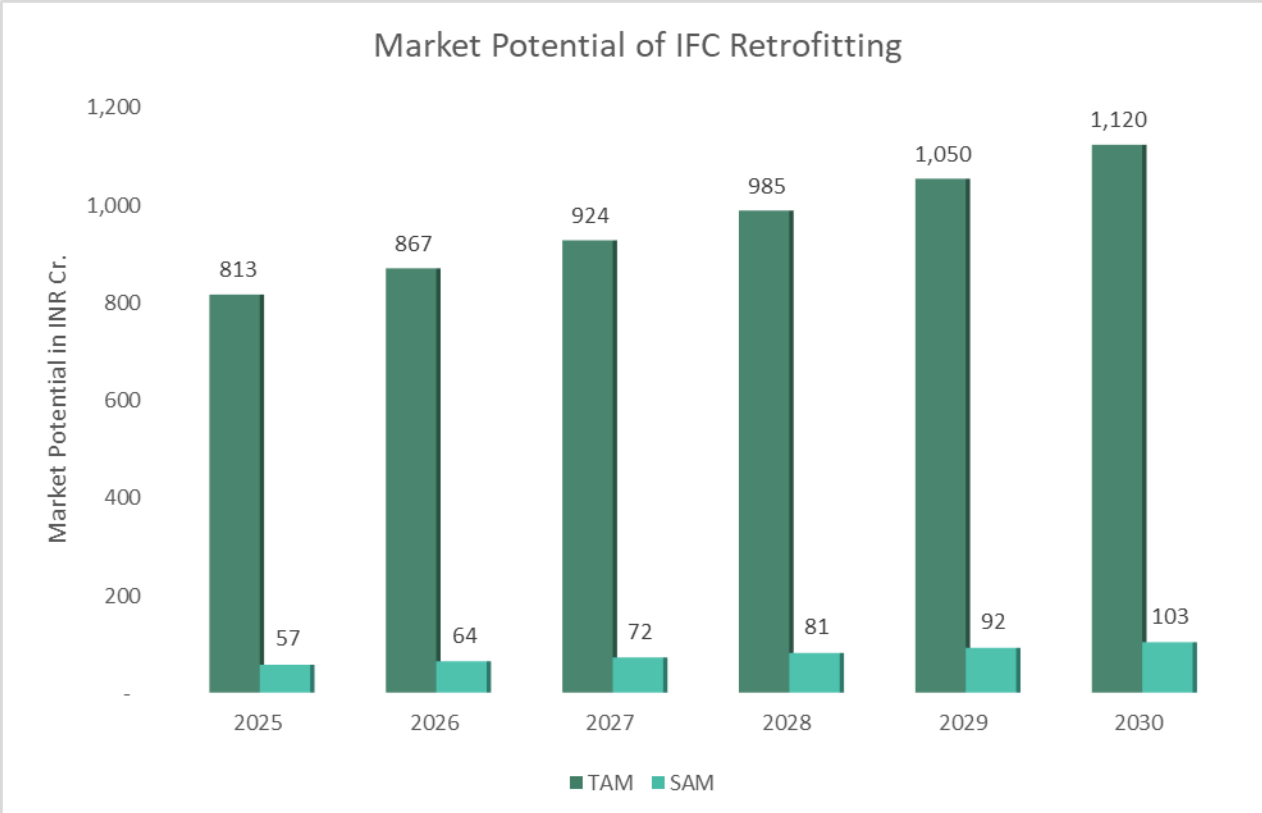


Figure 21: Market Potential of IFC Retrofitting

Summary of Recommendations for Air Compressors and Compressed Air Distribution System

Our market assessment indicates significant market potential within the air compressor industry, which is given hereunder:

Total Addressable Market (TAM): The potential of current Total Addressable Market (TAM) is estimated at INR 5,705 Cr in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6%. As a result, the market for this is expected to reach approximately INR 7,854 Cr. by 2030.

Serviceable Addressable Market (SAM): The potential of current Serviceable Addressable Market (SAM) is estimated at INR 1,073 Cr. in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.6%. As a result, the market for this is expected to reach approximately INR 1,942 Cr by 2030 as shown in Figure 22.

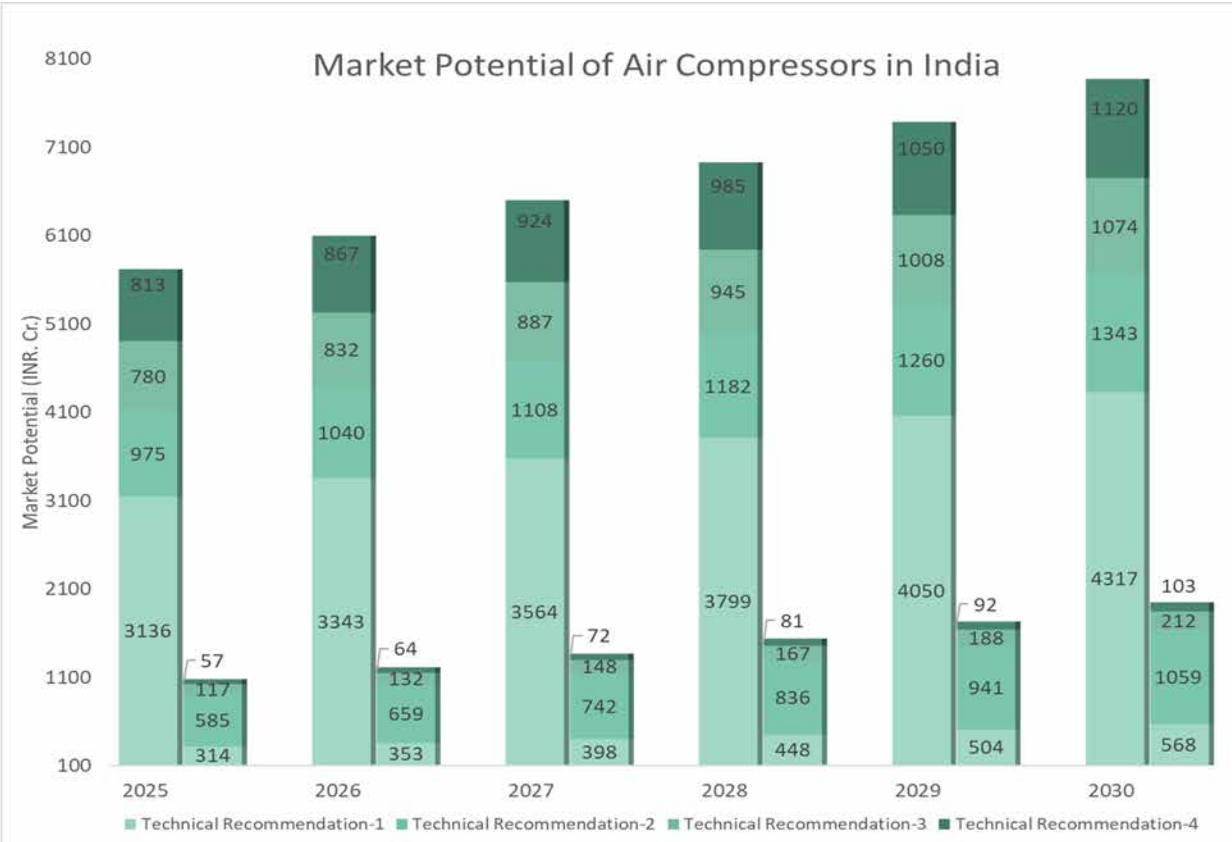


Figure 22: Total Market Potential of India

3.3.2 Water Pumps

In water pumping systems, one key strategy has been identified to optimize the water pumping system and enhance its efficiency.

Technology Recommendation: VFD Retrofitting in Existing Water Pumping System

Total Addressable Market (TAM): The potential of the current Total Addressable Market (TAM) is estimated at INR 1,063 Cr in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 4.5%. As a result, the market for this is expected to reach approximately INR 1,324 Cr. by 2030.

Serviceable Addressable Market (SAM): The potential of the current Serviceable Addressable Market (SAM) is estimated at INR 425 Cr. in 2025. This dynamic sector is poised for robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 4.5% and an annual service growth of 6%. As a result, the market for this is expected to reach approximately INR 700 Cr by 2030 as shown in Figure 23.

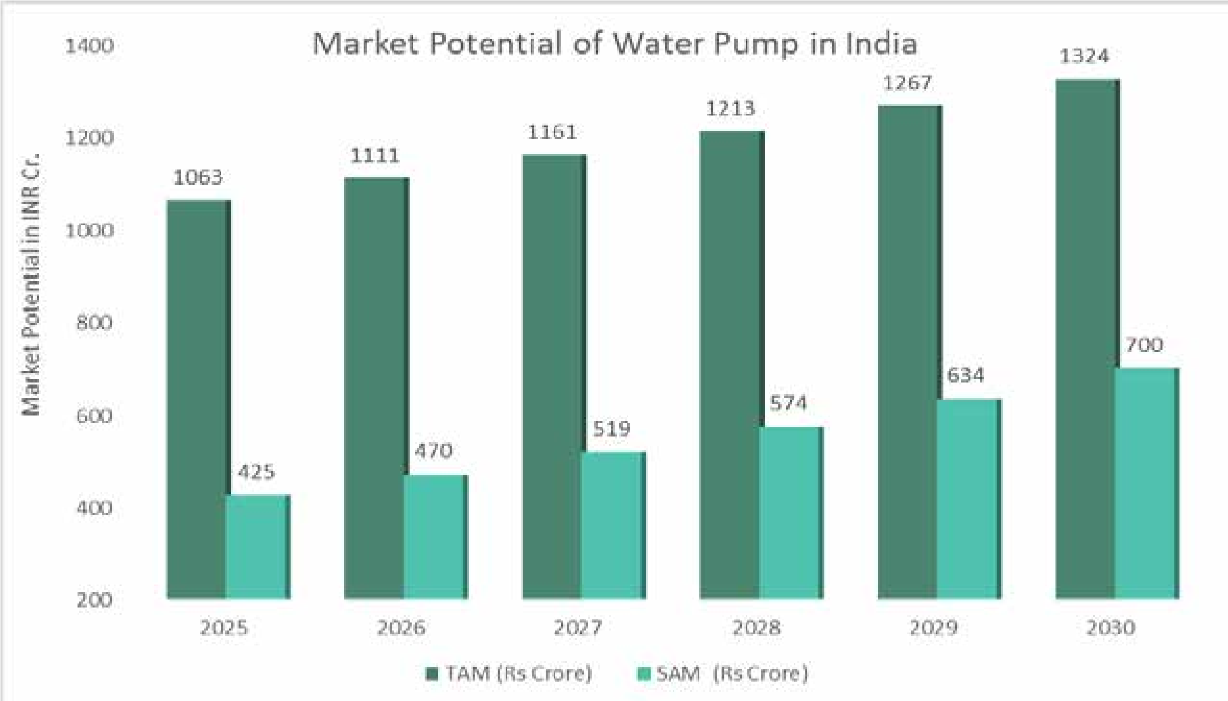


Figure 23: Market Potential of Water Pump in India

Condensate extraction pumps play a pivotal role in efficiently operating power plants and melting applications in the steel industry. These high-performance pumps are essential for optimizing steam generation and cooling processes, ensuring maximum energy output, and minimizing operational downtime.

The Indian power sector exhibits a diverse ownership structure, contributing to the market's multifaceted nature. State-owned entities dominate, accounting for 66% of the market share. The central sector follows closely with a 24% share, while the private sector comprises approximately 9%. For the purposes of our analysis, we have assumed a 60% replacement rate. This diverse ownership landscape presents both challenges and opportunities for manufacturers and suppliers of condensate extraction pumps.

3.3.3 Fans & Blowers

Our comprehensive market research and extensive stakeholder engagement efforts have revealed a significant opportunity for innovation within the fan and blower technology industry. This presents a compelling avenue for advancements and improvements in existing technologies. To capitalize on this opportunity, two distinct and promising approaches have been identified. These approaches represent unique pathways towards realizing the full potential of fan and blower technology.

Technology Recommendation: VFD Retrofitting in Fans & Blowers

Total Addressable Market (TAM): It's the total revenue opportunity available for a product or service. The potential of the current Total Addressable Market (TAM) is estimated at INR 1,753 Cr in 2025. This dynamic sector is poised by robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.8%. As a result, the market for this is expected to reach approximately INR 2,436 Cr. by 2030.

Serviceable Addressable Market (SAM): It's the portion of the TAM that a company can realistically reach and target. SAM is a portion of TAM. The potential of the current Serviceable Addressable Market (SAM) is estimated at INR 526 Cr. in 2025. This dynamic sector is poised by robust growth, driven by a projected Compound Annual Growth Rate (CAGR) of 6.8% and service growth of 6%. As a result, the market for this is expected to reach approximately INR 772 Cr by 2030 as shown in Figure 24.

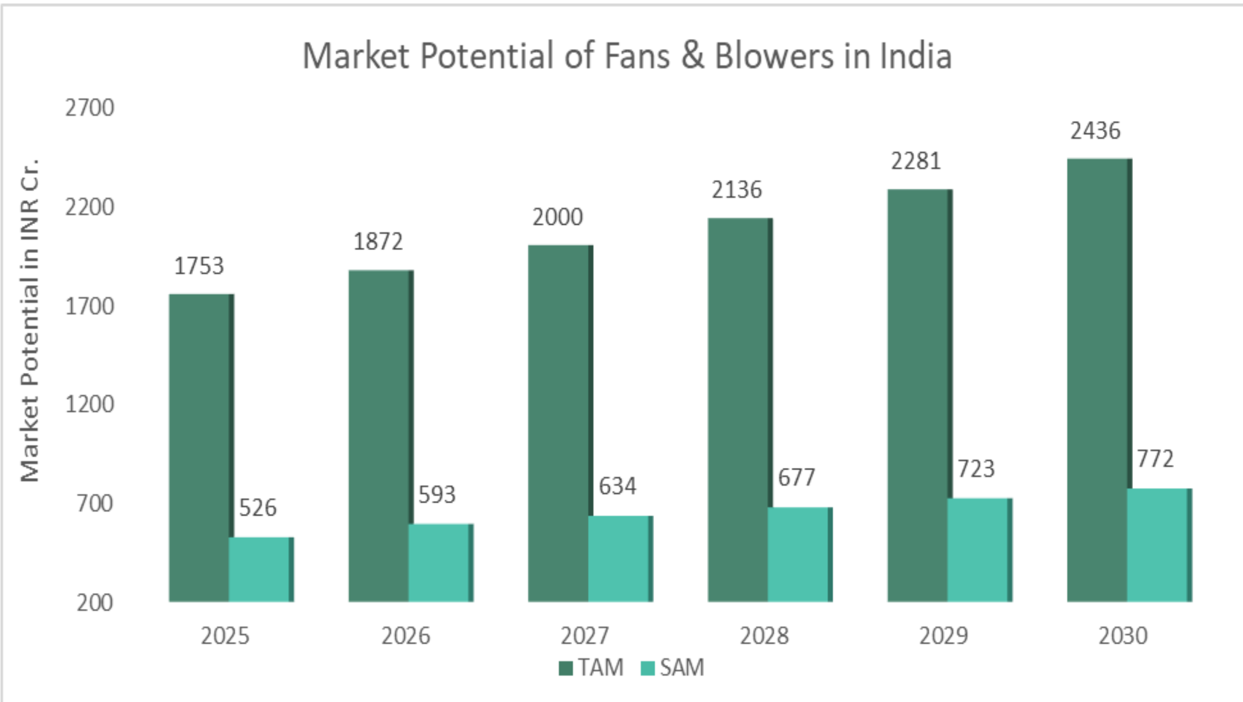


Figure 24: Market Potential of Fan & Blowers in India

MAPPING OF TYPICAL EQUIPMENT CAPACITIES

4. MAPPING OF TYPICAL EQUIPMENT CAPACITIES

4.1 Equipment Categorization

This section provides classification or grouping of the three technologies into different categories based on their function, purpose, or specific characteristics.

4.1.1 Air Compressor

In our comprehensive analysis, the examined air compressor systems collectively offer a total capacity of 120 MW, with a focused investigation on the PAT industry. The data reveals that screw and reciprocating compressors dominate the landscape—together accounting for over 85% of the units evaluated. Screw compressors, have a 59% market share, are favoured for their exceptional efficiency and low maintenance requirements, making them the preferred solution in PAT applications. Reciprocating compressors follow with a 25% share, while centrifugal compressors comprise roughly 15% of the total units deployed. This categorization establishes a clear framework for mapping typical equipment capacities and highlights the prevailing technological trends within the PAT industry.

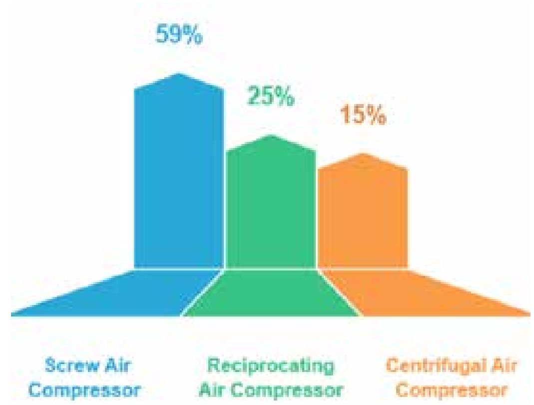


Figure 25: Distribution of Air Compressor

4.1.2 Water Pumps

As per analysis, the aggregate installed capacity of water pumps across all surveyed industries amounts to approximately 203 MW. Centrifugal pumps dominate the industrial water pump market, representing nearly 100% of the total installed capacity. This dominance can be attributed to their simple design, low maintenance requirements, durability, versatility, and high efficiency. Centrifugal pumps offer a compelling combination of cost-effectiveness and enhanced safety features, making them suitable for a wide range of applications across all industrial sectors surveyed.

4.1.3 Fans & Blowers

An analysis of fan and blower installations across various industries, conducted through primary and secondary surveys, revealed a total installed capacity of 227 MW. Centrifugal blowers constitute the dominant segment, accounting for approximately 92% of the total installed capacity. These are widely utilized in sectors such as power generation, cement, aluminum, iron & steel, textiles, and food & beverage processing. The remaining 8% comprises other fan and blower types, including axial, turbo, and root blowers, serving diverse industrial applications. Axial blowers, among these, exhibit the highest kW share.

4.2 Capacity Analysis

This section provides analysis of three technologies based on their typical capacities primarily in kW and divided into groups.

4.2.1 Air Compressor

Air compressors with capacities ranging from 5 kW to over 1600 kW are deployed across various industrial sectors, with the available capacity range strongly influenced by the compressor type. As illustrated in Figure 26, reciprocating compressors are predominantly medium to large units, which together account for more than 65% of the overall kW capacity. Notably, large reciprocating compressors (76 to 250 kW) represent over 56% of this capacity, while extra-large units contribute nearly 31% and medium units about 12%. In contrast, small reciprocating compressors (below 15 kW) comprise a mere 0.40% of the total capacity, underscoring their limited use in heavy industrial applications.

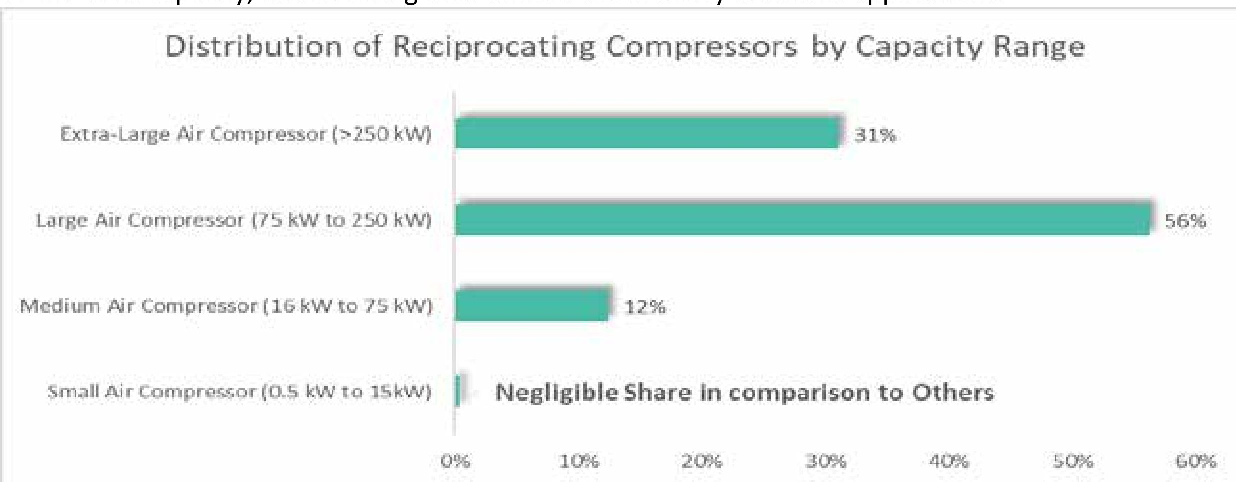


Figure 26: Distribution of Reciprocating Compressors by Capacity Range

Figure 27 shows that the majority of screw compressors fall into the large (76 to 250 kW) and extra-large categories, which together hold more than 85% of the total kW share. Medium screw compressors (16 to 75 kW) account for approximately 8% of the capacity, whereas small screw compressors (5 to 15 kW) represent less than 1%, highlighting their niche application in industrial settings that demand continuous, high-capacity performance.

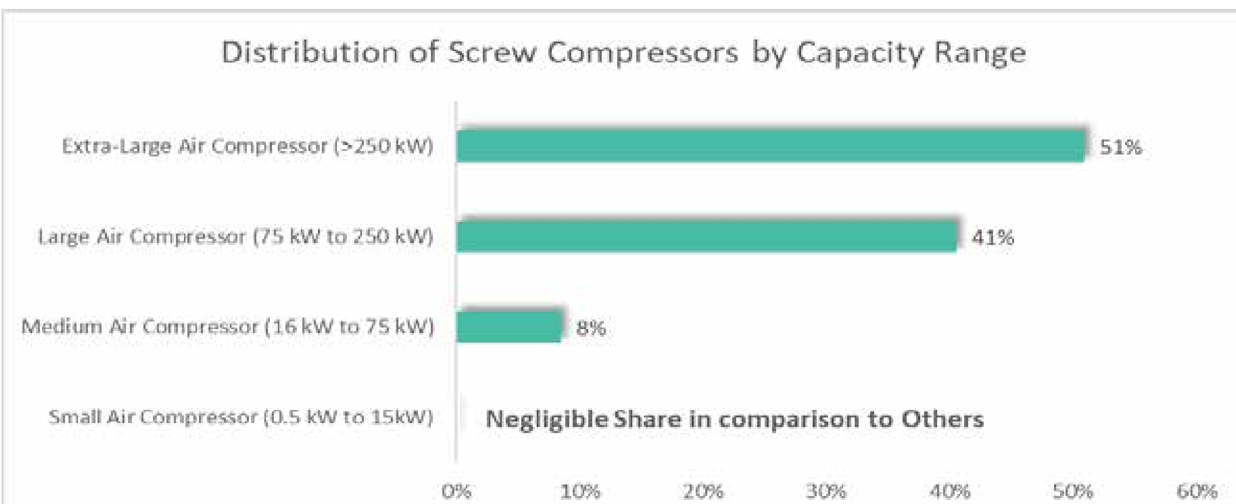


Figure 27: Distribution of Screw Compressors by Capacity Range

Similarly, Figure 28 presents the distribution of centrifugal compressors, where the bulk of the capacity —around 85%—is provided by large (501 to 1000 kW) and extra-large (above 1000 kW) units. Medium centrifugal compressors (101 to 500 kW) contribute roughly 13% to the total, and small centrifugal compressors (below 100 kW) account for only about 1% of the capacity.

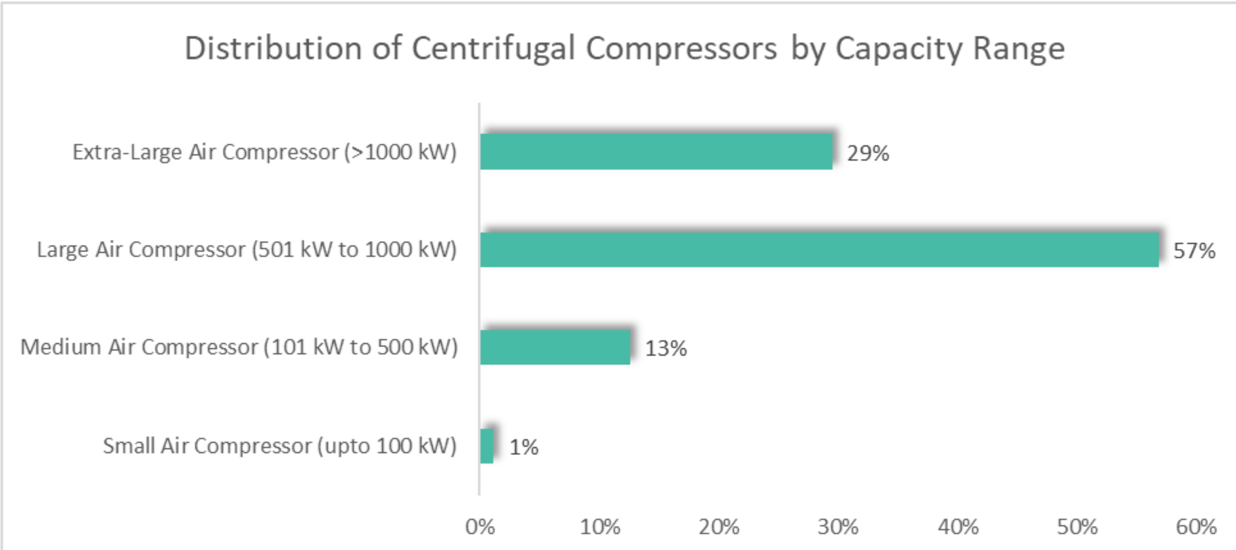


Figure 28: Distribution of Centrifugal Compressors by Capacity Range

Figure 29, Figure 30 and Figure 31 illustrate the distribution of air compressor types within different capacity ranges, measured in kilowatts (kW) utilized across various industrial sectors. It highlights how specific operational demands influence compressor requirements across industries and the diverse preferences within different industries based on their specific air compression needs.

Reciprocating Compressor

Large reciprocating compressors (76 kW to 250 kW) have the most significant share in sectors such as power plant (24.2%), cement (13.3%), aluminum (11.4%) and paper and pulp (7.3%) industries while extra-large compressors (above 250 kW) are primarily used in the glass sector (31.1%). Medium compressors (16 kW to 75 kW) have a relatively moderate share of cement (10.8%), and with a very small share in power plants industries. On the other hand, small compressors (Above 15 kW) have a minimal share with most of their share in textiles and other sectors.

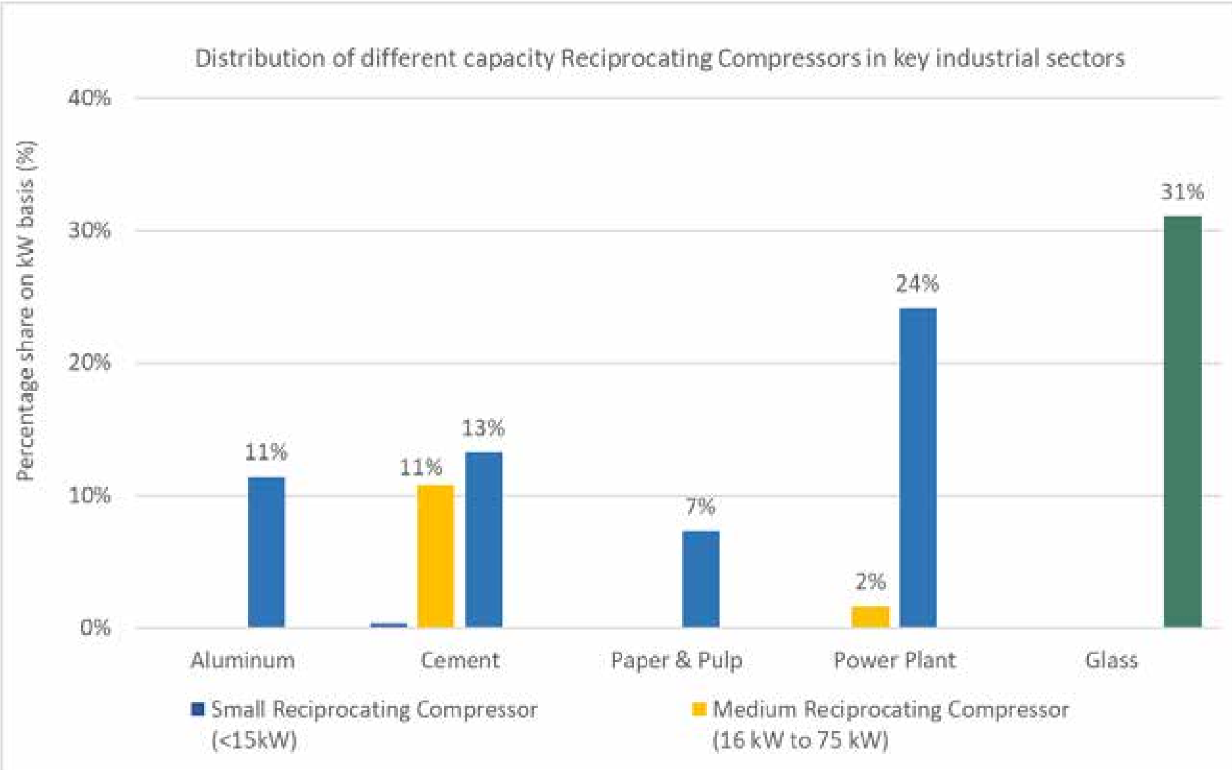


Figure 29: Distribution of different capacity Reciprocating Compressors in key industrial sectors

Screw Compressor

Large screw compressors (76 kW to 250 kW) dominate in sectors such as power plants (7.4%), glass (8.2%), and textiles (12.6%), cement (4.9%), automobile (2.5%), and very less amount for iron & steel, paper & pulp and food and beverage industries, where higher capacity is necessary to meet larger operational needs while extra-large screw compressors (above 250 kW) are primarily utilized in power plants (35.3%) and to a lesser extent in the iron and steel, textile and glass industries reflecting their capacity to support high-demand industrial processes. Small screw compressors (below 15 kW) have a minimal presence across most sectors, with the highest share in textiles (0.3%) while on the other hand, medium screw compressors (16 to 75kW) have around 3 to 9% share in iron & steel, textile, cement, and other sectors.

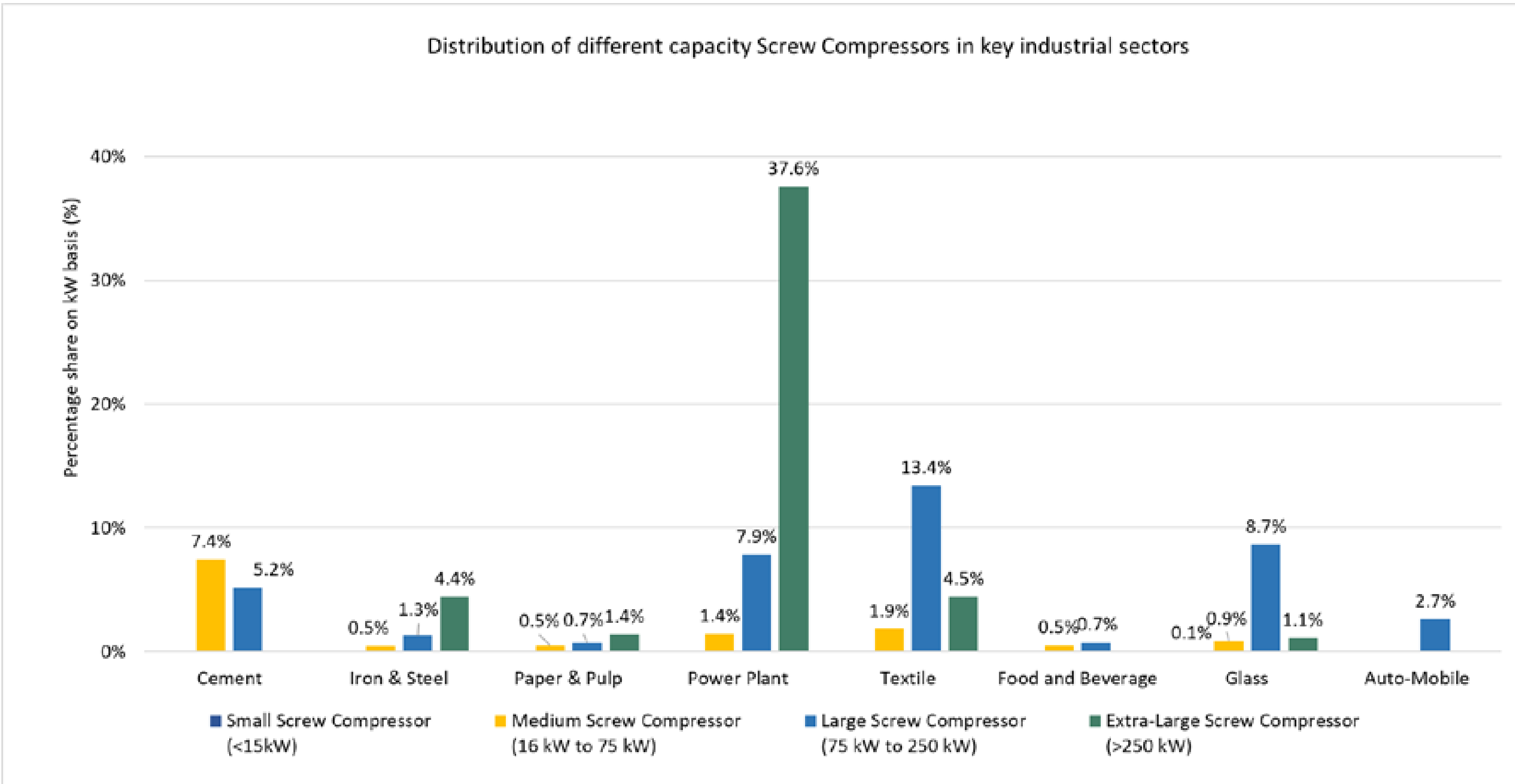


Figure 30: Distribution of different capacity Screw Compressors in key industrial sectors

Centrifugal Compressor

Large centrifugal compressors (501 to 1000 kW) show notable usage in iron and steel (10.8%), paper and pulp (5.5%), Petro-Chemical (9.5%), and power plants (13.1%), while extra-large centrifugal compressors (Above 1000 kW) are majorly utilized in textiles (23.4%). In contrast, Small centrifugal compressors (Below 15 kW) have minimal usage in the cement industry (1.2%) across sectors. Medium centrifugal compressors (100 to 500 kW) are more prevalent, with shares in power plants (7.6%), textiles (2%), cement (1.5%), paper and pulp (1.5%).

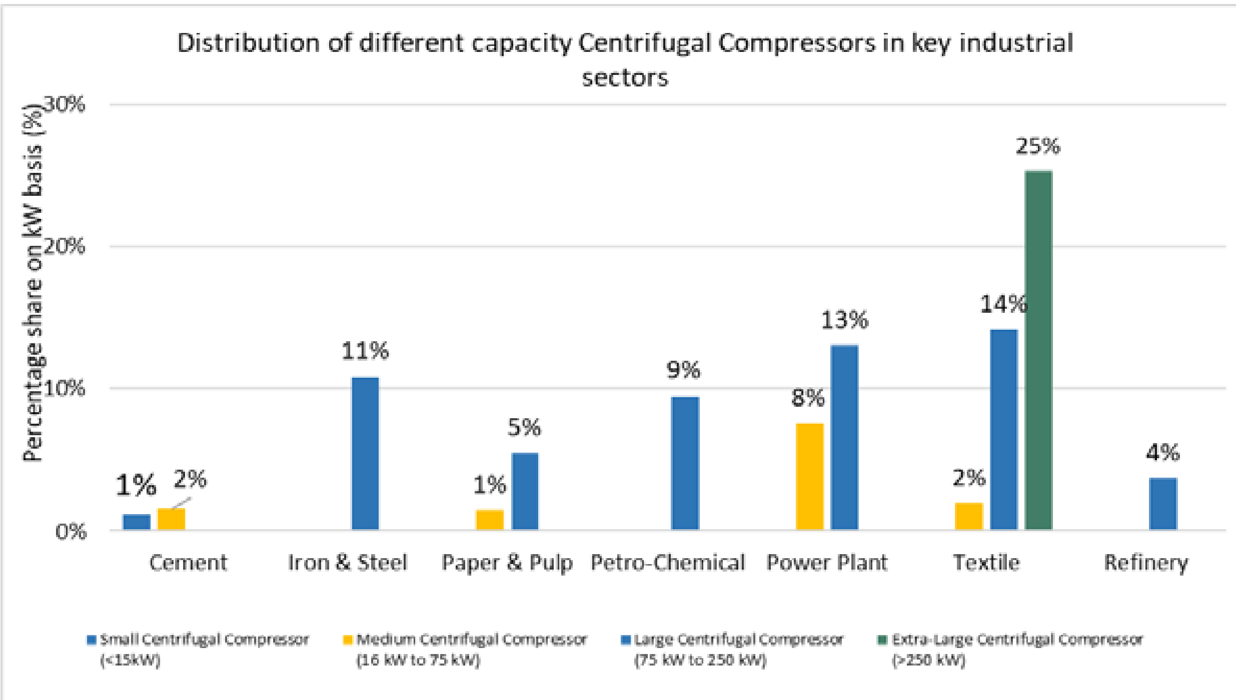


Figure 31: Distribution of different capacity Centrifugal Compressors in key industrial sectors

4.2.2 Water Pumps

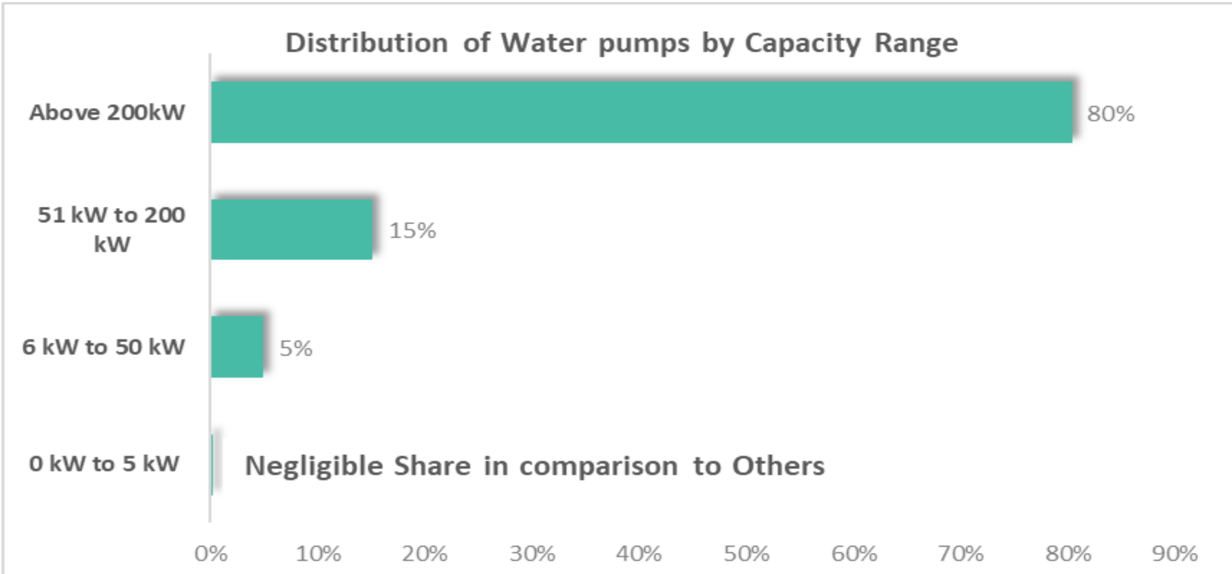


Figure 32: Distribution of Water pumps by Capacity Range

Figure 32 clearly illustrates the distribution of water pump capacities across various industrial sectors. We see a significant concentration of larger pumps, with approximately 80% above 200 kW. The presence of high-capacity pumps, which account for roughly 15% of industrial applications, highlights the paramount importance of energy efficiency. Medium-sized pumps (6-50 kW) make up about 5%, typically found in smaller-scale operations or specialized processes. And while pumps below 5 kW exist, they represent a smaller segment of the overall market.

Figure 33 illustrates the distribution of centrifugal pump capacities across diverse industrial sectors. Notably, capacities exceeding 200 kW are concentrated in energy-intensive industries such as refineries, power plants, iron and steel, cement, and aluminum manufacturing. Power plants heavily rely on these high-capacity pumps, primarily for critical applications like boiler feed water supply. Pumps within the 50-200 kW range find significant application in sectors such as pulp and paper, iron and steel, and, to a lesser extent, power generation. Lower-capacity pumps (below 5 kW) are typically installed in specific industrial sectors and do not represent a significant portion of the overall market.

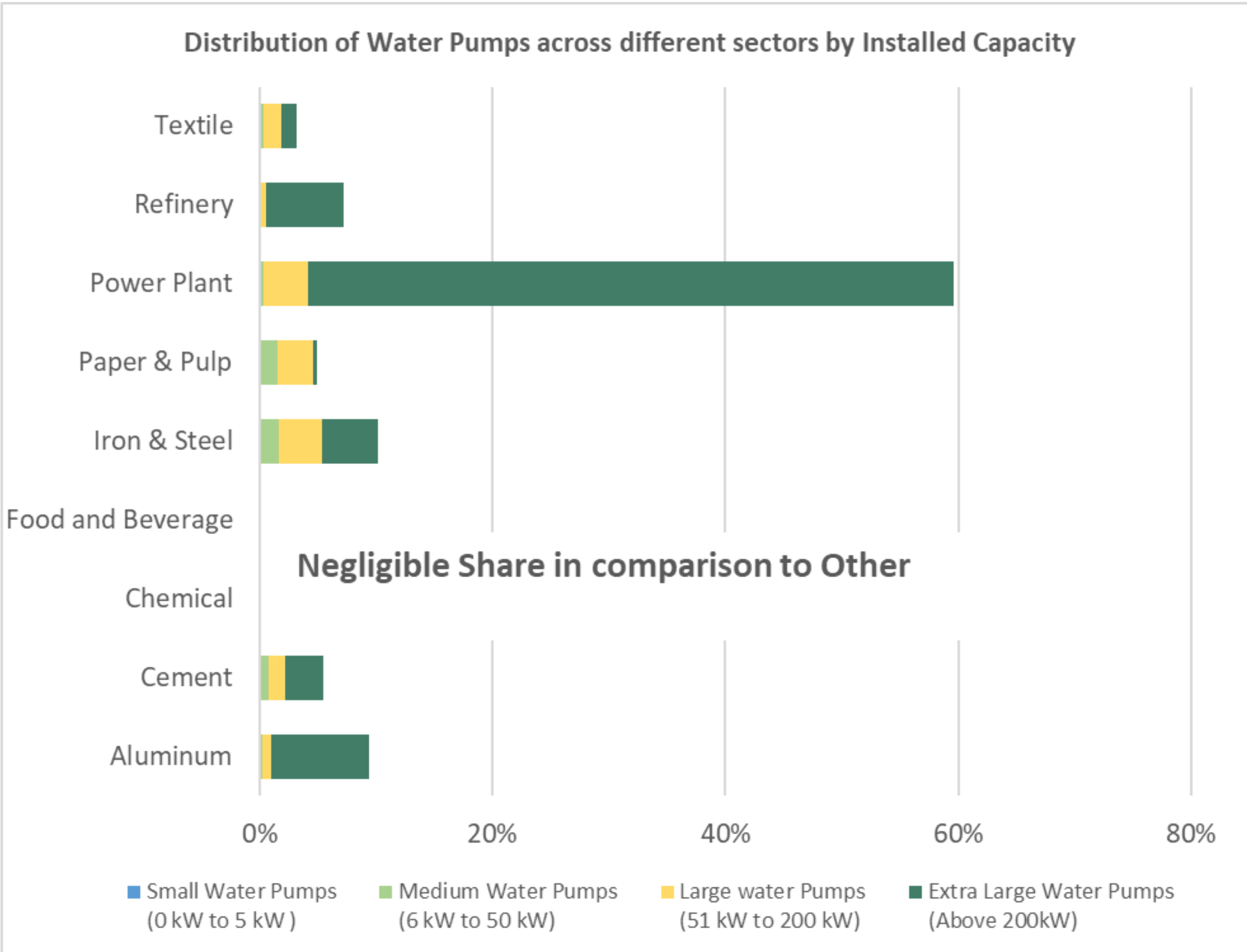


Figure 33: Distribution of Water Pumps across different sectors by Installed Capacity

4.2.3 Fans & Blowers

Fans and blowers of varying capacities, ranging from 0.5 kW to over 4000 kW, are used across different industrial sectors. Figure 34 shows a clear distribution of the different ranges of blower capacities present.

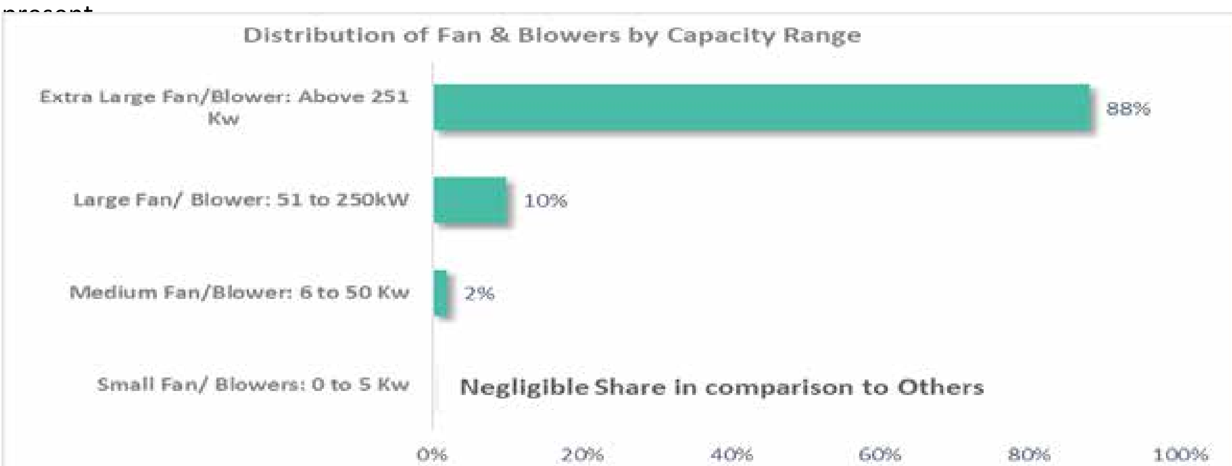


Figure 34: Distribution of Fans/Blowers by Capacity Range

within various industrial sectors. The data indicates a prevalence of extra-large fans and blowers, consuming more than 251 kW, which account for a substantial nearly 88% of the total. Large fans and blowers (51-250 kW) represent 10%, while medium-sized ones (6-50 kW) constitute 2.00% of the total. Notably, small fans and blowers (0-5 kW) have a negligible presence.

Figure 35, Figure 36 and Figure 37 illustrate the distribution of air blower types within different capacity ranges, measured in kilowatts (kW) utilized across various industrial sectors. It highlights how specific operational demands influence blower requirements across industries showcasing the distinct preferences that arise based on individual industry requirements.

A. Medium Fan/Blower- 6 to 50 kW

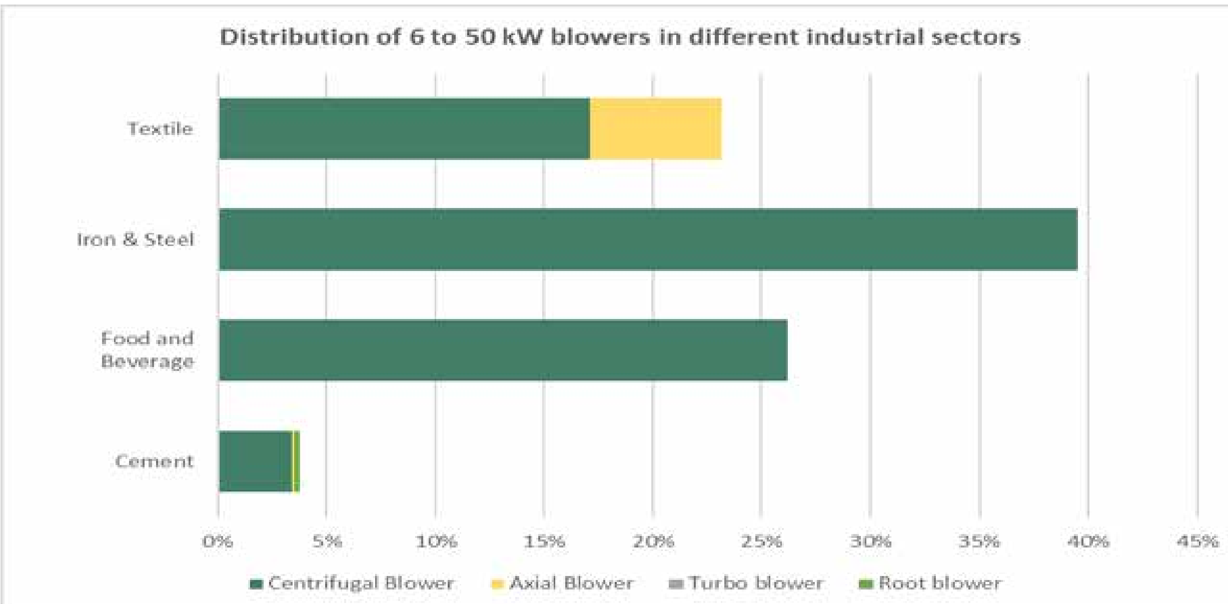


Figure 35: Distribution of 6 to 50 kW blowers in different industrial sectors

B. Large Fan/ Blower- 51 to 250 kW

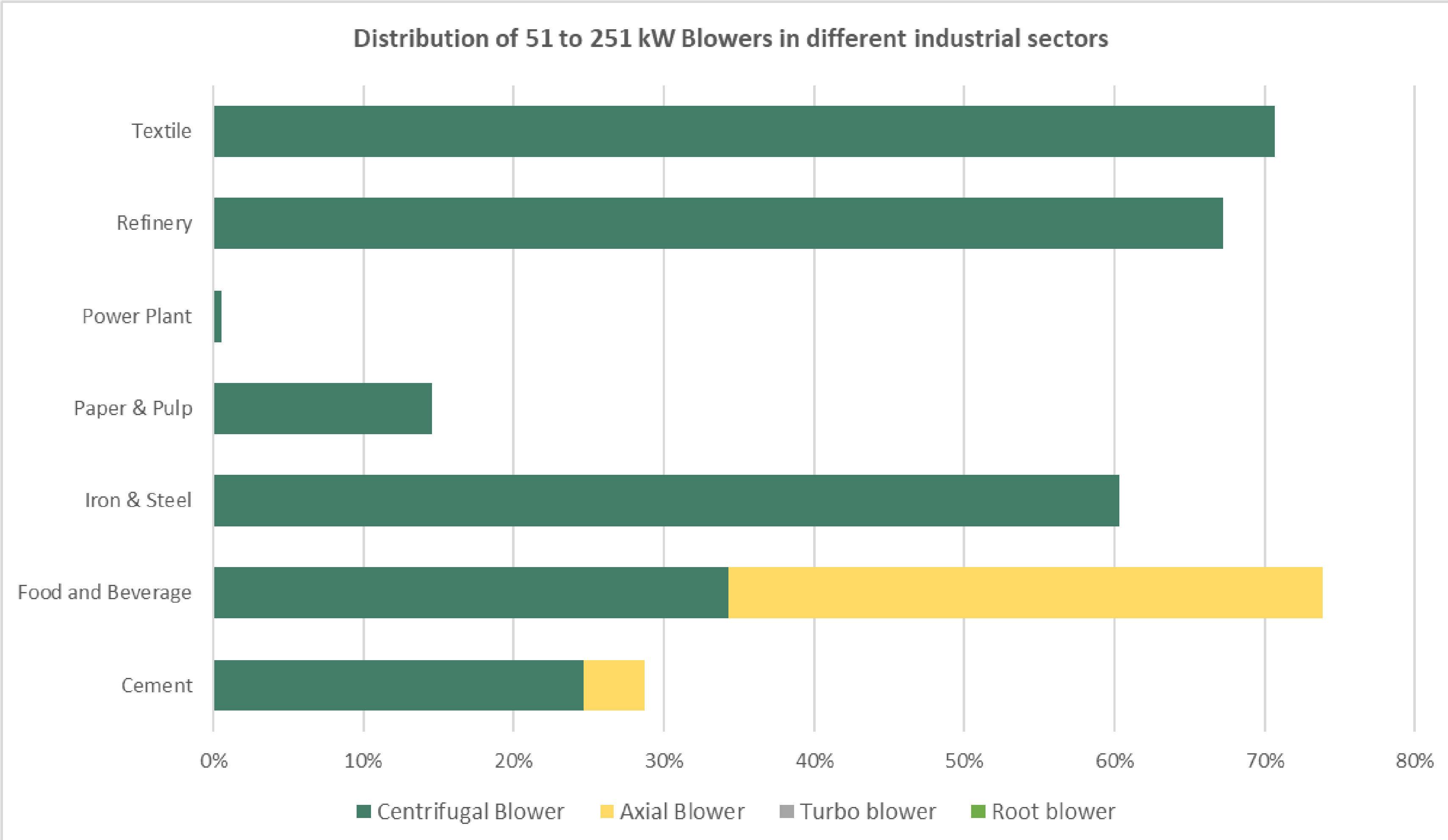


Figure 36: Distribution of 51 to 251 kW Blowers in different industrial sectors

C. Extra Large Fan/Blower- Above 251 kW

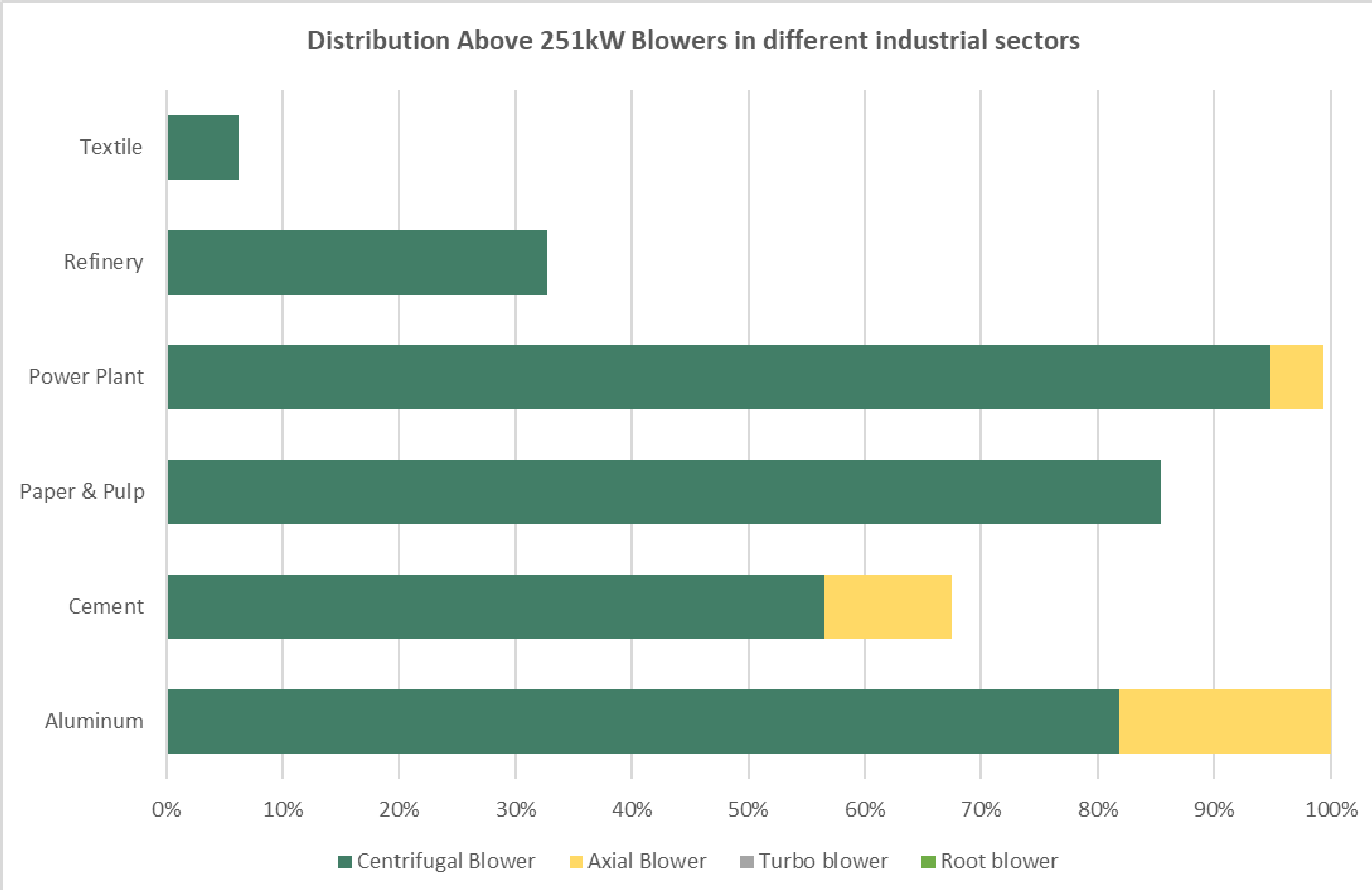


Figure 37: Distribution Above 251kW Blowers in different industrial sectors

The data reveals significant variation in the distribution of blowers (based on kW) across different industrial sectors based on different capacity ranges. The analysis of the above figures can be summarized in the following key points:

Up to 5 kW Range: The analysis indicates that small fans and blowers with power consumption below 5 kW are rarely installed in PAT-DC and large industrial settings. This limited usage directly indicates a significantly lower overall energy consumption compared to other types of equipment. Notably, the Iron & Steel and Cement industries stand out with particularly low energy consumption attributed to these small-scale fans and blowers.

6-50 kW range: Centrifugal blowers dominate the 6-50 kW power range across all sectors, with significant usage observed in iron & steel, cement, textile, and food & beverage industries. Axial blowers also play a notable role, particularly in the cement and textile sectors. In contrast, turbo and root blowers see limited application, primarily confined to the cement industry.

51-250 kW range: Centrifugal blowers are the dominant technology in the 51-250 kW range, finding application across all sectors. They are particularly prevalent in textile, refinery, iron & steel, and other industries. The food & beverage, cement, and paper & pulp sectors also exhibit a strong reliance on centrifugal blowers. While axial blowers have a notable presence, their usage is concentrated primarily in the cement and food & beverage industries.

Above 250kW range: Centrifugal blowers dominate the above 250 kW range, particularly in power plants, aluminum, and cement industries. They are utilized across nearly all sectors, with significant usage also observed in paper, pulp, and refinery industries. Axial blowers also find considerable application, primarily in power plants, cement, and aluminum industries.

Centrifugal blowers are the most prevalent technology across all capacity ranges, particularly well-suited for high-volume, low to medium-pressure applications. Axial blowers find greater application in lower capacity ranges, while turbo and root blowers have limited usage across sectors and capacities, suggesting their niche or specialized applications.

4.3 Performance Analysis

This section provides an analysis of the performance of the three technologies based on their Specific Energy Consumption (SEC) or based on their operational efficiency.

4.3.1 Air Compressor

The Specific Energy Consumption (SEC) of a compressed air system is the ratio of electrical energy consumed (in kW) to the amount of compressed air generated (m3/min or CFM). SEC, typically measured in kW per cubic meter of compressed air produced, provides insight into energy consumption relative to output which is essential for evaluating the performance of the compressed air system. The SEC of different capacities operating in the Indian industries has been estimated, as shown in Figure 38, Figure 39 and Figure 40.

Reciprocating Compressor

Reciprocating compressors have a higher SEC as compared to other compressor types owing to different factors such as use of IE1 or IE2 motors, comparatively older technologies, and operating practices leading to poor utilization among others.

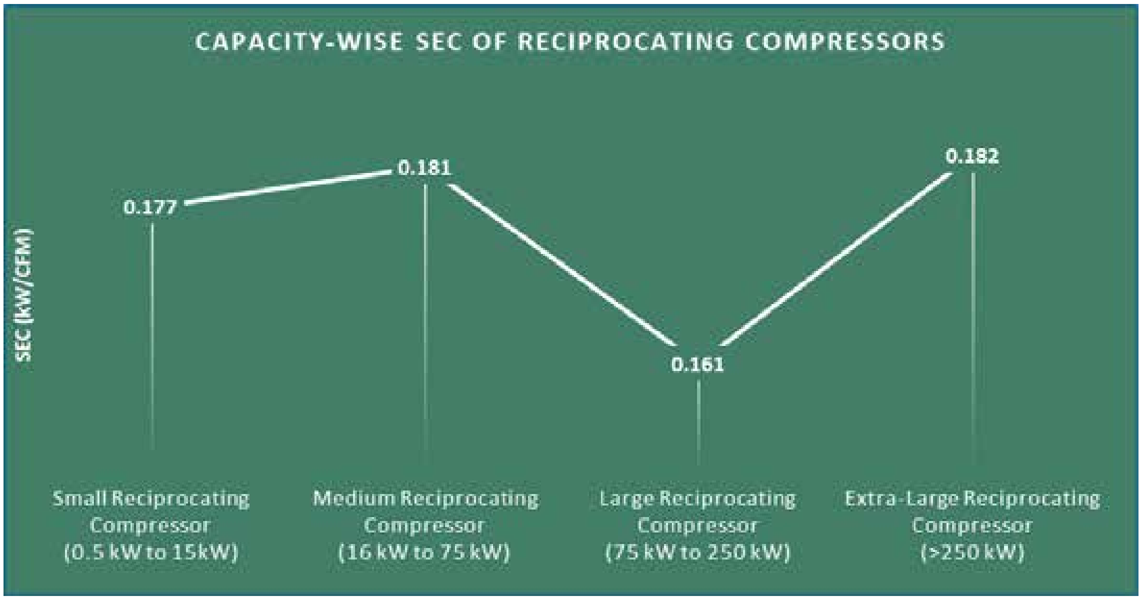


Figure 38: Capacity-wise SEC of Reciprocating Compressors

Screw Compressor

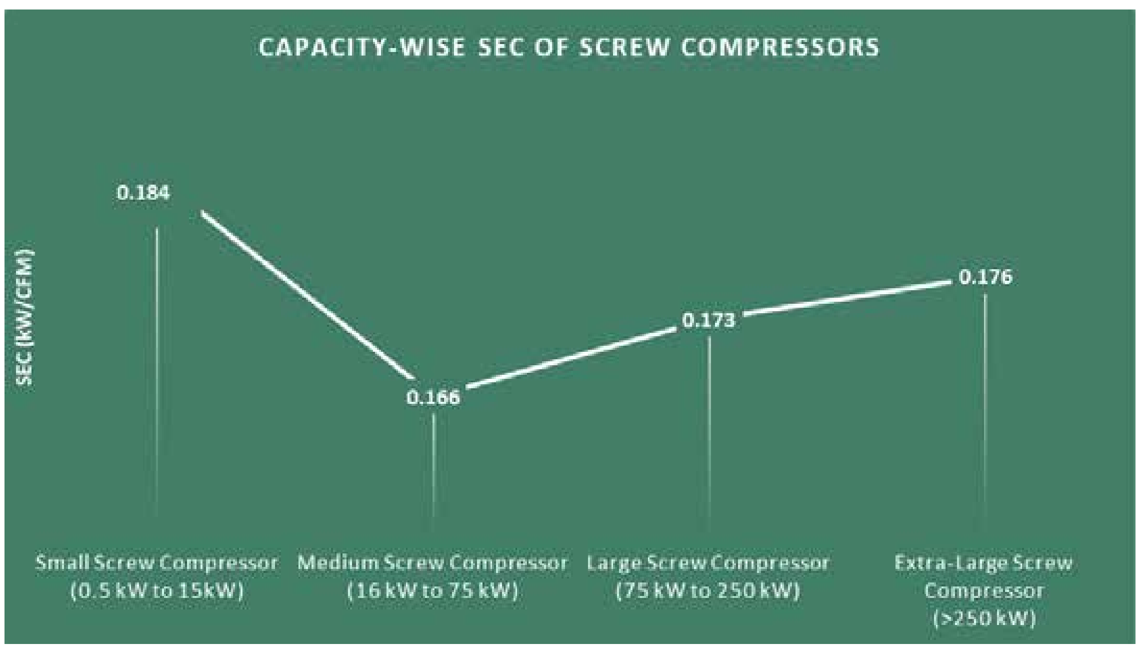


Figure 39: Capacity-wise SEC of Screw Compressors

Screw compressors demonstrate SEC, peaking at 0.176 for extra-large compressors, and reducing to 0.166 in medium compressors (16 kW to 75 kW), before rising again to 0.173 in large compressors. This indicates a more noticeable variation in energy efficiency as capacity increases.

Centrifugal Compressors

Centrifugal compressors show the lowest SEC across all compressor types, starting at 0.149 for small compressors and increasing up to 0.156 in extra-large compressors, making them the most energy-efficient choice among compressor types, particularly at small & medium sizes.

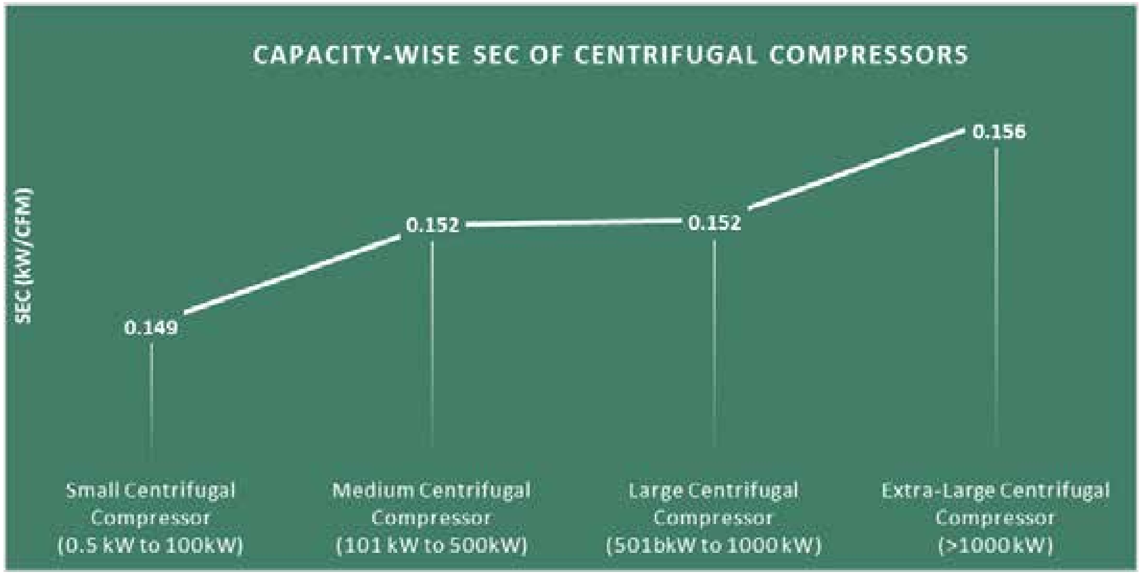


Figure 40: Capacity-wise SEC of Centrifugal Compressors

4.3.2 Water Pumps

The operational efficiency of a water pump directly reflects its performance. By comparing actual operational efficiency to best-practice efficiency values, we can identify potential energy savings within industrial sectors. Best-practice efficiency, determined based on market data, varies depending on pump capacity and typically ranges from 70% to 85%. Figure 41 illustrates the comparison between operational efficiencies and best-practice values.

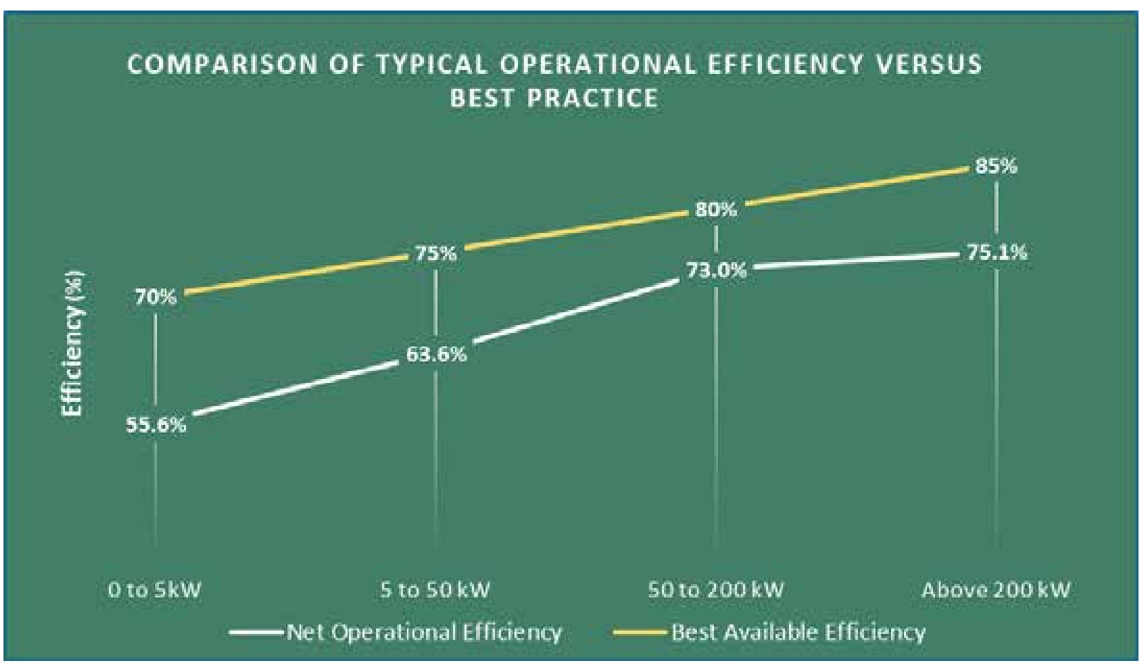


Figure 41: Comparison of Typical operational efficiency versus best practice

Analysis shows that smaller pumps (below 5 kW) tend to exhibit lower operational efficiencies compared to best-practice values. As pump capacity increases within the 5-50 kW and 50-200 kW ranges, we observe a general trend of improved operational efficiency and a decreasing deviation from best-practice values. While larger systems (above 200 kW) already demonstrate high operational efficiencies with minimal deviation from best-practice values, even small percentage improvements in this range can translate into substantial energy savings due to their significant installed capacity.

4.3.3 Fans & Blowers

The operational efficiency of fans and blowers directly reflects the performance of installed equipment. By comparing these efficiencies with best-in-class values, potential energy savings across industrial sectors can be identified. Best-in-class efficiency values for fans and blowers, which vary based on their capacity, are derived from market data. These values typically range from 70% to 85%. Figure 42 presents a comparison of the operational efficiencies of fans and blowers across various capacity ranges, alongside their respective best practice values.

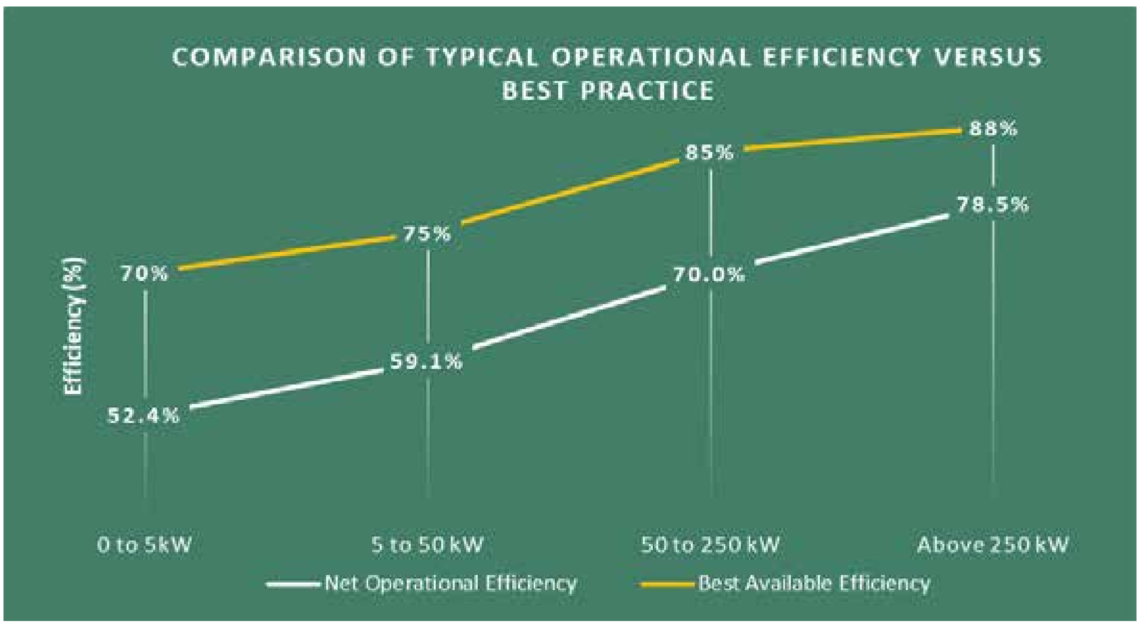


Figure 42: Comparison of Typical operational efficiency versus best practice

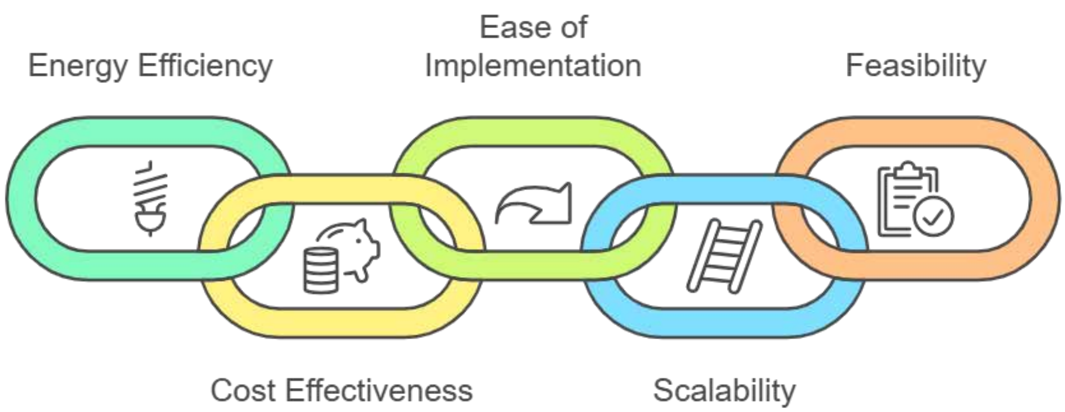
It can be concluded that blowers with a capacity of under 5 kW exhibit lower net operational efficiencies when compared to the suggested values. As the capacity increases to between 5 and 50 kW, there is a noticeable improvement in operational efficiency, along with a reduction in deviation from the proposed values. A similar pattern is evident in the 50-250 kW range. While larger systems, particularly those exceeding 200 kW, demonstrate even higher operational efficiencies and minimal deviations from the proposed values, even slight percentage enhancements in this category can result in substantial energy savings due to their significant installed capacities.

Priority Matrix Development

5. PRIORITY MATRIX DEVELOPMENT

5.1 Criteria Definition

The priority matrix has been created for each of the three classifications, using the results of the techno-economic analysis and stakeholder feedback, to rank technologies based on their scalability potential in the Indian market. This matrix is structured around five key criteria, outlined below:



- Energy Efficiency is estimated by comparing the operating efficiencies of blowers in Indian industries with the global best practices and identifying potential improvements from the adoption.
- Cost-effectiveness is assessed by whether the upfront investment needed for the technology is justified by the benefits it delivers over time, typically in the form of reduced energy consumption, reduced operating costs and the environmental impacts due to the technology.
- Ease of implementation is the ability to implement technology into an existing system, without facing too many hurdles.
- Scalability is assessed by considering the market size, penetration, and growth of the selected technologies in Indian industries, alongside global trends.
- Feasibility is evaluated by considering the technical, economic, and institutional barriers and enablers for implementing the selected technologies in Indian industries.

The matrix also identifies the gaps and opportunities for improving the performance and adoption of the technology, as well as the best practices and success stories from India and other countries. The technological solutions proposed are evaluated using the priority matrix, which provides us with the priority rank to adopt the proposed technology.

5.1.1 Air Compressor

Table 14: Priority Matrix for Air Compressors

Technology Type	EE	Cost-Effectiveness	Ease of Implementation	Market Readiness	Scalability Potential	Score	Priority Rank
Weightage	**30%**	**10%**	**20%**	**20%**	**20%**	**-**	**-**
Replacing Reciprocating Compressors with PMSM Screw Compressor	8	6	8	8	8	**7.8**	**1**
VFD Retrofitting for Screw Compressors		9		8		**7.4**	**2**
Replacement of Screw Compressor with PMSM Screw Compressors		6	8			**7.1**	**3**
IFC Retrofitting in Existing Air Compressor System	6	9	8	6		**6.9**	**4**
Centrifugal Compressor	5		6		6	**6**	**5**
Piping and Pipe Material (Distribution)		8	3	5	6	**5.7**	**6**

5.1.2 Water Pumps

Table 15: Priority Matrix for Water Pumps

Technology Type	EE	Cost-Effectiveness	Ease of Implementation	Market Readiness	Scalability Potential	Score	Priority Rank
Weightage	**30%**	**10%**	**20%**	**20%**	**20%**	-	-
Adoption of VFDs to enhance efficiencies of new pumps				8	8	7.4	1
Replacement of energy-inefficient pumps with EE pumps	6		8	8	8	7.3	2
Application of smart monitoring systems for energy-efficient new pumps	8	6	5	6	5	6.2	3

Technology Type	EE	Cost-Effectiveness	Ease of Implementation	Market Readiness	Scalability Potential	Score	Priority Rank
Replacing the old pumps with energy-efficient pumps with smart monitoring and bi- and tri-directional valve controls.	9		4	5	4	6	4

5.1.3 Fans & Blowers

Table 16: Priority Matrix for Fans & Blowers

Technology Type	EE	Cost-Effectiveness	Ease of Implementation	Market Readiness	Scalability Potential	Score	Priority Rank
Weightage	**30%**	**10%**	**20%**	**20%**	**20%**		
Adoption of VFDs to enhance blower efficiencies	9	8		9		**8.1**	**1**
Selection of optimal capacity blowers	8			8	8	**7.7**	**2**
Adoption of IE4 and IE5 motors for blowers with lower IE values	9	6	6	7	8	**7.5**	**3**
Impeller replacement to o tain the highest efficiencies.	8		6	8	8	**7.5**	**4**

Table 16 represents the priority ranks of different energy-efficient measures for fans and blower systems based on the above five parameters.

5.2 Scoring and Ranking

The priority matrix is developed by considering the weightage of each of the parameters to be assessed for the technological options. Scores are assigned from 0-10, with zero being an extremely low probability of adoption of the technology and 10 being the best technology for adoption. The scores are based on the techno-economic analysis and the stakeholder feedback. Priority ranks are assigned to the technologies according to their potential for scaling up in the Indian market. The matrix considers multiple criteria, such as energy savings, cost savings, payback period, carbon emissions reduction, market size, market penetration, customer awareness, customer satisfaction, and policy support to score the technology.

The weighted score is calculated as:

Score=∑(Weightage × Rating for Criterion)/100

5.2.1 Air Compressor

The following sections elaborate on the recommended energy and GHG reduction strategies for the air compressors and compressed air distribution system, as identified using the priority matrix.

Recommendation -1 Replacing Reciprocating Compressors with PMSM Screw Compressor: These compressors exhibit high energy efficiency, ease of implementation, readily available market supply, and scalability, making them a preferred choice for compressor technology. The PMSM screw compressor is assigned a score of 7.8, which making them emerges as a strong contender for implementation.

Recommendation -2 VFD Retrofitting the Screw Compressors: VFD Retrofitting is one of the most cost-effective, easy-to-implement, and effective energy-saving solution as they are readily available in the market and offers good scalability. The VFD Retrofitting is assigned a score of 7.3, which making them a very preferred contender for implementation.

Recommendation -3 Replacement of Screw Compressor with PMSM Screw Compressors: These compressors exhibit high energy efficiency, ease of implementation, readily available market supply, and scalability, making them a preferred choice for compressor technology. The PMSM screw compressor is assigned a score of 7.1, which making them emerges as a strong contender for implementation.

Recommendation -4 IFC Retrofitting in Existing Air Compressor System: VFD Retrofitting is one of the most cost-effective, easy-to-implement, and effective energy-saving solution as they are readily available in the market and offers good scalability. The VFD Retrofitting is assigned a score of 6.9, which making them a preferred contender for implementation.

Recommendation -5 Centrifugal Compressors: These compressors offer a good balance of cost-effectiveness and market availability, with moderate efficiency and ease of implementation. This technology is assigned a score of 6 and represents a viable and readily accessible option for implementation.

Recommendation -6 Piping and Pipe Material (Distribution Network): Optimizing the compressor distribution network presents a significant opportunity for cost savings and scalability, while also delivering moderate improvements in energy efficiency. The technology is assigned a score of 5.7 and is ranked last in terms of implementation priority.

5.2.2 Water Pumps

The following sections elaborate on the recommended energy and GHG reduction strategies for the water pumps, as identified using the priority matrix.

Recommendation 1 Adoption of VFDs to enhance efficiencies of new pumps: VFDs allow precise control of pump motor speed, matching energy usage with demand. They are relatively easy to retrofit into existing systems or integrate into new installations. Their market readiness and scalability make them the top choice for efficiency improvements. Technology is assigned a score of 7.4, making it the first choice.

Recommendation 2 Replacement of inefficient pumps with energy-efficient pumps: Replacing old, inefficient pumps with modern, high-efficiency models reduces energy consumption significantly. This solution is cost-effective and easy to implement in most set-ups due to market availability. Technology is assigned a score of 7.3, making it the next best choice for implementation.

Recommendation 3 Application of smart monitoring systems for energy-efficient new pumps: Smart monitoring involves IoT-enabled systems to track pump performance and energy use in real-time. These systems enhance operational control but are more expensive and challenging to implement. Technology is assigned a score of 6.2, making it the third option.

Recommendation 4 Replacing old pumps with energy-efficient pumps combined with smart monitoring and bi/tri-directional valve controls: This solution involves advanced technologies like valve controls to optimize flow direction along with smart monitoring and EE pumps. It offers the best efficiency potential; the complexity and cost of implementation make it less feasible for widespread adoption at this stage. Technology is assigned a score of 6.0, making it the least favorable option for implementation.

5.2.3 Fans & Blowers

Recommendation 1 Selecting the Right Capacity of Blowers Needed for the Industry: This approach ranks the highest due to its substantial impact on energy efficiency, market availability, and cost-effectiveness, with only moderate complexity in terms of implementation. It is ideal for industries aiming for optimal performance. The technology is assigned a score of 8.1, making it the ideal implementation option for the blowers.

Recommendation 2 Adoption of VFDs to Enhance Blower Efficiencies: VFD adoption is a highly effective solution for improving energy efficiency and system flexibility, with a solid market presence and good scalability potential. The main drawbacks are its higher initial cost and the need for some technical installation expertise. The technology is assigned a score of 7.7, making it the next ideal implementation option.

Recommendation 3 Adoption of IE4 and IE5 motors for blowers with lower IE values: IE4 and IE5 motors offer excellent energy efficiency benefits as some of the other technologies. Their implementation is more expensive, and the scalability is more relevant for industries facing extreme conditions. The technology is assigned a score of 7.5, making it the third preferred implementation option.

Recommendation 4 Impeller Replacement to Obtain the Highest Efficiencies: Impeller replacement can significantly improve energy efficiency, but its initial cost and complexity of implementation make it a slightly more difficult solution to execute compared to others. However, for industries that need significant performance boosts, it remains a high-value solution. The technology is assigned a score of 7.5, making it the last preferred implementation option.

Savings Potential and Carbon Emission

6. SAVINGS POTENTIAL AND CARBON EMISSION

This chapter provides analysis of potential for energy savings and carbon emissions savings. The anticipated improvements and efficiencies of the new technologies under consideration are being evaluated. Sector-specific models are being used to estimate potential reductions in energy use and carbon emissions.

6.1 Baseline Analysis

6.1.1 Air Compressor

To assess potential energy savings, carbon emission reductions, and the economic viability of compressor technology, a baseline for energy consumption was established. Emissions resulting from the current technology's performance were analysed using industry benchmarks. The anticipated improvements and efficiencies of the new technologies under consideration are being evaluated. Sector-specific models are being used to estimate potential reductions in energy use and carbon emissions. The economic analysis involves assessing costs, including capital investment, operating expenses, and savings, to determine the return on investment and payback periods.

Table 17: Baseline Assessment of Air Compressors

Type	Baseline Energy Consumption (MU)	Baseline SEC (kW/CFM)	Best Available SEC (kW/CFM)
1. Replacement of Reciprocating Compressors with PMSM Compressors	1,171	0.181	0.15
2. VFD Retrofitting in Existing Screw Compressor	6,555	0.174	0.15
3. Replacement of Screw Compressor with PMSM Screw Compressors	437	0.174	0.15
4. IFC Retrofitting in Existing Air Compressor System	2,746	0.172	0.16

6.1.2 Water Pumps

A baseline energy consumption profile was established to quantify the potential energy savings, carbon emission reductions, and overall economics associated with the proposed water pump upgrades. This baseline was derived from an analysis of current technology performance, operational efficiencies, and relevant industry benchmarks, allowing for the determination of baseline emissions. The expected performance enhancements and efficiency gains offered by the new water pump technologies under consideration are currently being evaluated. Sector-specific models are being employed to estimate the potential reductions in energy consumption and associated carbon emissions.

Table 18: Baseline Assessment of Water Pumps

Technology	Total installed capacity (MW)	Baseline Energy consumption (MU)	Operational Efficiency (%)
Water Pumping System	1,932	4,637	68.2%

6.1.3 Fans & Blowers

Our baseline analysis of fan and blower systems reveals a significant opportunity for energy savings. With a total installed capacity of 1,052 MW, the current baseline energy consumption is a substantial 5,890 MU annually. Following the implementation of proposed interventions, we project a reduction in energy consumption to 5,026 MU. This translates to a potential energy savings of 864 MU per year, highlighting the significant impact of the proposed improvements.

Table 19: Baseline Assessment of Fans and Blowers

Technology	Total installed capacity (MW)	Baseline Energy consumption (MU)	Operational Efficiency (%)
Fans and Blowers	1,052	5,890	75

6.2 Saving Potential Analysis

6.2.1 Air Compressor

The analysis involved calculating baseline data for various installed capacities. This data was then compared with best-available efficiency values to determine potential energy savings and the corresponding reduction in carbon emissions. The results of this analysis are summarized in the table below.

Table 20: Saving Potential of Air Compressors

Technology	Baseline Energy Consumption (MU)	Post-intervention Energy (MU)	Energy saved (MU)	Estimated saving (%)	Carbon Emission Reduction (M-tCO2/Yr)
1. Replacement of Reciprocating Compressors with PMSM Compressors	1,171	970	201	17%	0.14
2. VFD Retrofitting in Existing Screw Compressor	6,555	5,659	896	14%	0.64
3. Replacement of Screw Compressor with PMSM Screw Compressors	437	37	60	14%	0.04
4. IFC Retrofitting in Existing Air Compressor System	2,746	2,663	82	3%	0.06

6.2.2 Water Pumps

The current baseline energy consumption for these pumps is a significant 4,637 MU annually, operating at a net operational efficiency of 68.2%. By implementing the proposed technological upgrades, we anticipate increasing the operational efficiency to 85%. This enhancement translates to a projected energy savings of 20%, representing a considerable reduction in overall energy consumption.

Table 21: Savings Potential of Water Pumps

Technology	Baseline Energy Consumption (MU)	Post-Intervention energy consumption (MU)	Potential Energy Saved (MU)	CO2 emission (M-tCO2/Yr)
Water Pumping System	4,637	3,722	914	0.65

6.2.3 Fans & Blowers

Fans and blower systems currently consume 5890 MU of energy annually at 75% operational efficiency. Improvements to achieve the best efficiency of 88% are projected to reduce energy consumption by 17%.

Table 22: Saving Potential of Fans and Blowers

Technology	Post Intervention energy consumption (MU)	Operational Efficiency (%)	Estimated Saving (MU)	Estimated Saving (%)	CO2 emission (M-tCO2/Yr)
Fans and Blowers	5,026	88	864	17	0.6

6.3 Economic Analysis

6.3.1 Air Compressors

The market presents substantial opportunities for energy efficiency improvements in air compressor systems. Total Addressable Market (TAM) is estimated at Rs. 5,705 Cr, with a Serviceable Addressable Market (SAM) of Rs. 1,073 Cr and a savings potential of Rs. 558 Cr. The cumulative estimated payback period for all technologies is 2 years, indicating the financial viability of investments.

Table 23: Financial Analysis of Air Compressors

Technology	Total Addressable Market (Rs in Cr.)	Serviceable Addressable Market (Rs in Cr.)	Monetary Saving Potential (Rs in Cr)	Estimated Payback Period (Years)
1. Replacement of Reciprocating Compressors with PMSM Compressors	3,136	314	90	3.5
2. VFD Retrofitting in Existing Screw Compressor	975	585	403	1.5
3. Replacement of Screw Compressor with PMSM Screw Compressors	780	117	27	4.4
4. IFC Retrofitting in Existing Air Compressor System	813	57	37	1.5

6.3.2 Water Pumps

The water pumping system market presents a promising opportunity for energy efficiency improvements. The Total Addressable Market (TAM) is estimated at Rs. 1,062 crores, with a

Serviceable Addressable Market (SAM) of Rs. 425 crores. Realizable savings potential is Rs. 411 crores, with a short payback period of 1.03 years.

Table 24: Financial Analysis of Savings Potential of Water Pumps

Technology	Total Addressable Market (Rs in Cr.)	Serviceable Addressable Market (Rs in Cr.)	Monetary Saving Potential (Rs in Cr)	Estimated Payback Period (Years)
Water Pumping System	1,062	425	411	1.03

6.3.3 Fans & Blowers

The fan and blower market offers a promising opportunity for energy efficiency gains. With a Total Addressable Market (TAM) of nearly Rs. 1,754 Cr and a Serviceable Addressable Market (SAM) of Rs. 526 Cr, the potential energy savings are estimated at Rs. 389 Cr. These improvements offer a short payback period of 1.3 years.

Table 25: Economic Analysis of Fans and Blowers

Technology	Total Addressable Market (Rs in Cr.)	Serviceable Addressable Market (Rs in Cr.)	Monetary Saving Potential (Rs in Cr)	Estimated Payback Period (Years)
Fans and Blowers	1,754	526	389	1.3

CONCLUSION

7. CONCLUSION

This market assessment reveals a significant opportunity for energy-efficient air compressor, water pump and Fan & blowers technologies within the Indian industrial sector. Driven by rising energy costs, increasing awareness of sustainability, and government initiatives promoting energy conservation, the demand for such solutions is poised for substantial growth. While initial investment may be a barrier for some, the long-term cost savings and environmental benefits offer a compelling value proposition. Further research into specific industry needs and targeted marketing strategies will be crucial for successful market penetration. This report highlights the key factors that will shape its evolution.

A. Economic barriers

A primary obstacle hindering the widespread adoption of energy-efficient technologies is their often-high upfront costs. This financial burden can be a significant deterrent for businesses with limited capital. Furthermore, the perceived long-term return on investment (ROI) may not always be readily apparent, leading to hesitancy in investing in these technologies. Additionally, a lack of access to affordable financing options, such as low-interest loans or subsidies, can further exacerbate these economic challenges.

B. Technical Barriers

Outdated technologies and limited access to modern solutions are key challenges for Industries. Weak supplier linkages and low awareness of advanced technologies hinder upgrades. To stay competitive and profitable, these units must improve energy efficiency but face significant technical barriers in adopting energy-efficient technologies.

Figure 43: Challenges to Technology Adoption

C. Institutional barriers

Institutions play a vital role in driving the adoption of energy-efficient technologies. However, several institutional barriers can impede their widespread implementation. These challenges include inconsistent policies and regulations that fail to adequately incentivize energy efficiency, cumbersome permitting and regulatory processes that increase costs and delays, and a shortage of training and capacity-building programs for industry professionals and government officials. Addressing these issues is essential to effectively support and accelerate energy efficiency initiatives.

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