2024 CENTRIFUGAL PUMPS MARKET OUTLOOK IN CARBON CAPTURE

WHITE PAPER

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JFMA CONSULTING

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JFMA Consulting is an independent advisory company dedicated to serving small and medium-sized industrial companies that operate in rotating and reciprocating equipment and flow-control technologies. We provide data-driven, strategic insights across energy and process industry markets, and build tailored strategies to help our clients drive sustainable revenue growth, scale their business, and create substantial value.

With over 100 years of combined experience across rotating equipment and flow control industries, our team has hands-on knowledge to ensure we deliver practical and actionable insights. Ultimately, we aim to empower our clients to make more informed decisions and capitalize on new growth opportunities.

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Executive Summary

Centrifugal pumps are mission-critical fluid handling equipment that are poised to play a pivotal role in scaling up Carbon Capture and Storage (CCS). From the initial capture of carbon dioxide (CO_2) to their final sequestration, these pumps will be deployed across the entire CCS value chain and are essential to decarbonization efforts. This paper delves into the overall market outlook and growth pathways for centrifugal pumps under two International Energy Agency (IEA) scenarios, explores the current and emerging challenges faced by the pump industry, and examines the observed strategic actions of pump original equipment manufacturers (OEMs) and service providers. Ultimately, this analysis provides insights on how pump companies can capitalize on the nascent CCS market and gain a competitive edge.

This study only covers centrifugal pumps used specifically in carbon capture, transport, and sequestration, and excludes those deployed in the direct uses of CO_2 (e.g. enhanced oil recovery and conversion pathways such as sustainable fuels production and supercritical CO_2 power generation) and in marine applications.

Centrifugal pump market outlook and insights:

- Market Size and Growth: The global CCS centrifugal pumps market is currently estimated at ~$45 million (M) in 2024 and is forecasted to exceed $310M by 2030 in our base case scenario, which is broadly aligned with the IEA Announced Pledges

Scenario. The market is projected to further accelerate in the 2030s and could reach a potential market size of ~$2.0 billion (B) by 2040. In a low growth scenario tracking the IEA Stated Policies Scenario, the centrifugal pump market grows at a slower pace to ~$155M and ~$500M by 2030 and 2040, respectively.

- Regional Dynamics: North America, with its established infrastructure of operational CCS facilities and CO_2 pipelines, is expected to remain the largest centrifugal pump market under both scenarios, accounting for ~40 to ~50% of the total market size by 2030. Pivotal to achieving this growth is the approval and build-out of new infrastructure (i.e. pipelines) to transport captured CO_2 from its capture source to the location of sequestration. Other key growth regions include China and energy producing regions in Europe and the Middle East, although growth is contingent on the adoption of attractive policies and economic incentives. It is important to note that regional market size refers to the geographical location where the pumps are used, not where they are manufactured or assembled.
- Pump Type: Engineered centrifugal pumps could constitute ~50% of the market value by 2030 in our base case, driven by engineering requirements for new plant configurations and new designs for CO_2 transport and sequestration. As engineering, procurement and construction companies (EPCs), pump manufacturers, and end-use operators gain more CCS experience, standard pumps are expected to become more prevalent by the 2030s and this should reduce overall total cost of ownership for CCS equipment. In the low growth scenario, engineered pumps represent a higher portion of the market as fewer pump manufacturers dedicate resources to standardize their pump designs and scale up production to serve the CCS market.
- Aftermarket: In our base case scenario, the CCS centrifugal pump aftermarket channel is expected to grow steadily at 20%+ cagr as the installed base expands. Higher-value pump repair and replacement services accelerate in the early 2030s and could create an aftermarket opportunity worth ~$1.4B by 2040. The aftermarket for engineered and standard API segments will primarily be outsourced to both pump manufacturers and independent service providers, while operators will carry-out most of the basic service needs internally. In the low growth scenario, we expect independent service players to play a larger role in maintenance, repair, and operations (MRO) as pump OEMs concentrate resources in serving other decarbonization segments.

Observed strategies of pump manufacturers and service companies:

- Strategic Positioning: Pump companies are starting to position themselves to compete and differentiate as the CCS market evolves. Leading pump OEMs such as

Flowserve and Sulzer are declaring CCS as a strategic growth pillar and actively prioritizing winning flagship projects to build references and installed base. However, given the long-term uncertainties on how CCS could develop, most pump OEMs appear to be taking a cautious approach and hedging their investment bets. As such, we observe that most pump OEMs prefer to sell existing, proven pump solutions (often reconfigured to meet CO_2 application requirements) rather than launching CO_2 specific product lines. Finally, we are starting to observe increasing M&A activities as pump OEMs expand into attractive adjacencies and acquire new technologies, and we expect this trend to accelerate in the coming years.

- Technology Innovation: Centrifugal pump innovators are investing in new technologies to address unique challenges of CO_2 handling. These include new pump designs to handle stringent supercritical CO_2 operating conditions and higher-flow and pressure injection applications, advanced materials and/or coating solutions for corrosion resistance, and digital monitoring of pump assets. In some applications, pump components (e.g. mechanical seals) could be the critical limiting technology and it's important that pump companies collaborate with their supply chain on new designs and innovation
- Services: We are observing large oilfield service providers with pump offerings broadening their portfolio and capabilities, focusing on the CCS sequestration market. While independent pump service providers and value-add distributors have primarily been observing market developments and only beginning to craft strategies on how to compete in the CCS landscape

How can pump companies build competitive advantage and unlock growth in CCS

- For pump manufacturers and service companies considering how to build a leading position in CCS market, we recommend a set of targeted actions. **Companies should consider these actions as part of a comprehensive CCS strategy with a clear implementation roadmap.**
- Develop a scenarios-based CCS strategy and roadmap:
    - Establish a comprehensive, scenarios-based strategy taking into consideration potential size of the overall CCS market, how quickly the company can scale its business, gaps and differentiation at both the product and customer level, and how to create optionality to pivot if the market accelerates or takes longer to develop
    - Develop a clear implementation roadmap that takes into consideration the factors stated above along with financial investment requirements, resource and capability constraints, and other competing strategic priorities
- Commercial and Marketing:

    - Leverage Existing Installed Base - Pump companies should prioritize systematic documentation of existing install base in operational CCS sites to understand references, performance history and technical capabilities
    - Prioritize Existing Customers – Develop targeted sales and marketing strategy to prioritize existing customers that are funding new CCS projects
    - Market Proven Capabilities - Launch new marketing campaigns highlighting proven CCS solutions, deploying AI-driven tools for content development and enhanced outreach
    - Invest in Training – Develop training programs to improve the knowledge of pump solutions in CCS for both internal sales teams and external customers
- Product Management and Innovation:
    - Define Flagship Products – Identify and prioritize the preferred flagship products to offer across existing CCS applications
    - Pursue Value Engineering – invest in value-engineering solutions that reduce upfront product and/or running costs for CCS pumps
    - Strategically Invest in New Technology Innovation - develop new innovation in areas such as supercritical carbon dioxide handling and advanced materials, and new digital solutions. Leading innovators often can gain a technology edge not only in CCS applications, but can leverage these advancements across their entire portfolio to improve ROI and competitiveness
- M&A and Industry Collaboration:
    - Strategic Acquisitions - Actively evaluate and strategically pursue M&A opportunities within the CCS sector, particularly to address technology gaps and expand into new attractive CCS markets
    - Strengthen industry collaboration efforts with suppliers, EPCs, and operators, as this is seen as pivotal to scaling up the ecosystem. Examples include more open information sharing, collaborative R&D, and setting industry wide standards

If you would like to access the CCS centrifugal pump outlook Excel data set, please contact info@jfmaconsulting.com. The detailed Excel data set provides centrifugal pump market projections to 2040 under both scenarios that we've analyzed. It includes in-depth quantitative information on market size and growth outlook by geographical regions, end-use markets, sales channel, pump types, and aftermarket services.

Chapter 1: Carbon Capture and Storage Market Introduction

Potential Growth Pathways

Carbon capture and storage (CCS) is forecasted to play a vital role in decarbonization, particularly for hard-to-abate sectors such as refining, chemical, ethanol and cement. While projections vary, CCS is expected to contribute significantly to global climate goals, with estimates suggesting it could account for 5-10% of total global carbon dioxide emissions reduction by 2050 (when measured versus 2023 carbon dioxide emissions levels).

To assess the potential market opportunity for centrifugal pumps in CCS, we've considered two scenarios based on the IEA World Energy Outlook report published in October 2024:

- **Stated Policies Scenario (This is our low growth scenario):** This scenario reflects the current energy sector's direction of travel based on the latest market data, technology costs, and prevailing policy settings in countries around the world. CCS deployment is less ambitious in this scenario with total captured CO_2 increasing from ~40 million metric tons (Mt) in 2023 to 122Mt and 261Mt in 2030 and 2040, respectively. North America (primarily the United States and Canada) will maintain their policy and regulatory incentives in CCS, while regulatory momentum stalls in many other countries. Fewer than half of the announced CCS projects in the current pipeline are deployed, and overall CCS investment remains subdued compared with other decarbonization technologies such as renewables. While volume growth is lower, we anticipate higher prices for CCS centrifugal pumps given reduced competition among manufacturers.
- **Announced Pledges Scenario (This is our base case scenario):** This scenario assumes full implementation of current national energy and climate targets made by governments. CCS becomes a key decarbonization lever that contributes nearly 10% of total carbon dioxide emissions reduction by 2050. CCS development is highly ambitious with total captured CO_2 increasing to 410 Mt and 2,143Mt in 2030 and 2040, respectively. The majority of announced CCS projects in the existing pipeline are deployed, even if some projects are temporarily delayed. More attractive government policies and financial support in CCS will emerge in many countries with large existing oil and gas and hard-to-abate industries (e.g. cement).

For this study, we have assumed the Announced Pledges Scenario as our base case scenario. However, results from both scenarios are presented to demonstrate a potential range of outcomes and market opportunities for centrifugal pumps.

The estimated total CO_2 captured and removed under both IEA scenarios is shown in Exhibit 1 below.

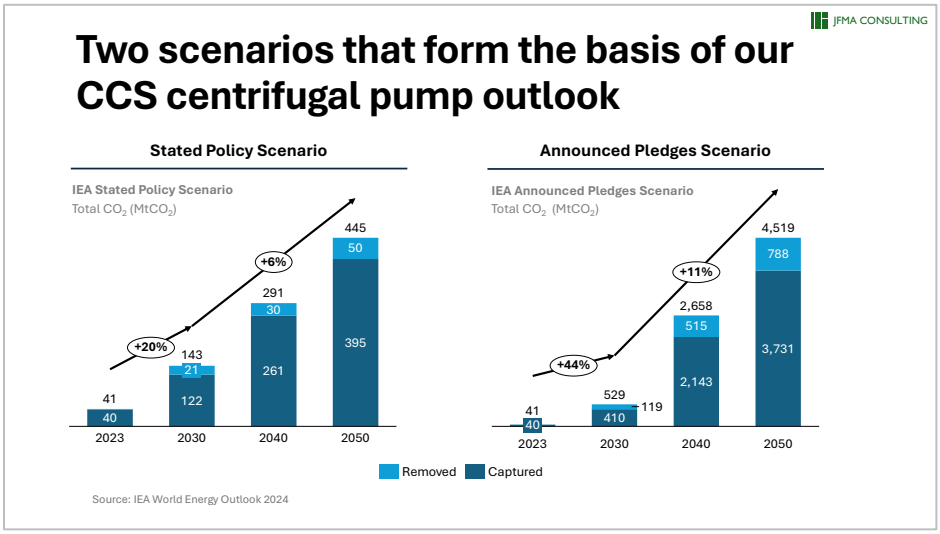

Exhibit 1: The two IEA scenarios that form the basis of our centrifugal pump outlook

Our pump forecasts to 2030 integrates these scenarios and a comprehensive analysis of the 700+ CCS projects announced worldwide as tracked in the IEA CCS Projects Database from March 2024. If these projects are fully implemented, it is projected to capture, transport, and store ~2,150Mt of carbon dioxide. To align our centrifugal pump forecasts with the CO_2 capture targets outlined in both the IEA Stated Pledges and Announced Policy scenarios, we've applied probability-based adjustments to account for potential project delays or cancellations. This provides a more realistic centrifugal pump market outlook.

A summary of the overall CCS projects landscape is presented below in Exhibit 2.

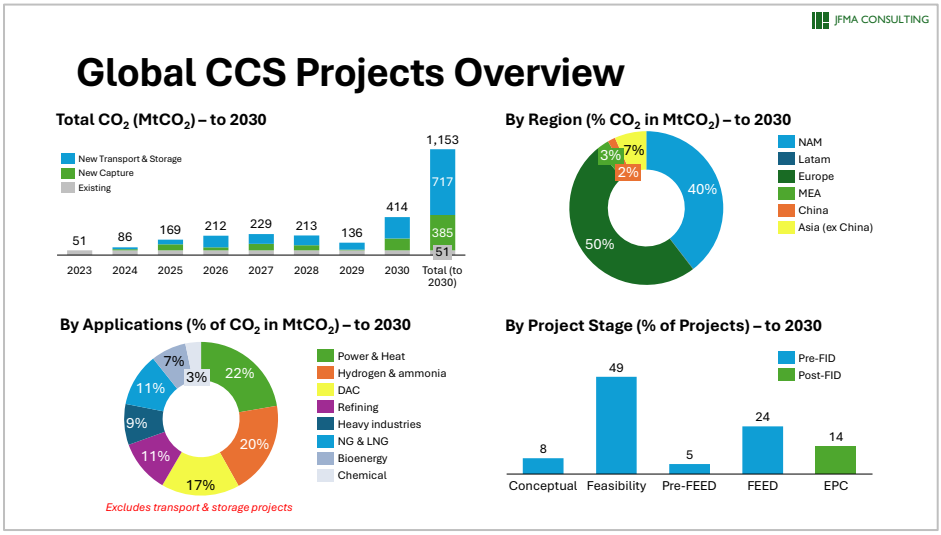

Exhibit 2: Overview of global CCS projects (Source: IEA CCS Projects Database, EIC)

Centrifugal Pumps Introduction

Centrifugal pumps are widely used across process industries due to their ability to efficiently move large volumes of fluid (in particular, handling high flow rates in low-viscosity fluids). They are expected to play a pivotal role across the carbon capture and storage (CCS) value chain, being integral to capturing, transporting, and sequestering carbon dioxide. Centrifugal pumps are used not only in direct conveying of CO_2, but also in the various processes that support the balance of plant (BoP) operations at a carbon capture facility. These include circulating solvents for capturing CO_2, transporting and circulating feedwater, and moving other fluids essential to BoP operations. Exhibit 3 below highlights some of the applications where pumps are used in both pre- and post-combustion carbon capture (source: ITT Goulds).

Not all pumps used in CCS facilities will be centrifugal. The choice of pump technology depends on several factors such as fluid flow rate, viscosity, operating pressure, and other application-specific requirements. Depending on these parameters, alternative pump types like reciprocating pumps, screw pumps, or even compression systems may be more suitable. When considering all pump types across a CCS facility, pumps and their associated systems can represent over 10% of the total facility cost, underscoring their critical role in the site's overall financial performance.

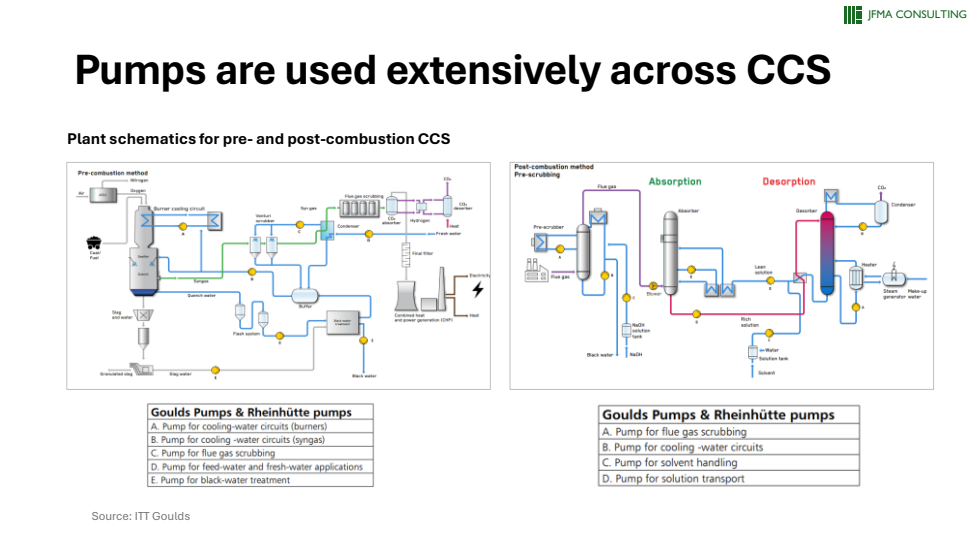

Exhibit 3: Schematics highlighting the various applications where pumps could be installed across carbon capture (Source: ITT Goulds)

The use of centrifugal pumps in carbon capture and storage is not new. As of mid-2024, there are over 50 operational CCS facilities worldwide, with some having decades of runtime experience. Additionally, there are more than 5,000 miles of existing CO_2 pipelines, many of which rely on pumps to transport CO_2 across the network and inject CO_2

underground for enhanced oil recovery. This extensive operational experience provides pump manufacturers, independent service companies, and operators with valuable knowledge on how centrifugal pumps work in the carbon capture ecosystem.

Centrifugal pumps can be broadly categorized into *engineered* and *standard* configurations. Engineered pumps are designed for demanding operating conditions (e.g. high-pressure environments or handling supercritical CO_2 flow) where safety and reliability are paramount. Typically, larger sized, multi-stage pumps used in high flow, pressure, or head applications are considered engineered. Many engineered pumps follow the American Petroleum Institute (API) 610 standard, a globally recognized standard used in the oil, gas, and petrochemical industries that establishes comprehensive benchmarks for performance, reliability, and safety. Standard pumps are typically used in less severe and well-established operating environments. While standard pumps in oil and gas often conform to API 610, many standard centrifugal pumps used in general purpose applications (e.g. water, pulp and paper, and other industries) will follow ANSI B73.1 or other standards that are less prescriptive than API 610 requirements. This makes standard pumps more cost effective. Exhibit 4 below illustrates the landscape of centrifugal pumps within CCS, highlighting their applications and configurations across the value chain.

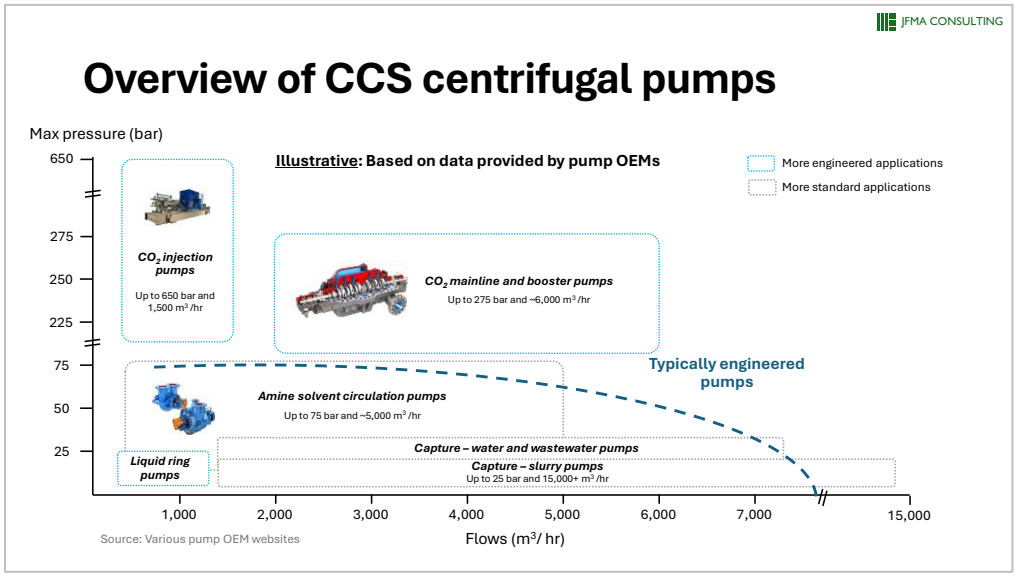

Exhibit 4: Illustrative example of CCS centrifugal pump landscape

Chapter 2: Centrifugal Pumps Market Outlook

Growth Outlook – Total addressable market for centrifugal pumps could exceed $2.0 billion by 2040 in our base case scenario, with attractive long-term growth trajectory to 2050

In our base case scenario aligned with the 2024 IEA Announced Pledges Scenario, the total addressable market for centrifugal pumps in CCS is projected to grow from ~$45M in 2024 to ~$313M by 2030, reflecting a compound annual growth rate (cagr) of ~38%. Growth is expected to continue at attractive double-digit rates in the 2030s, potentially reaching a market size of ~$2.0B by 2040. As a comparator, the global pumps market in oil and gas is estimated at ~$10B in 2023. A year-on-year estimate of the market size in our base case scenario is shown in Exhibit 5 below.

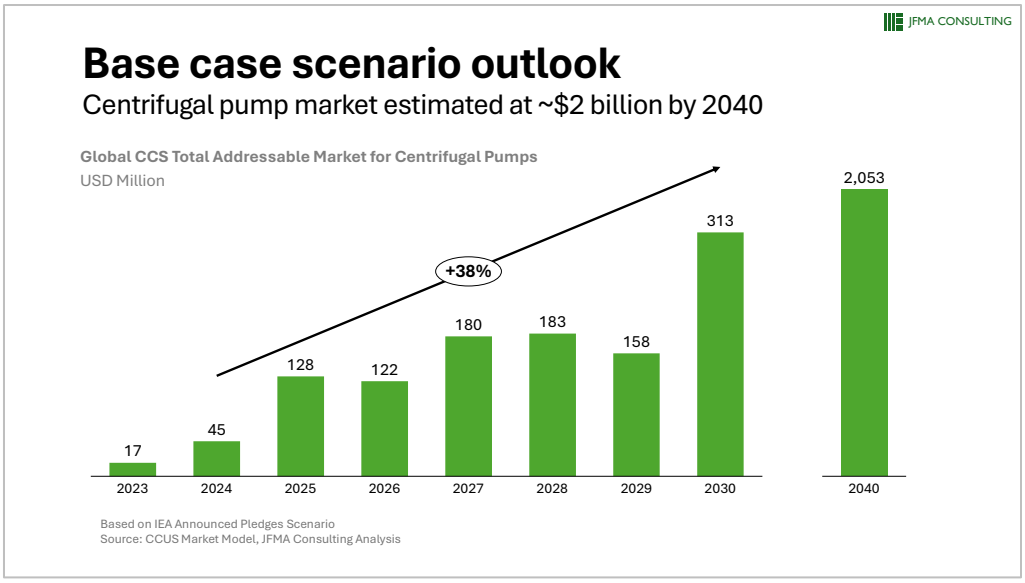

Exhibit 5: CCS centrifugal pump total addressable market growth in our base case scenario

In the low growth scenario aligned with the IEA Stated Policies Scenario, the market grows at a more moderate pace to ~$155M by 2030 with a cagr of ~23%. Growth continues beyond 2030 but at a significantly slower pace compared with our base case scenario, with the total addressable market estimated at ~$500M by 2040.

By Channel – original equipment (OE) sales will be the primary growth driver in the next decade, while aftermarket and MRO services growth should accelerate in the 2030s

Under both scenarios, market growth through 2030 will be primarily driven by original equipment sales as new CCS sites are constructed and become operational. In the base case scenario, the OE channel is projected to account for ~54% of the total centrifugal

pump market by 2030. In the low growth scenario, the OE channel represents a slightly smaller share at ~45% of the total market by 2030 due to reduced project investment and overall equipment demand. Exhibit 6 provides a breakdown of the market growth by channel, highlighting the relative contributions of OE and aftermarket channels.

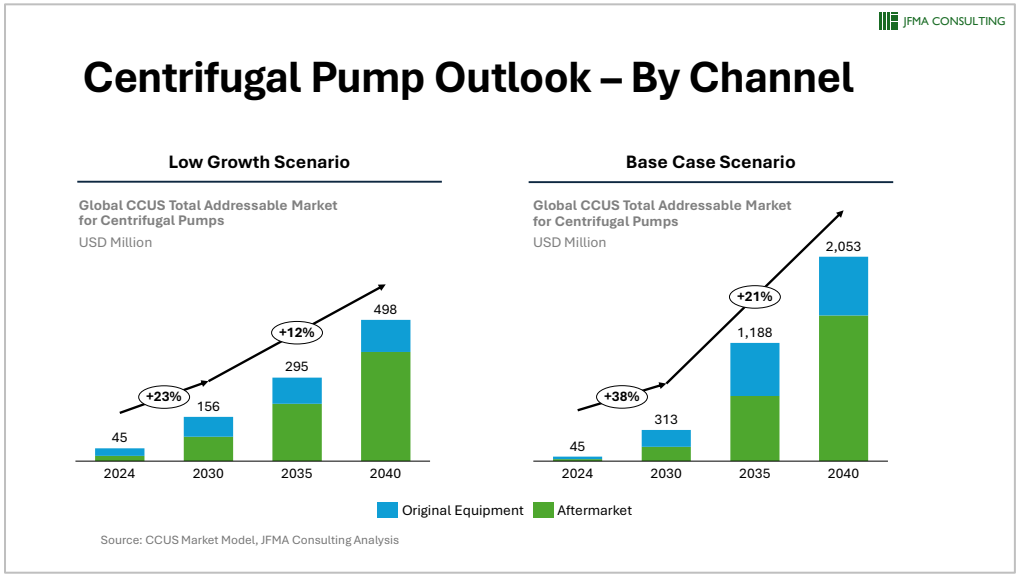

Exhibit 6: Centrifugal pump market outlook by channel

The volume growth of OE sales is expected to follow an uneven year-over-year pattern, as this is dependent on the timing of project financial investment decisions (FIDs) and the subsequent awarding of pump contracts to OEMs. By 2030, the total installed base of centrifugal pumps across the CCS value chain is forecasted to approach ~5,000 and ~12,000 units in the low growth and base case scenarios, respectively.

Pricing for OE pumps is anticipated to vary significantly, influenced by the project application, regional factors, and whether the project is deemed strategic by the pump OEMs (e.g. these strategic projects is likely to generate intense competition as pump OEMs target flagship wins to build references). While the location of manufacturing could also impact pricing, we have not taken this factor into consideration given the complexity in accounting for this variable.

The aftermarket channel, encompassing maintenance, repair, and operations (MRO) and services is expected to experience steady growth as the installed base of CCS pumps increases. In 2024, this channel is estimated at ~$19M, corresponding to the addressable potential market of the ~50 CCS facilities currently in operation. While this represents a relatively smaller share of the overall market when compared with OE, aftermarket is expected to steadily expand throughout the 2020s and into the 2030s as more facilities come online and aging equipment requires servicing or replacement. In our base case

scenario, the centrifugal pump aftermarket is forecasted to reach ~$145M by 2030 and grow substantially to ~$1.4B by 2040. In our low growth scenario, the aftermarket is projected to be ~$85M by 2030 and potentially ~$385M by 2040.

Aftermarket dynamics for centrifugal pumps in CCS are expected to mirror trends observed in the industries where the corresponding carbon capture equipment is installed. The emergence of new digital solutions and predictive maintenance could also create new business models, driving incremental growth opportunities. Further analysis of MRO and aftermarket opportunities is detailed in the Aftermarket Section below.

Geographical Regions – North America to remain the market leader over the next decades, while growth in Europe, China, and Middle East dependent on policy evolution.

North America is the largest centrifugal pump market for CCS, currently accounting for ~62% of the total market size as shown in Exhibit 7. This is predominantly driven by the region's well-established CCS infrastructure and extensive installed base of pumps. For instance, North America currently captures ~60% of the global captured carbon dioxide and nearly all operational CO_2 pipelines.

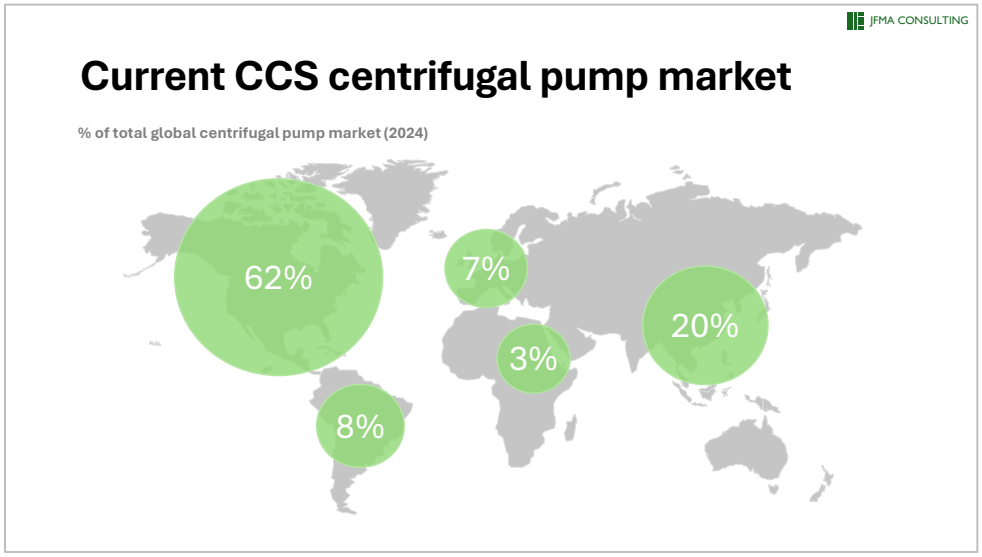

Exhibit 7: 2024 centrifugal pump market size by regions

This leadership position is expected to continue through 2030 and beyond under both scenarios, supported by favorable regulatory policies and financial incentives (e.g. 45Q tax credit) in the United States and Canada, an existing infrastructure of carbon dioxide pipelines for CO_2 transportation, and the knowledge and capabilities of the existing workforce in carbon management.

While North America leads, select countries in Europe, the Middle East, and China are also projected to witness significant growth during this period, contingent on the implementation of more favorable policies and incentives. In general, regions with extensive energy infrastructure (e.g. North Sea and the Middle East) should present the largest opportunities for centrifugal pumps growth from both a volume and price standpoint. Market demand in other parts of the world will remain more limited to select countries such as Australia, Brazil, China, and Malaysia, etc., primarily driven by oil and gas companies operating CCS-enabled facilities. Exhibit 8 provides a breakdown of the regional growth outlook for centrifugal pumps under both scenarios.

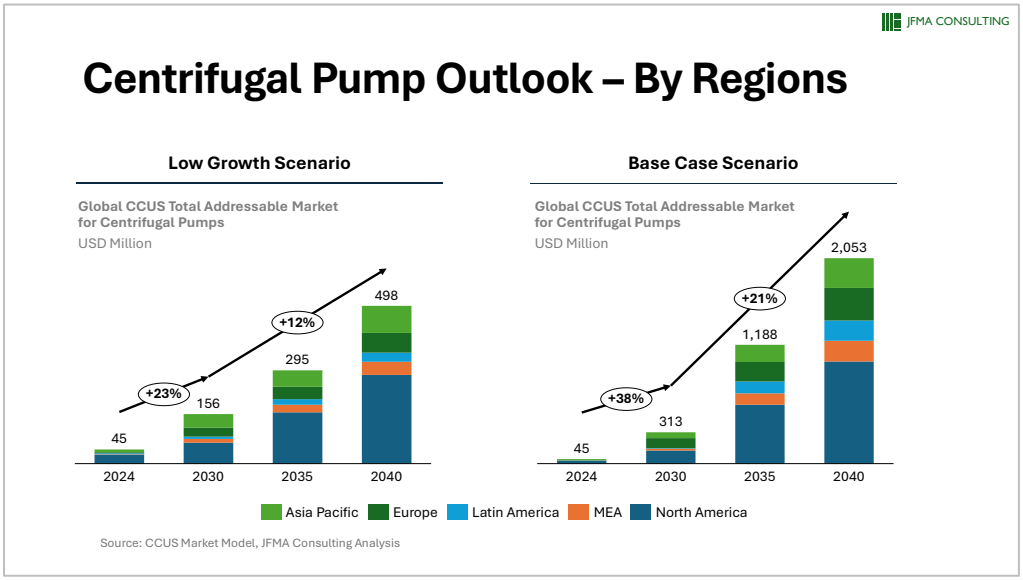

Exhibit 8: Centrifugal pump market outlook by regions

End-Use Markets – Oil and gas forecasted to be the largest end-use market, while pipeline and sequestration are expected to grow considerably in the late 2020s and 2030s. Regional opportunities in fertilizer, ethanol, and cement are also expected to emerge.

From an end-use perspective, the oil and gas sector is poised to remain the largest market for centrifugal pumps in CCS applications. This includes carbon capture used in the production of low-carbon hydrogen, natural gas processing, and liquefied natural gas (LNG). Pumps in this sector are often built to stringent API standards and sold at premium prices. In our base case scenario, the oil and gas market for CCS centrifugal pumps could grow to ~$100M and ~$715M by 2030 and 2040, respectively. Even under a low growth scenario, the market potential remains significant at an estimated ~$190M by 2040.

The infrastructure sector, which primarily includes transporting CO_2 via pipelines and injection for sequestration, also represents a substantial market opportunity for centrifugal

pumps. These applications demand reliable, high-performance equipment capable of operating under stringent conditions. Pumps used in high-pressure injections are often designed and sold as part of a large, engineered skid compliant with API standard and can command prices exceeding $1M USD per unit. In our base case scenario, the centrifugal pump market for transport and sequestration could surpass $500M by 2040. A potential upside exists if pipeline operators start retrofitting existing natural gas pipelines for CO_2 transport, which could drive demand for higher-value retrofitted pumps. However, a notable downside risk would be higher adoption of compressor technologies in CO_2 pipeline applications. This shift could significantly reduce the overall addressable market for centrifugal pumps especially in the base case scenario.

The power generation sector, including pre-combustion, post-combustion, and oxyfuel technologies, holds long-term potential for centrifugal pumps. However, widespread adoption is unlikely before the 2030s due to high capital costs and the technological challenges of capturing diluted CO_2 from flue gas. CCS in power generation is likely to remain economically unattractive versus other decarbonizing technologies such as renewables.

Within other industries, the bioenergy sector, encompassing ethanol and ammonia production, presents a key near-term growth area, particularly in the United States. However, most of the pump equipment in this end-market is expected to be lower cost standard designs. The market growth is also contingent on the approval of several major CO_2 pipeline projects across the U.S. Midwest, which are essential to the viability of CCS in bioenergy facilities. The uncertainty surrounding these approvals introduces a higher degree of risk to the sector's growth trajectory. CCS deployment within cement production also presents opportunities for centrifugal pumps, however, this application is anticipated to remain a smaller, niche market compared to other end-use sectors.

Direct air capture (DAC) is not expected to significantly impact centrifugal pump growth until at least the mid-2030s in our base case. This reflects the nascent stage of DAC technologies and its current high capital and operational costs. While companies like Oxy are investing heavily in DAC and aim to deploy 70 large-scale facilities by 2035, the technology faces significant economic and technical hurdles. In the low growth scenario, DAC remains a minor contributor to the centrifugal pump market even by 2040.

Modular carbon capture solutions are also a nascent technology to monitor. There are a multitude of companies investing in this sector (e.g. Carbon Clean, Baker Hughes through its CCC acquisition), however, the technology is still in the early stages of commercial readiness. Centrifugal pumps are typically installed on a pre-designed modular skid package in most modular CO_2 capture applications, limiting the direct market opportunity

for pump OEMs. Therefore, the total centrifugal pump market potential in modular carbon capture is expected to be limited until the mid-to-late 2030s.

A summary of the centrifugal pump market size across end-use verticals in our base case scenario in 2030 is shown in Exhibit 9.

Exhibit 9: Market outlook in 2030 split by end-use markets in our base case scenario

The growth outlook by end-use markets under both scenarios is shown in Exhibit 10

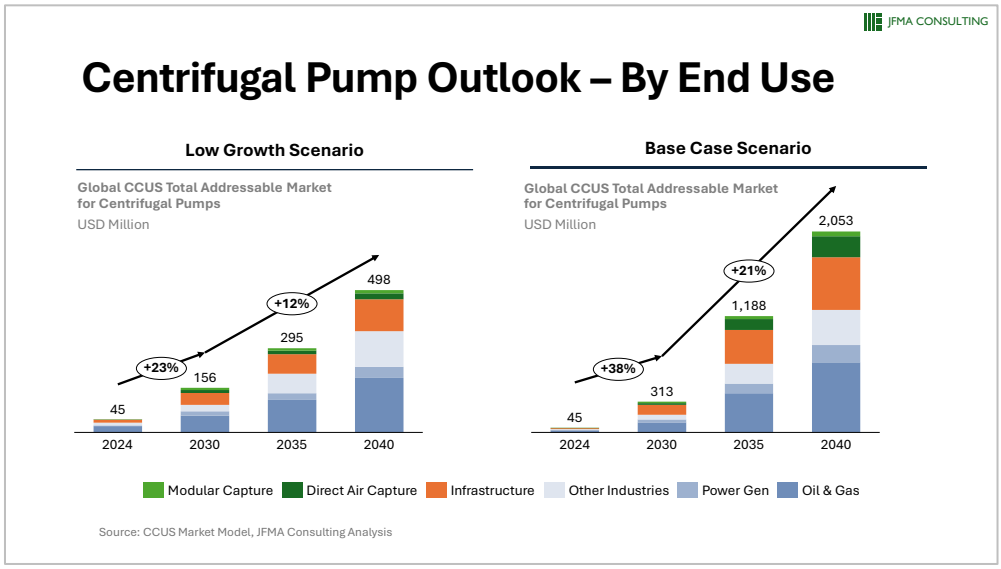

Exhibit 10: Centrifugal pump market outlook by end-use markets

Pump Types – Engineered pumps forecasted to be the primary value driver over the next decade as pump OEMs re-engineer proven pump solutions to new CCS applications. Designs will become more standardized, and standard pumps expected to dominate future volumes by the 2030s

The CCS value chain will require a range of both engineered and standard centrifugal pump configurations to meet its diverse technical and economic challenges. By 2030, engineered pumps are projected to account for ~50% of the market by value, driven by their critical role in technically demanding applications. Examples include pumping supercritical CO_2 in pipelines and injection skids for high-pressure underground storage. These pumps must meet stringent API standards and are expected to be customized to fit specific plant configurations and layouts.

Standard pumps, including both API-compliant and non-API models, are expected to be widely used in less demanding applications, such as feedwater circulation or operations in non-oil and gas facilities like ethanol production. Although standard pumps are expected to constitute ~50% of the market by value in 2030, they will dominate in terms of overall volume due to their prevalence in less stringent use cases (Exhibit 11 below). As more CCS facilities become operational and key stakeholders (e.g. EPCs, OEMs and operators) gain valuable learnings and experience from handling and running CCS plants, standard pump configurations are anticipated to gain an even larger share of the market. This shift will likely drive down the cost of mature pump designs, enhance reliability through proven performance and best practice implementation, and ultimately support scaling of CCS.

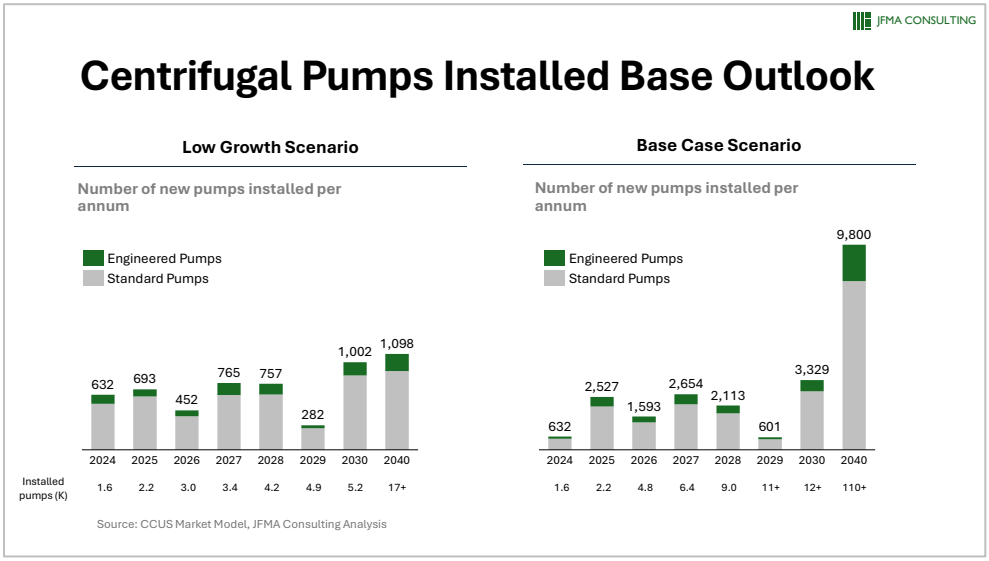

Exhibit 11: Estimated annual installations and cumulative installed base of centrifugal pumps under both scenarios

A summary of the market opportunity by pump types and categories in our base case scenario in 2030 is shown in Exhibit 12 below.

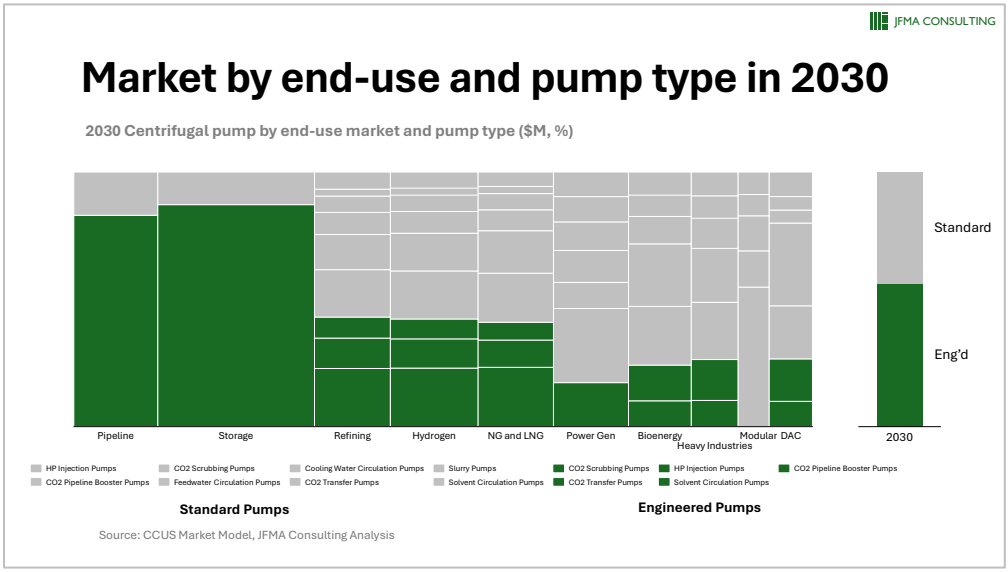

Exhibit 12: Market outlook in 2030 by engineered vs standard pumps in our base case scenario

Aftermarket and MRO – attractive, high-margin aftermarket forecasted to reach ~$1.4 billion by 2040 in our base case scenario, with pump OEMs and independent service providers all playing vital role to support facility reliability, operations, and performance.

As the installed base of centrifugal pump increases, the MRO and services market is forecasted to steadily increase and presents a highly attractive, long-term growth opportunity. By 2030, the global centrifugal pump MRO and services market is estimated to reach ~$145M in our base case scenario, with a pathway to reach ~$1.4B by 2040. Even under the low growth scenario, this market could reach ~$385M by 2040.

Aftermarket demand is forecasted across three main service categories:

- **Level 1: Basic Services** – Routine visual inspections, basic pump performance monitoring, and operator training and education.
- **Level 2: Pump Repair** – Advanced diagnostics (e.g., vibration analysis), health audits, replacement of consumables and seals, and other mid-level repairs.
- **Level 3: Pump Replacement** – Replacement of critical components, re-rating of pumps, and other major interventions.

Exhibit 13 provides an outlook on the aftermarket growth across these service categories under both scenarios.

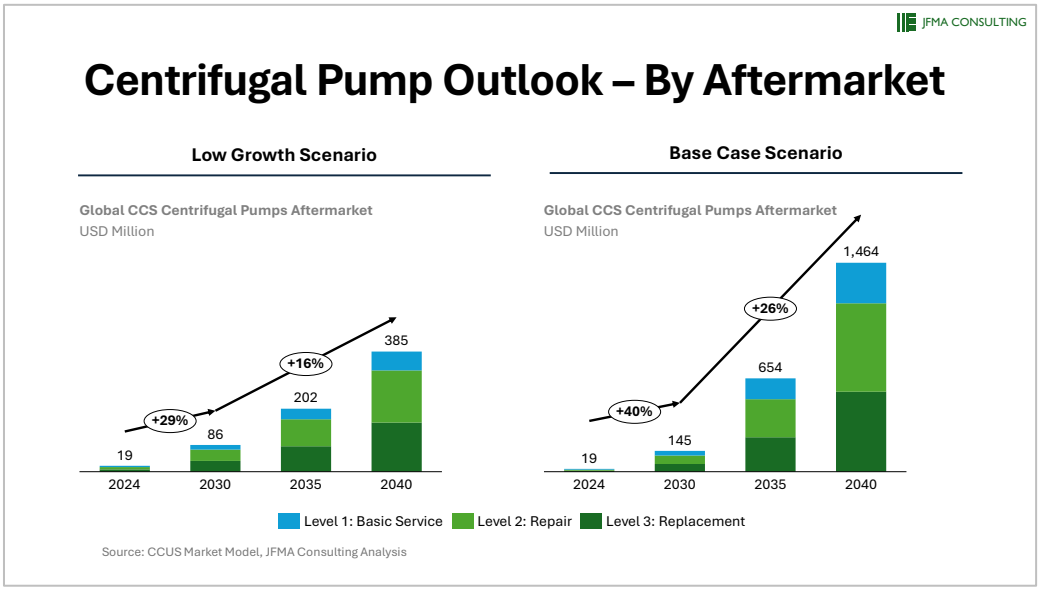

Exhibit 13: Centrifugal pump aftermarket growth outlook by service categories

The aftermarket dynamics for CCS centrifugal pump are likely to mirror those of traditional markets where the CCS equipment is installed, particularly in oil and gas, chemical, and power generation. This includes estimated gross margins and profitability, route to market, and business models to generate revenues. This is primarily driven by the fact that many CCS projects involve retrofitting existing facilities, which have well-established procurement processes, design standards, supply chains, and pricing expectations. Additionally, a large portion of new greenfield CCS projects are being developed by oil and gas companies. These companies often maintain long-standing relationships with pump OEMs and service providers and have existing pricing agreements and service contracts, which would likely ensure continuity in aftermarket dynamics.

The 2020s is likely to mark a period of learning for many operators, resulting in more frequent inspections and repairs of centrifugal pumps to ensure reliable and safe operations. Increase levels of replacement and change-outs are also anticipated during the initial few years. These service activities are expected to be primarily handled by pump OEM under initial warranties (typically 12–18 months after installation), and then under transactional or service agreements.

As warranties expire and CCS operators gain more experience and confidence managing CCS applications, independent service providers are anticipated to play an increasingly vital role in maintaining and refurbishing pumps, especially for less demanding applications and designs. This shift is expected to drive down the total cost of ownership

for operating these pumps and potentially enhance the economic viability and financial attractiveness of CCS facilities. This is similar to trends observed in traditional oil and gas facilities and power plants.

A summary of expected aftermarket trends and implications is highlighted in Exhibit 14.

CCUS engineered pumps aftermarket dynamics

	Activities	2030 Market ($M) & cagr (%)	% outsourced	Estimated Margin %	Forecasted CCS trends
Leve 1: Basic Service	• Routine inspection • Basic monitoring • Education & training	In data set	Up to 50%	10 – 25%	• More regular inspections to catch potential issues early on • Most activities completed in-house or by 3rd party service providers (non-OEMs)
Level 2: Pump Repair	• Advanced Diagnostics / Health Audits • Vibration analysis • Seal/parts replacement	In data set	80%+	30 – 50%	• Frequent pump repairs required due to uncertain operating conditions • More bad actors expected in early stage • Gradually stabilize as operators learn • Most repair activities to be outsourced
Level 3: Pump Replacement	• Re-rating or re-mfging • Critical parts / component upgrade • Test bed facility	In data set	95%+	50 – 70%	• High chance of early pump failures as operators gain CCS experience • Most operators will use pump OEMs due to technical capabilities / testing requirements

Exhibit 14: CCS centrifugal pump aftermarket forecasted trends and dynamics

Chapter 3: Observed Strategies of Pump Manufacturers, Service Providers, and EPCs

While the centrifugal pump market for CCS is in its early stages, it holds significant potential for growth. Pump companies are beginning to position themselves strategically to compete and differentiate as the market evolves. We observe the following emerging strategies and broad actions being implemented by pump manufacturers, independent service companies, and EPCs in response to this nascent opportunity.

Pump Original Equipment Manufacturers (OEMs) – most pump OEMs recognize the CCS market is still in its early stages but holds significant growth potential in the medium term. Companies with large exposure to the energy sector are beginning to develop core grow initiatives to strengthen their positions in the CCS market. Key actions observed include:

- Declaring CCS as a strategic growth priority – several large pump OEMs with exposure to both the energy value chain and the North America market have announced CCS as a cornerstone of their growth strategies. For example, Flowserve has made CCS a central component of its 3D Growth strategy and is actively pursuing flagship CCS projects across the value chain.
- Promoting proven pump solutions – many pump OEMs have proven solutions and installed base across CCS applications and are leveraging these references to establish credibility. These companies are promoting and marketing their experience and product set through new brochures and collaterals, though these efforts often repurpose existing product content rather than presenting new, tailored CCS-specific solutions
- Prioritizing strategic flagship projects – pump OEMs are emphasizing the importance of securing flagship CCS projects to build a strong reference list. Some have started to elevate the strategic importance of CCS projects in their capital allocation decisions, allowing for higher prioritization of these projects. We believe this could increase competitive bidding for these reference projects, ultimately driving down OE pump prices
- Building broader industry collaboration – several leading OEMs are deepening partnerships with EPCs and end-use operators to showcase their existing capabilities in CCS. Although still in early stages, such collaborations have the potential to facilitate knowledge sharing and cement these larger OEMs as leaders in specific CCS applications
- Invest in select technology innovation – Broad-based innovation into new CCS pumps remains limited due to finite resources and competing strategic priorities at many of the OEMs. However, several of the major pump OEMs are investing in

targeted new solutions and capabilities such as new designs for handling supercritical CO_2, advanced materials to better resist corrosive CO_2 streams, and enhanced digital solutions for monitoring. These advancements not only support CCS applications but could also support other industrial markets, thus strengthening the business case for investment.

- Expand into new CCS adjacencies through M&A – some pump OEMs are using M&A to expand into new attractive adjacencies, gain broader exposure into the growing CCS value chain, and acquire new technologies. A recent example is ITT's acquisition of Svanehøj in January 2024, which enables ITT to expand in the marine pumps segment, a key equipment in transporting CO_2 to offshore sequestration sites.

Service companies – Large oilfield service providers with pump offerings are expanding their portfolio and capabilities, particularly targeting CCS sequestration market. Independent pump service providers and value-add distributors are primarily observing marketing developments and beginning to craft strategies on how to compete as the CCS market expands

- Large oilfield services companies – These companies recognize the significant growth potential in CCS and are actively expanding their portfolios and capabilities. Several are seeking to provide an end-to-end, comprehensive solution across CO_2 sequestration and monitoring, introducing new business models to generate revenue. While not all large service providers offer centrifugal pumps, companies like Baker Hughes stand out with their broad portfolio range, technology expertise, and global customer footprint. These capabilities position them well to compete in CCS-related applications in transport and sequestration
- Independent pump service companies – Smaller, independent pump services companies are starting to evaluate the CCS market. Many of these companies, especially those with service facilities in North America, may already be servicing pumps in operational CCS facilities, and this presents them with a platform to expand their business as the CCS market scales. Despite this existing presence, many independent service providers currently lack comprehensive knowledge of the CCS ecosystem and the technical expertise to handle newer CCS applications (e.g. supercritical CO_2 handling). This knowledge and capability gap may hinder their ability to compete effectively in more specialized CCS markets
- Value-add distributors - Distributors that provide value-add fluid control services are also assessing the CCS market with some starting to promote their experience and pump product portfolio for these applications. Like pump OEMs, distributors

such as DXP Enterprises are mostly marketing existing pump solutions and capabilities which are already proven in non-CCS applications.

Engineering, Procurement, and Construction companies – EPC firms are playing an increasingly critical role in shaping the development of the CCS market, particularly its impact on the centrifugal pump sector. Their actions demonstrate a focus on building specialized CCS expertise and fostering collaborations across stakeholder groups. Key observed actions include:

- Establishing dedicated CCS teams and resources - Large EPCs have formed specialized CCS teams equipped with dedicated technology and engineering resources. These teams are enhancing internal process expertise in CCS plant design and configuration by deploying advanced simulation and modeling tools and strengthening their technical acumen in CCS. This could help to optimize CCS system designs and the selection process of key rotating equipment.
- Partnering with OEMs – Rotating equipment selection is a critical aspect of CCS projects, particularly for CO_2 transport and injection systems. Most EPCs lack in-house expertise in evaluating this technology decision and are increasingly partnering with OEMs. While many EPCs aim to remain technology-agnostic, these partnerships are expected to help them navigate key decisions, such as the trade-offs between compressors versus pumps, or selecting the optimal pump type (e.g. centrifugal, positive displacement, screw) for specific flow applications. Centrifugal pump OEMs have started collaborating with EPCs on key technology discussions and should further expand these collaborations to effectively demonstrate their capabilities and highlight the importance of centrifugal pumps as a preferred technology for a broad range of CCS applications
- Emergence of smaller, specialized EPCs – in addition to large EPCs, we have observed the emergence of smaller engineering companies dedicated to serving the CCS market. These companies often possess a greater willingness to collaborate with equipment manufacturers (including pump companies) to better understand existing equipment technologies, share detailed insights into CCS process flows and parameters, and explore new go-to-market business models. These specialized and more agile firms could present a new avenue for pump companies to establish partnerships and influence technology adoption in CCS projects.

Chapter 4: Unlocking Future Growth and Gaining Competitive Advantage

While the macro-level development of CCS lies largely outside the direct influence of the centrifugal pump industry, pump companies and stakeholders play a pivotal role in enabling the CCS market and unlocking future growth. Their contributions are critical in ensuring the reliability, operability, safety, and total cost of ownership of the CCS facility.

We recommend a set of targeted actions that pump companies can implement to gain a competitive edge in the CCS market, while actively contributing to the scale-up of CCS deployment. **Pump companies should consider these actions as part of a comprehensive CCS strategy with a clear implementation roadmap**

Develop a scenarios-based CCS Strategy

- Establish a comprehensive, scenarios-based strategy taking into consideration potential size of the overall CCS market, how quickly the company can scale its business, gaps and differentiation at both the product and customer level, and how to create optionality to pivot if the market accelerates or takes longer to develop
- Develop a clear implementation roadmap that takes into consideration the factors stated above along with financial investment requirements, resource and capability constraints, and other competing strategic priorities

Commercial and Marketing

- Leverage existing installed base - Many pump companies and independent service providers already possess years of fleet experience in CCS. However, much of this expertise and data is fragmented—spread across disparate IT systems or retained as institutional knowledge within the workforce. Pump companies that prioritize the systematic documentation of their existing installed base, references across customers, and sales force and engineering capabilities in CCS will be better equipped to demonstrate their expertise. This data will also enable better understanding of current operability windows, performance history, and technical limitations associated with their pump portfolio, allowing these companies to support CCS projects more effectively
- Prioritize existing customer CCS projects – By analyzing their documented capabilities, pump companies often discover that their equipment is already serving end-use operators investing in new CCS projects. Leveraging this information through a targeted sales and marketing strategy can yield significant advantages. Companies that prioritize resources (e.g. sales efforts, bidding activities, and marketing campaigns) towards these existing customers and projects where they

already possess references can enhance win rates and expand market share in both new and retrofit opportunities

- Market proven CCS solutions while leveraging AI tools – many pump companies already operate a fleet of centrifugal pumps in existing CCS facilities, but often underutilize this proven track record in their marketing efforts. Lack of knowledge on the existing installed base, resource constraints, and competing priorities are common barriers that hinder the creation of such marketing content. Companies that actively prioritize this area while deploying new AI-driven tools for content creation, data analysis, and repackaging existing materials, can gain a competitive marketing advantage.
- Invest in education and training – Education is essential to improve the knowledge and understanding of pump solutions in the CCS market among both internal sales teams and external stakeholders across the CCS value chain (e.g., operators, EPCs, project developers, and investors). The best practitioners offer a comprehensive training curriculum that combines both digital and hands-on learning, while specifically messaging how their pump solutions address specific CCS deployment challenges

Product Management and Innovation

- Define flagship products for existing CCS applications – Many pump OEMs currently do not have a preferred pump type for existing CCS applications. This can lead to prolonged, iterative bidding cycles that increase costs for both manufacturers and customers. As many existing CCS applications have well-defined operating conditions, pump companies that define flagship products can gain speed and cost advantages in the bidding process. It is important for companies undertaking this process to engage a cross-functional team to ensure business alignment on the selected flagship products, the new process flow to bid on these CCS applications, and how to communicate these product selections across the organization.
- Reduce upfront product costs through value engineering - As pumps and associated systems can represent up to 10% of total CCS project costs, cost reduction is essential to scale CCS. Pump OEMs that invest in value engineering to reduce costs while maintaining reliability and durability would gain a competitive advantage servicing this market. This requires a cross-functional approach focused on areas such as selecting flagship products, decreasing the number of necessary part counts, simplifying balance of plant and system designs, and ultimately standardizing designs and configurations for specific applications
- Increase pump energy efficiency – Energy consumption is one of the largest cost drivers in CCS operations. Pump systems often contribute a significant portion of

this energy demand, and optimizing their energy consumption and improving energy efficiency is an important lever in enhancing the economic viability of CCS. Many existing solutions such as deploying variable speed drives and intelligent control systems can optimize pump operational performance and reduce energy consumption. Pump companies should evaluate incorporating these features as standard offerings for CCS projects, promoting lower total cost of ownership for customers

- Invest in new strategic technologies and innovations (e.g. supercritical CO_2 handling) – Addressing technical challenges related to supercritical CO_2 handling offers pump companies a significant opportunity for competitive differentiation. Supercritical carbon dioxide is the preferred phase of transport as large quantities of CO_2 can be transported while minimizing pressure losses. However, challenges such as material degradation and corrosion risks from multiphase flow must be overcome. Developing technical innovations such as advanced materials or coating could be critical to scale up this solution. In addition, many of these new technologies and solutions such as advanced materials, could be leveraged across a broader product portfolio, enhancing the business case for these R&D investments
- Deploy digital solutions as a standard offer – Given the heightened scrutiny on CCS projects, reliability and safety are critical attributes. Many pump companies already offer digital monitoring (e.g., vibration sensors) and predictive analytics, but making these features standard in mission-critical CCS applications could provide significant benefits. While this will clearly be an economic and strategic decision for pump companies, the widespread adoption of digitally enabled pump solutions can reduce safety-related risks, improve operational reliability, and reduce overall cost. This could not only enhance customer confidence, but also help mitigate risks that could hinder industry adoption

Industry Enablers

- Strengthen ecosystem collaboration – Greater collaboration among key industry stakeholders such as EPCs, pump OEMs, independent service providers, and end-use operators is crucial to scale up CCS. For instance, EPCs and operators could share critical operating parameters for the future CCS site (e.g. purity levels of the carbon dioxide) earlier in the project cycle, while pump OEMs could share more detailed technical performance data for their solutions to enable more informed decision-making. Independent service providers could also be engaged at earlier phases of the project to leverage their expertise in pump maintenance and aftermarket performance

- Engage the broader supply chain – across demanding CCS applications and operating environments, the limiting technical or performance bottleneck could be a critical component such as mechanical seals rather than the centrifugal pump itself. Pump manufacturers and service providers could engage closer with their supply chain to share more insights on pump operating requirements, standardized designs, and best practices. This will enable their suppliers to better understand the customer requirements and allocate resources and investments more effectively to address these technical challenges
- Establish industry-wide standards – the absence of industry agreed design standards for CCS applications creates inefficiencies. For instance, the current reliance on customer-specific approaches and preferences on whether to use API vs. ANSI standards makes it challenging for pump manufacturers to standardize configurations, select a preferred flagship product for specific CCS applications, and ultimately reduce costs. Although this challenge extends beyond centrifugal pumps, it is essential for industry stakeholders to collaborate in defining and aligning on technical standards for pumps across common CCS applications. This would help streamline decision-making, enhance bidding reliability and accuracy, and improve manufacturing processes, and ultimately lower total cost of ownership

Appendix: Key Sources

Not exhaustive, but a representative of all key materials used in addition to proprietary JFMA Consulting analysis, expert interviews, and project experience.

- IEA World Energy Outlook 2024
- Global CCUS Institute
- IEA CCUS Projects Database 2024
- IEA CCUS in Clean Energy Transition
- IEA Energy Technology Perspectives
- BCG Carbon Capture and Utilization as a Decarbonization Lever (2024)
- MIT Climate Portal
- US NPC Reports 2022
- Website and publicly available information from pump manufacturers and independent service companies (e.g. Flowserve, Sulzer, ITT, Celeros Flow Technology, DXP Enterprises and others)
- Various interviews and feedback from pump experts

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