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Artificial intelligence in process manufacturing

Preparing for an AI-driven future

Examining the impact of AI on operations across chemicals, metals, pulp and paper, rubber and plastics, and other process-driven industries

January 2025

Why read this paper?

Process manufacturers are asking themselves, "How will AI change the way we operate tomorrow?"

AI is starting to influence manufacturing practices, R&D processes, and worker collaboration. The adoption of AI is opening new possibilities to enhance operations and drive business growth. Manufacturers in industries such as chemicals, metals, or pulp and paper are moving beyond foundational tools like smart sensors and control systems and are putting their focus on AI-enabled solutions for predictive maintenance, quality control, process optimization, and new product formulation. Early projects using generative AI (GenAI) are also showing promising results, helping to reduce time-to-market for new products and assisting workers in accessing accurate work instructions.

AI adoption faces data, integration, and expertise challenges. Many organizations still face challenges in understanding where and how to start their AI journey and whether it will be worth it. Common hurdles include data readiness, integration complexities, and a lack of internal expertise to deploy AI solutions effectively.

Guidance for manufacturers on AI integration. This paper presents insights into how manufacturers in process industries are prioritizing technology today and where AI fits into the broader picture. The findings are designed to serve as a guide to best practices for preparing R&D, plants, and operational teams for an AI-driven future.

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Key findings

1. The top transformation priorities are optimizing operational efficiency and increasing revenue.

- **Two main priorities:** As companies look to digitally transform their operations, improving operational efficiency (mentioned by 20% of respondents) and increasing revenue (also mentioned by 20%) are the two top priorities that companies look to achieve.
- **Technology is the key enabler for both:** Operational efficiency is achieved through integrating technologies like AI and IoT in operations, while revenue increases can be unlocked in R&D, with 78% of respondents highlighting AI's role in accelerating time-to-market for new products.

2. AI is a key technology to achieve the transformation priorities in the next 3–5 years.

- **AI is the top technology that companies are currently trialing:** 74% of companies are currently experimenting with AI-based machine vision, and 73% with AI-based predictive maintenance. With respondents expecting to achieve 2% operational cost reduction in the coming 3 years through AI, AI is no longer viewed as experimental.
- **Who is ahead with AI:** Pulp & paper manufacturers are ahead in rolling out AI solutions (23% of respondents). North American manufacturers (24%) are ahead of European or Asian counterparts.

3. GenAI adoption is gaining early momentum.

- 4 of 5 manufacturers are building GenAI solutions: 80% of respondents are either currently using GenAI or considering its adoption. Process optimization use cases are seen as the biggest opportunity (24% of respondents), followed by sustainability (15%), and product design (15%).
- Not everyone is successful: Some respondents have stopped their GenAI initiatives, as pilots failed to show measurable success. In contrast, a European chemicals company has started to roll out its first GenAI solutions for operations to thousands of employees globally.

4. Manufacturers should take a 4-step approach to AI success.

- **Getting started with AI requires a structured approach:** Microsoft has found that companies should focus on the following four steps:
    1. **Identify the business need** (by first focusing on the problem/challenge to solve)
    2. **Embrace structural flexibility** (by building multidisciplinary teams)
    3. **Getting the data in order** (by doing a structured data assessment)
    4. **Using AI to develop skills** (by using AI to train and upskill people)
- Global life sciences manufacturer Bayer has embraced this four-step approach for successfully rolling out AI globally.

Scope of this report: 7 process industries

Process industries transform raw materials into final products through continuous or batch processing, producing goods that, once created, cannot be separated back into their starting materials, such as reacting raw chemicals to create polymers. Continuous processes maintain a steady, uninterrupted flow, while batch processing takes place in distinct stages.

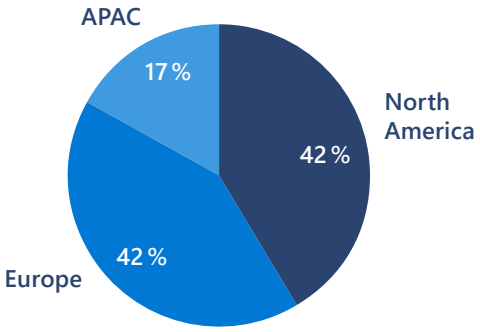
Process industries covered in this report:

1. **Chemicals**
2. **Petrochemical**
3. **Rubber and plastics**
4. **Metals**
5. **Pulp, paper, and wood**
6. **Stone, clay, and glass**
7. **Agribusiness**

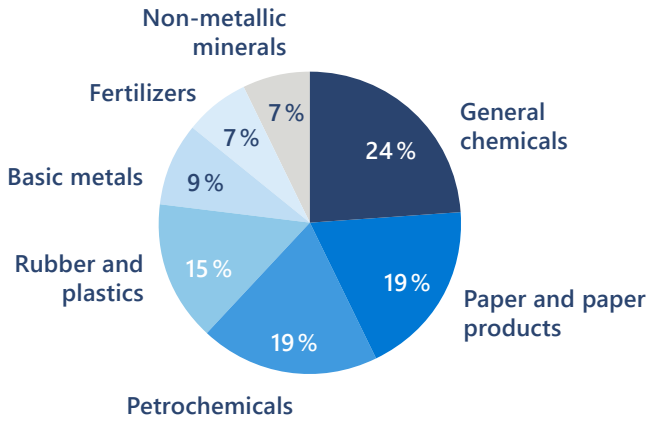
About the data: Survey of 120 executives in process industries

Overview of N=120 participants

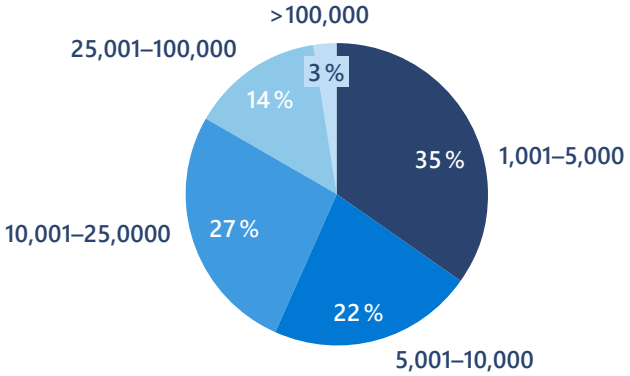
Share of respondents by region



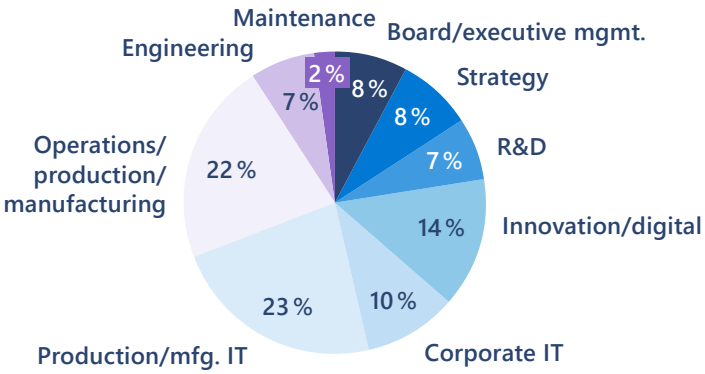
Share of respondents by industry



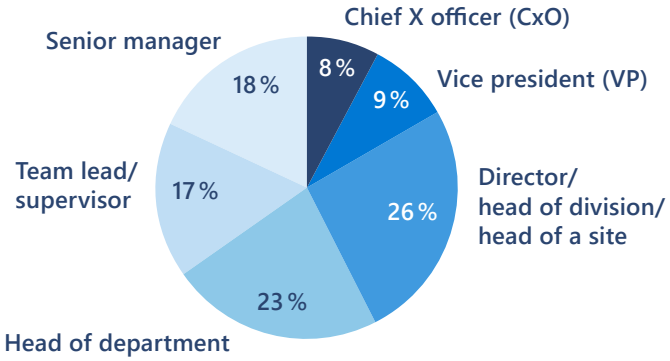
Share of respondents by company size (no. of employees)



Share of respondents by department



Share of respondents by seniority



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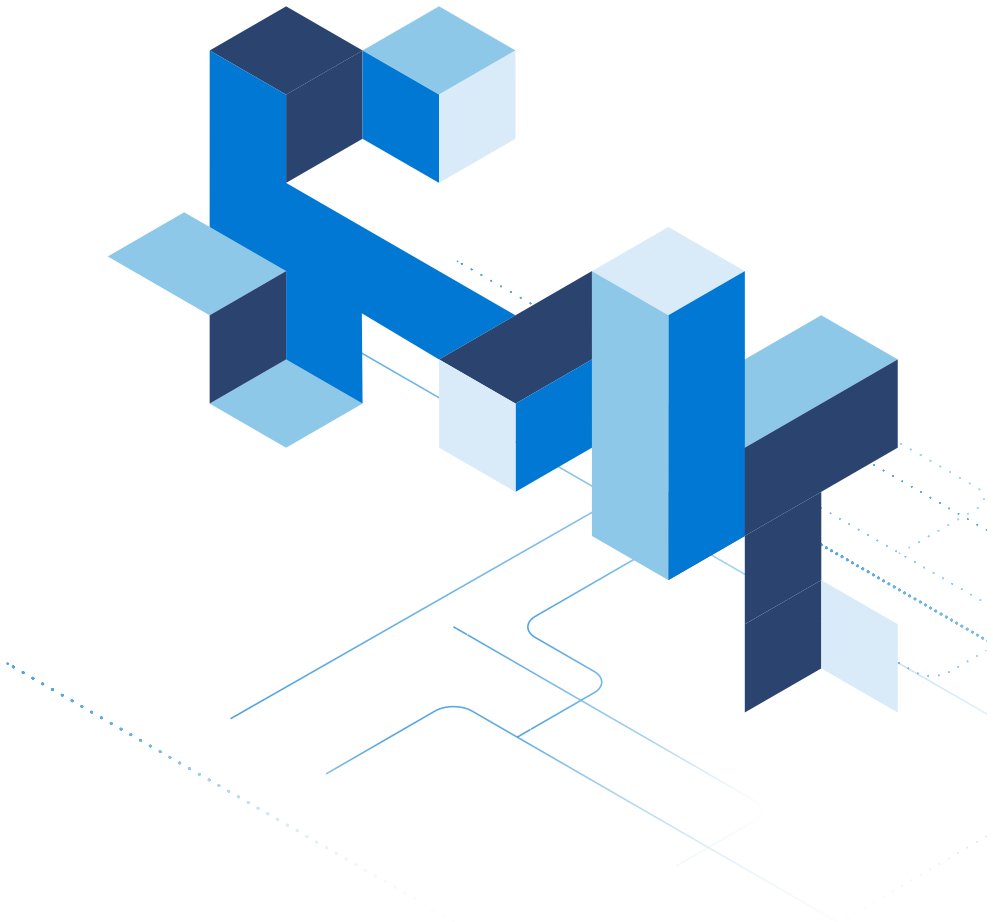

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Methodology

Microsoft developed this document in close collaboration with IoT Analytics, a boutique market research company focusing on IoT, AI, the cloud, edge technology, and Industry 4.0.

The centerpiece of this research is a survey conducted between October and December 2024 with a total of 120 respondents working in process manufacturing worldwide. The respondents are **key stakeholders in both plant operations and organizational strategy**, spanning roles in R&D, innovation/ digital initiatives, manufacturing, and maintenance. The survey respondents represent a diverse cross-section of process manufacturing, **covering major industries such as chemicals, petrochemicals, and rubber and plastics**. They come from key organizational functions, including operations, IT, and innovation, with **a majority holding senior leadership roles**. Geographically, the respondents are primarily from North America, Europe, and Asia-Pacific, and they work for companies ranging from mid-sized enterprises to **large multinationals, including those with over 100,000 employees.**

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1 Current state of technology & AI adoption

The current state of digital in process manufacturing

Process manufacturers are building on strong digital foundations with smart sensors, process automation, and advanced process control widely adopted today. As these manufacturers look into the future, operational efficiency and revenue growth are key. AI is emerging as a new technology, helping drive by use cases such as machine vision for quality control and predictive maintenance. Nonetheless, challenges like integration complexity, data security, and skill gaps still hinder progress.

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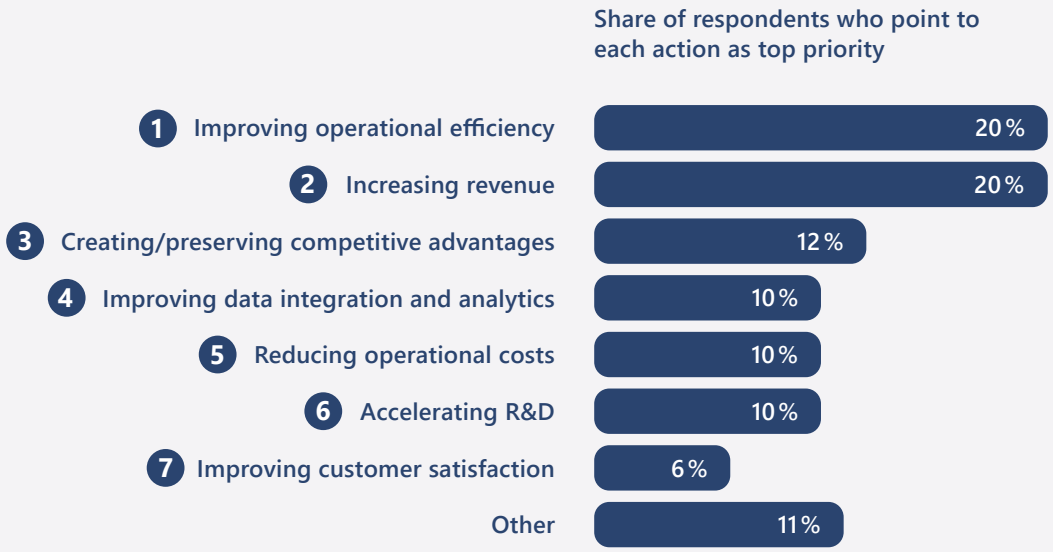
Top priority areas: Increase efficiency & revenue

Increasing operational efficiency and revenue are the top priorities for process manufacturers.

As process manufacturers transform their organizations' operations, 20% identify improving operational efficiency as the top priority, with an equal percentage placing increasing revenue at the forefront. The emphasis on these priorities underscores how digital transformation initiatives are rooted in addressing tangible operational and business demands. What also matters to these organizations: Creating a competitive advantage (12%), improving data integration (10%), reducing costs (10%), and accelerating R&D (10%).

Exhibit 1: Top organizational transformation priorities

Improving operational efficiency and increasing revenue are top priorities



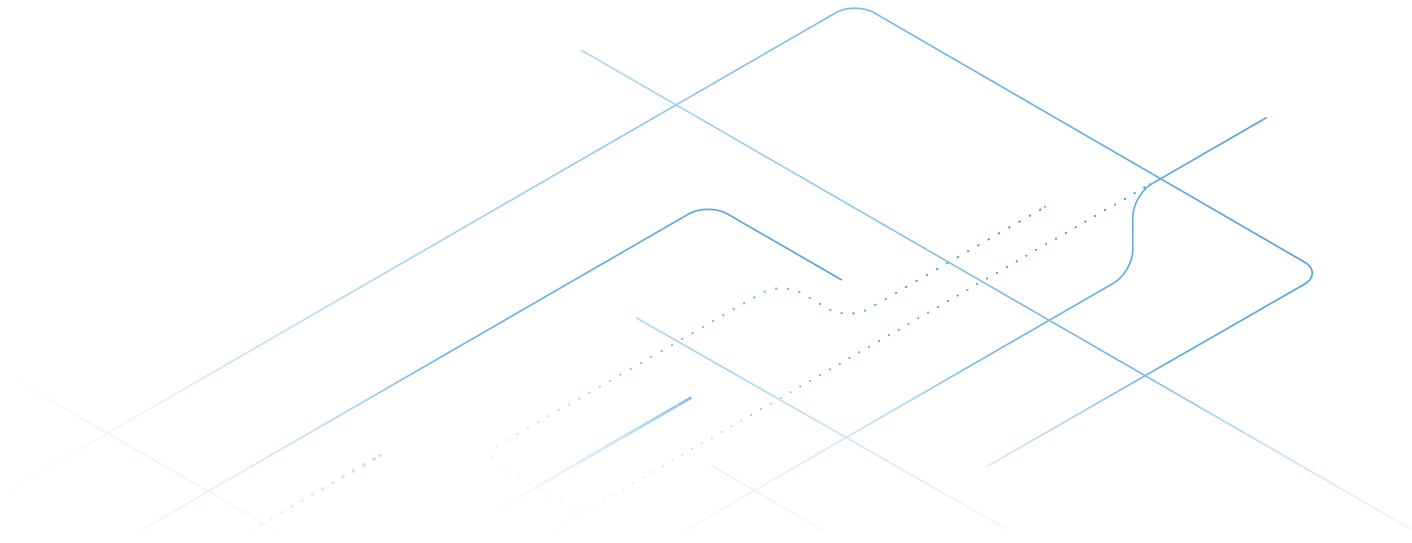
Q: To what extent is each of the following a top priority for transforming your organization's operations over the next 3–5 years?

What it means in practice

1. **Improving operational efficiency:** Prioritizing operational efficiency reflects a focus on optimizing production processes, reducing waste, improving resource utilization, and reducing operational costs.

> "In a chemical plant if you are losing four master batches a month, at $500K each, that is a straight $2 million loss. For something like a steam cracker, it's about focusing on key KPIs like asset availability, MTBF, throughput, waste, etc."
>
> —Digitalization director at a large chemical company

2. **Increasing revenue:** Companies prioritizing revenue growth are focusing on accelerating time-to-market for new products, expanding their product pipelines, coming up with new formulations, or increasing the throughput of production to allow the company to sell more. This emphasis highlights a forward-looking strategy leveraging R&D and operational expansion.



Technology drives operational efficiency

Operational efficiency maximizes productivity while minimizing costs and waste.

Operational efficiency involves optimizing resource utilization (such as energy, materials, and labor), minimizing waste and downtime, and streamlining workflows to achieve the highest possible productivity at the lowest cost. It often involves enhancing production processes, reducing variability, improving asset utilization, and ensuring consistent product quality.

Technology drives operational efficiency by integrating real-time monitoring, predictive analytics, and process optimization into core workflows. IoT and AI technologies enable actionable insights, allowing companies to detect inefficiencies, anticipate issues, and make rapid adjustments to processes. This results in streamlined operations, reduced downtime, and optimized resource utilization.

Four ways to enhance operational efficiency

1. **Eliminating bottlenecks and streamlining workflows:** Focus on removing process inefficiencies and ensuring interconnected workflows run smoothly.
2. **Maximizing uptime and optimizing asset reliability:** Improve scheduling, reduce changeover times, and ensure equipment reliability to boost capacity.
3. **Reduce rework and improve first-pass yields:** Enhance quality control measures and utilize inline monitoring to minimize defects.Address equipment issues proactively: Use advanced tools to predict and resolve potential equipment failures before they occur.
4. **Address equipment issues proactively:** Use advanced tools to predict and resolve potential equipment failures before they occur.

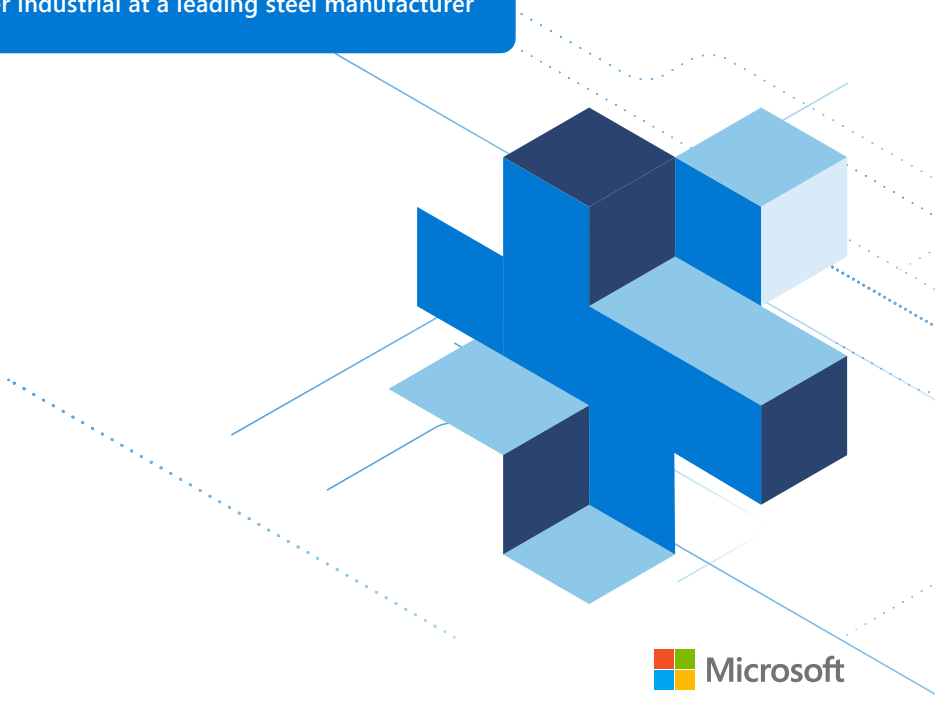
Process manufacturing executives stress adopting cutting-edge technology for the next level of efficiency gain.

"Over the past 7 years, we have significantly automated manual tasks like labeling, marking, and cutting samples of finished products by installing robots. We now need 25-30% fewer people to do the same job, which has led to substantial cost savings. Additionally, the robotized operations have improved quality by reducing defects caused by human inconsistency by up to 2%. Most notably, automation has boosted productivity by up to 5%, as robots consistently operate 24/7, unlike human workers who may experience fluctuations in performance."

—Head of engineering & maintenance at a leading steel manufacturer

"By implementing digital twins for operations like crane management and equipment such as electric arc furnaces or hot rolling mills, we have been able to reduce the time spent on fine-tuning our production flow for new products by more than 80%. In the past, this required halting production and dedicating shifts, but now, with the use of digital twins, we simulate the changes and optimize operations without stopping the line. This results in a significant time reduction, allowing us extra time to produce goods."

—Engineering manager industrial at a leading steel manufacturer



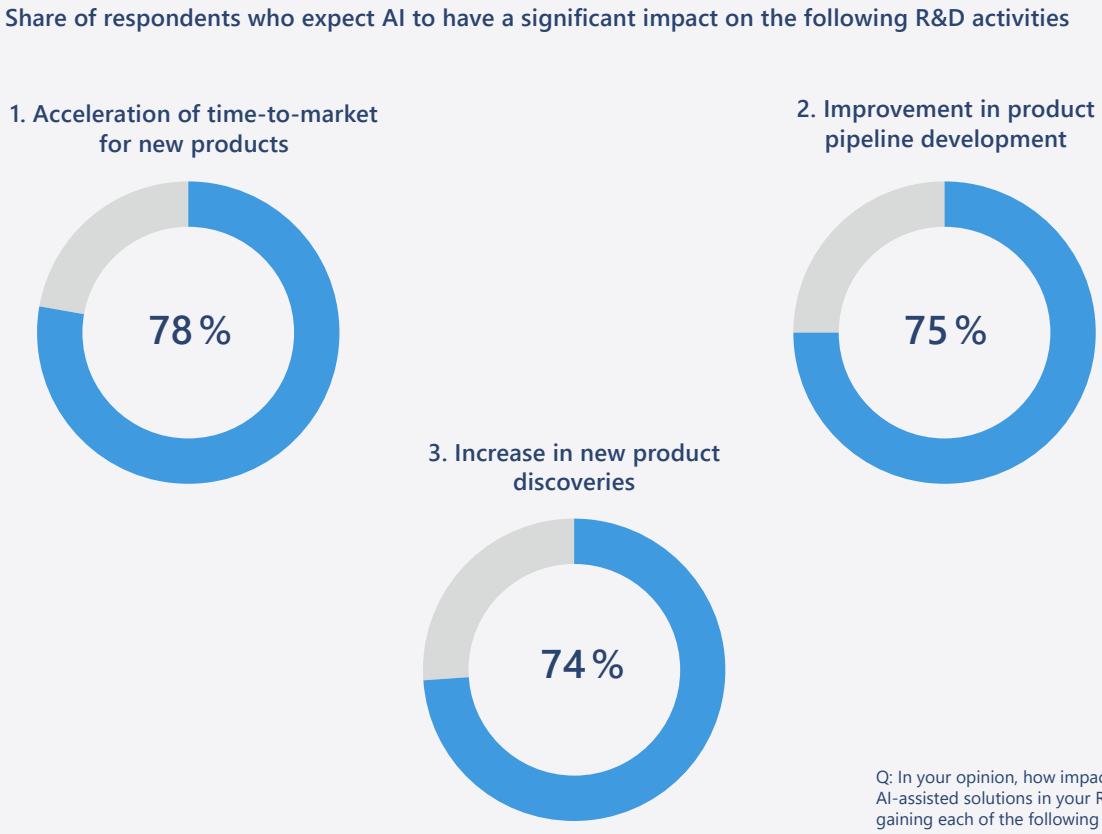
Technology also drives revenue increase

Technology fuels R&D, innovation, and revenue.

A significant 78% of respondents believe technology (specifically AI) accelerates time-to-market for new products, directly impacting revenue realization. Additionally, 75% point to its ability to improve product pipeline development, while 74% emphasize its role in enabling new product discoveries. As R&D becomes increasingly digitized, organizations leveraging advanced technologies will be better positioned to capture market share and drive long-term growth.

Exhibit 2: Top R&D activities benefiting from AI

Faster time-to-market, improved pipelines, and increased product discoveries are top R&D benefits



Q: In your opinion, how impactful will adopting AI-assisted solutions in your R&D activities be in gaining each of the following benefits?

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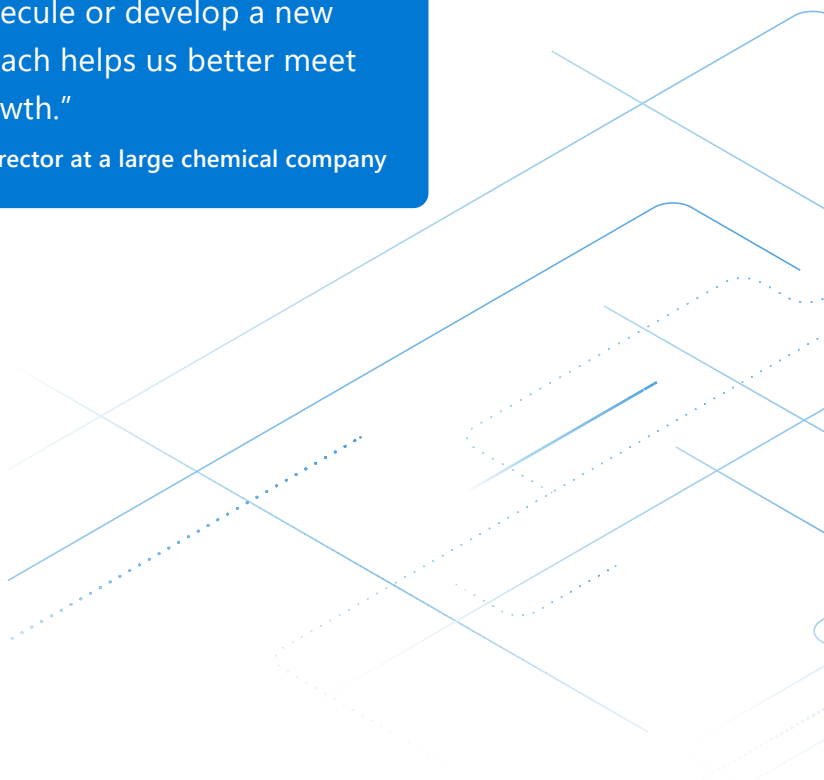
Where technology drives revenue

- **Accelerating time-to-market:** Technologies like AI and digital twins streamline simulations and trials, enabling faster delivery of products. For example, new chemical formulations, specialty alloys, or custom polymers.

- **Enhancing product pipelines:** Advanced analytics uncover opportunities for higher-performance products. For instance, specialty elastomers, high-strength plastics, or sustainable polymer blends.

- **Optimizing pricing and market strategies:** Predictive analytics refine pricing and market alignment. For example, in volatile markets like petrochemicals or pulp and paper.

> "Technology enables us to make smarter decisions in product development. For instance, we directly integrate the Net Promoter Score into our R&D process. We combine data from social media with product characteristics, such as viscosity, skin compatibility, and more, to identify the next product innovation. This allows us to prioritize whether to enhance an existing molecule or develop a new one. Ultimately, this technology-driven approach helps us better meet customer expectations and drive revenue growth."
>
> —Digitalization director at a large chemical company



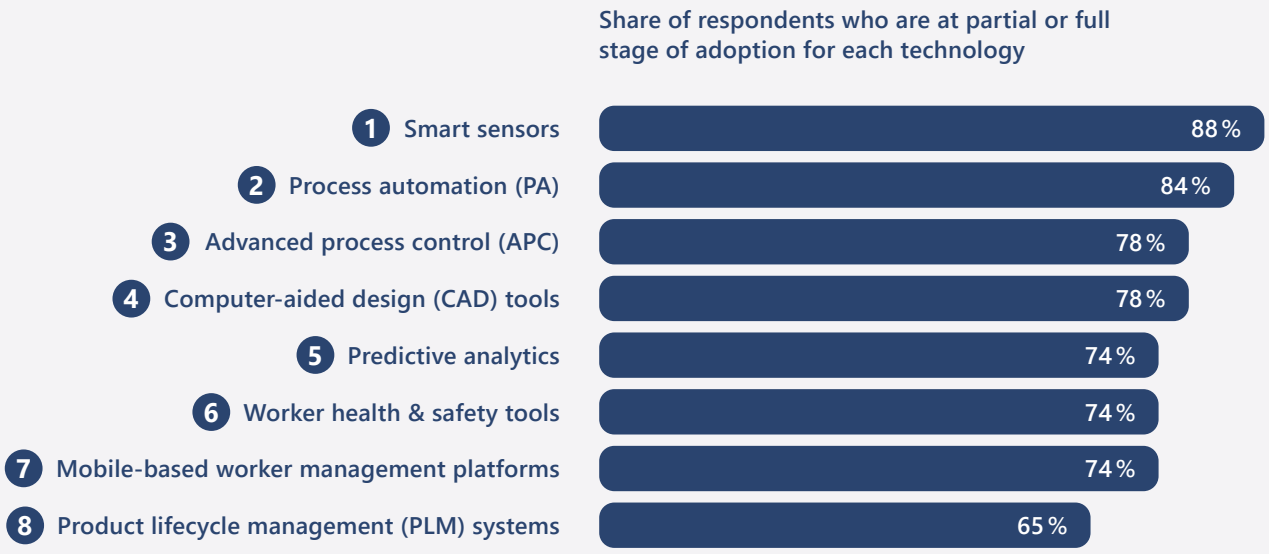
AI remains untapped in rolled-out technologies

AI remains largely untapped in plant optimization.

Process industries have successfully embraced foundational technologies such as smart sensors (88%), process automation (84%), and advanced process control (78%), which are essential for streamlining operations and maintaining baseline efficiency. These technologies are reliable and well-established, but their role remains largely operational rather than transformational. They lack the advanced decision-making capabilities that technologies like AI bring to the table. By establishing these foundational systems, organizations are creating a strong digital infrastructure—a necessary stepping stone for integrating more sophisticated solutions such as AI in the future.

Exhibit 3: Most adopted smart manufacturing technologies

Smart sensors and process automation are the most adopted smart manufacturing technologies



Q: At what stage is your plant in adopting the following technologies?

1. **Smart sensors enable AI by providing essential data.** Smart sensors act as the first layer of intelligence, capturing critical data that AI systems can later analyze for advanced insights. Without this raw data, AI's ability to generate predictions or optimize processes would be significantly limited.

2. **Process automation lays groundwork for AI optimization.** Process automation leverages control systems and software to manage and optimize production processes. While it ensures stability and efficiency, it operates within predefined rules, lacking AI's adaptive intelligence. It does, however, establish a foundation for AI to enable dynamic, real-time optimizations.

> "Six to seven years ago we began by installing IoT sensors and then later integrating standalone systems using advanced wireless and 5G technologies which laid the foundation for a networked ecosystem. This change from isolated systems to interconnected networks has been crucial for AI-driven solutions in our company."
>
> **—Head of engineering & maintenance at a leading steel manufacturer**

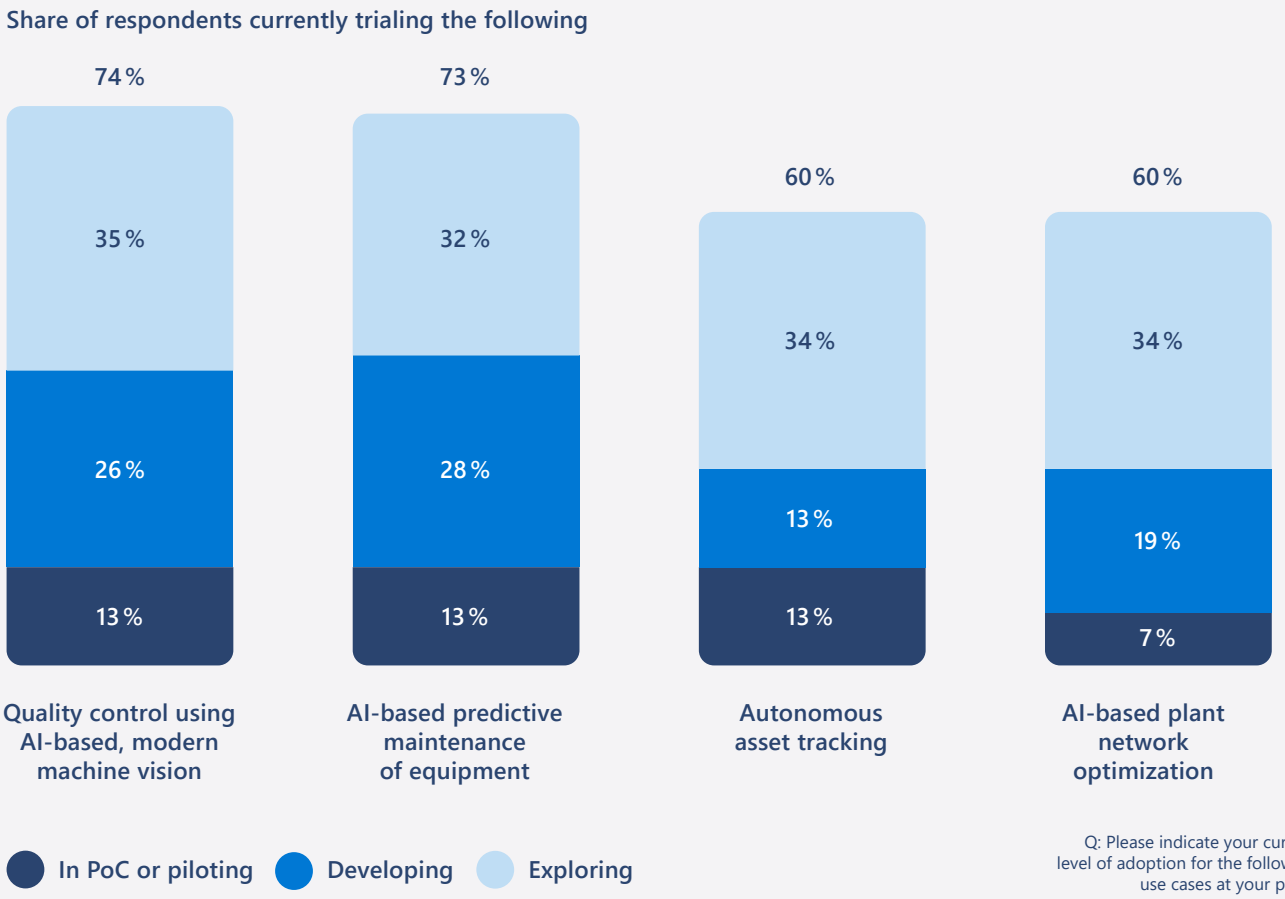
But AI is the next key thing for most companies

Manufacturers are actively exploring AI-based use cases.

Process manufacturers show a strong interest in exploring AI, with the top use cases being machine vision-based quality control (74%) and predictive maintenance of equipment (73%). These indicate a strong interest in embedding intelligence into core operations, moving beyond traditional automation. By targeting high-impact areas, companies aim to not only reduce inefficiencies but also set the stage for more adaptive manufacturing systems that can drive sustained operational excellence. AI is no longer seen as an experimental tool but as a practical solution to address critical industry challenges.

Exhibit 4: Top AI uses cases being trialed

Machine vision quality control and predictive maintenance are the top AI use cases being trialed



Q: Please indicate your current level of adoption for the following use cases at your plant.

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Top AI use case: AI-based machine vision

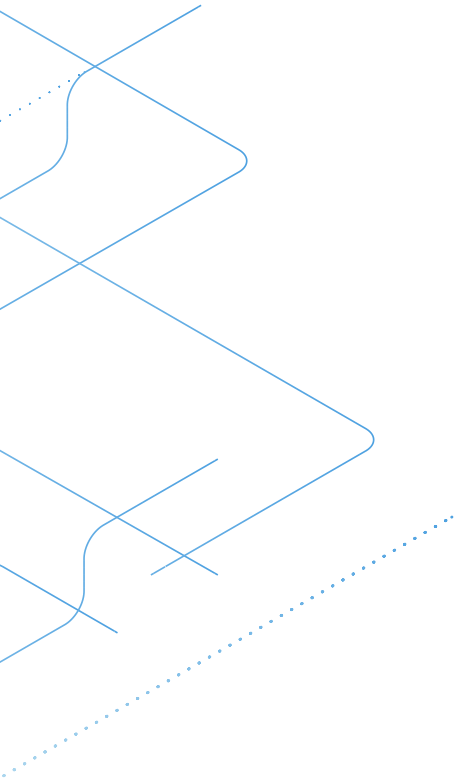
AI-driven machine vision for quality control is becoming the leading AI use case in process industries, with 74% of manufacturers currently trialing it. The use of AI-enabled cameras enables automated inspection of pipelines, reactors, or mixers to detect anomalies like leaks, discoloration, or contamination.

How much can AI help reduce costs?

Optimizing production through AI and analytics and implementing predictive maintenance of equipment is expected to reduce annual operating costs by a combined 2% over the next 3 years.

2%

Annual operating cost reduction expected through AI in next 3 years



Where is AI currently getting rolled out?

AI adoption leads in North America.

The survey reveals that AI rollout in process industries is most advanced in North America, where 24% of respondents report partial or full deployment, while Europe (6%) and APAC (5%) lag significantly. Among industry verticals, pulp and paper (22%) and specialty chemicals (15%) lead in AI adoption, followed by petrochemicals (13%), basic metals (9%), and rubber and plastics (6%). Company size shows minimal variation, with AI rollout nearly equal between mid-sized companies (13%) and corporate-level organizations (14%), suggesting a broad interest in leveraging AI across business types.

Exhibit 5: Regional view of AI roll out
North America leads AI roll out, while Europe and APAC lag

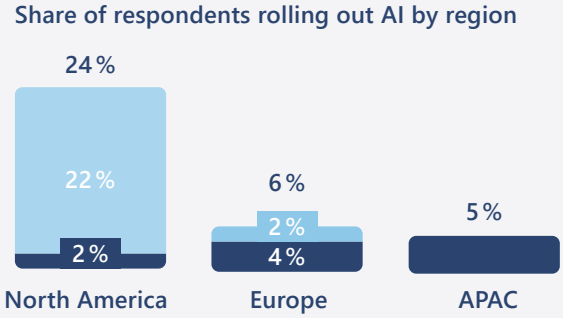


Exhibit 6: Vertical view of AI roll out
Pulp and paper and chemicals lead AI adoption

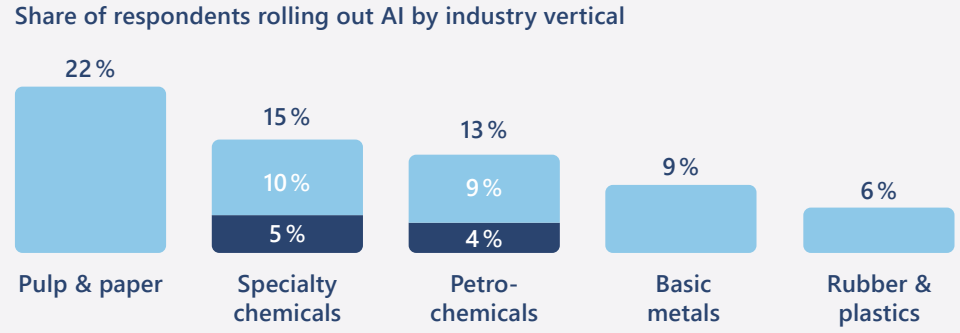
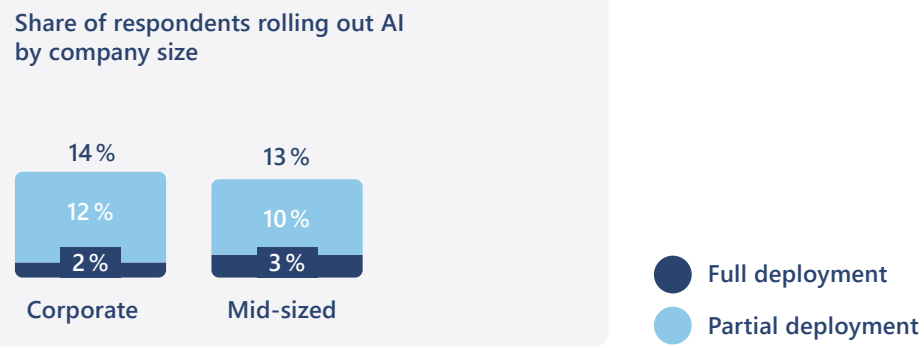


Exhibit 7: Company view of AI roll out
AI roll out is agnostic to company size



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AI seen as a key enabler for achieving goals

However, not everyone is ready for adoption

AI plays a key role in driving process optimization, predictive maintenance, and quality, among other goals. Many plants are leveraging AI to enhance efficiency, reduce operational costs, and minimize waste. Companies are carefully considering the best use cases. Despite the potential, many are not yet ready for full AI adoption, focusing instead on building the necessary infrastructure, like a strong data foundation first. Such companies feel they lack the necessary expertise to implement AI-driven solutions effectively. The journey to AI adoption isn't about rushing to implement, it's about laying the groundwork that ensures long-term success. Building data foundations, identifying scalable use cases, and fostering expertise are the steps that will differentiate industry leaders from the rest.

"We are not ready for AI yet. We lack expertise and we first need to lay the data foundation."

—CIO at a specialty chemicals company in North America

"We are thinking very hard about the best use cases for AI, particularly around maintenance & reliability of machines, quality inspection, and trying to improve human judgement."

—CXO at a general chemicals company in the UK

"AI can enhance steel production by optimizing processes, reducing energy consumption, and improving efficiency through predictive modeling and real-time process optimization."

—Team Lead at a basic metals company in South Korea

"Some operations, like hazardous crane operation, still require human guidance, despite efforts to automate and implement AI-based digital twins. While AI has been integrated into certain operations, there is still a need for human involvement in areas where full automation and AI is not yet reliable."

—Head of engineering & maintenance at a leading steel manufacturer

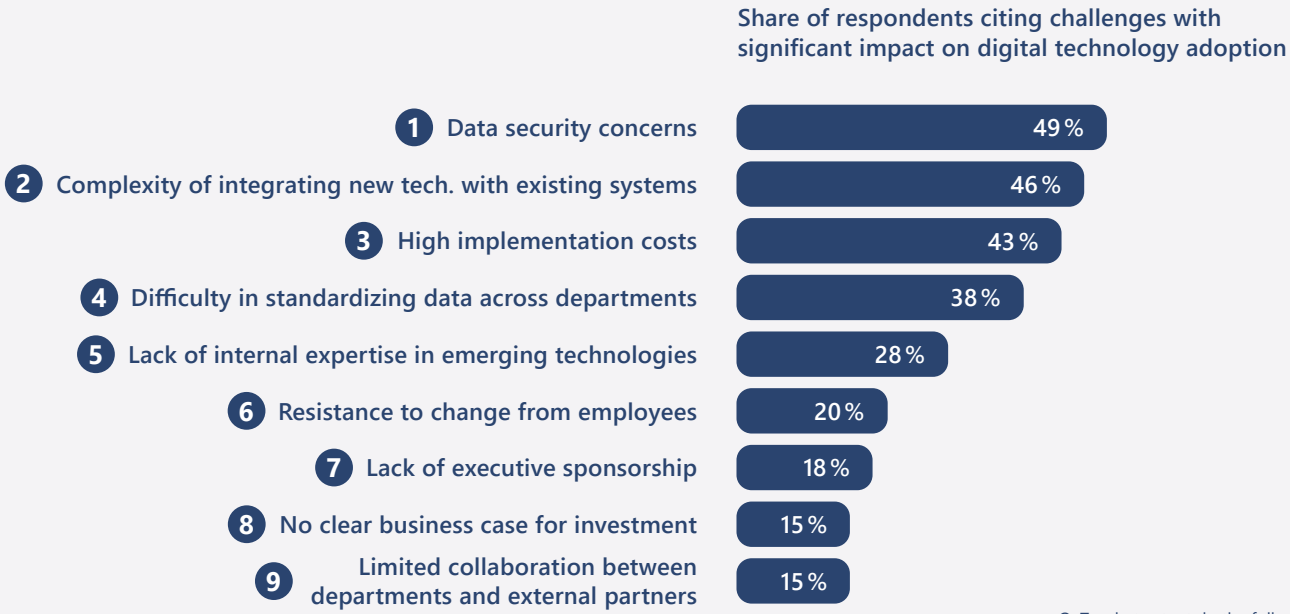
Current challenges: Security and complexity

Data security and integration issues hinder AI adoption.

Nearly half of the respondents indicate that data security concerns significantly impact their organization's adoption of digital technologies, especially AI, alongside integration complexity. The inability to fully leverage technologies like AI hinders real-time decision-making, which is critical for minimizing downtime, improving quality control, and reducing operational costs. Left unaddressed, these challenges could stall the transformative potential of advanced digital technologies in process industries.

Exhibit 8: Top technology adoption challenges

Data security and integration with legacy systems are the top technology adoption challenges



Q: To what extent do the following challenges significantly impact your organization's efforts to adopt digital technologies? *The question was presented in the context of adopting AI technologies.

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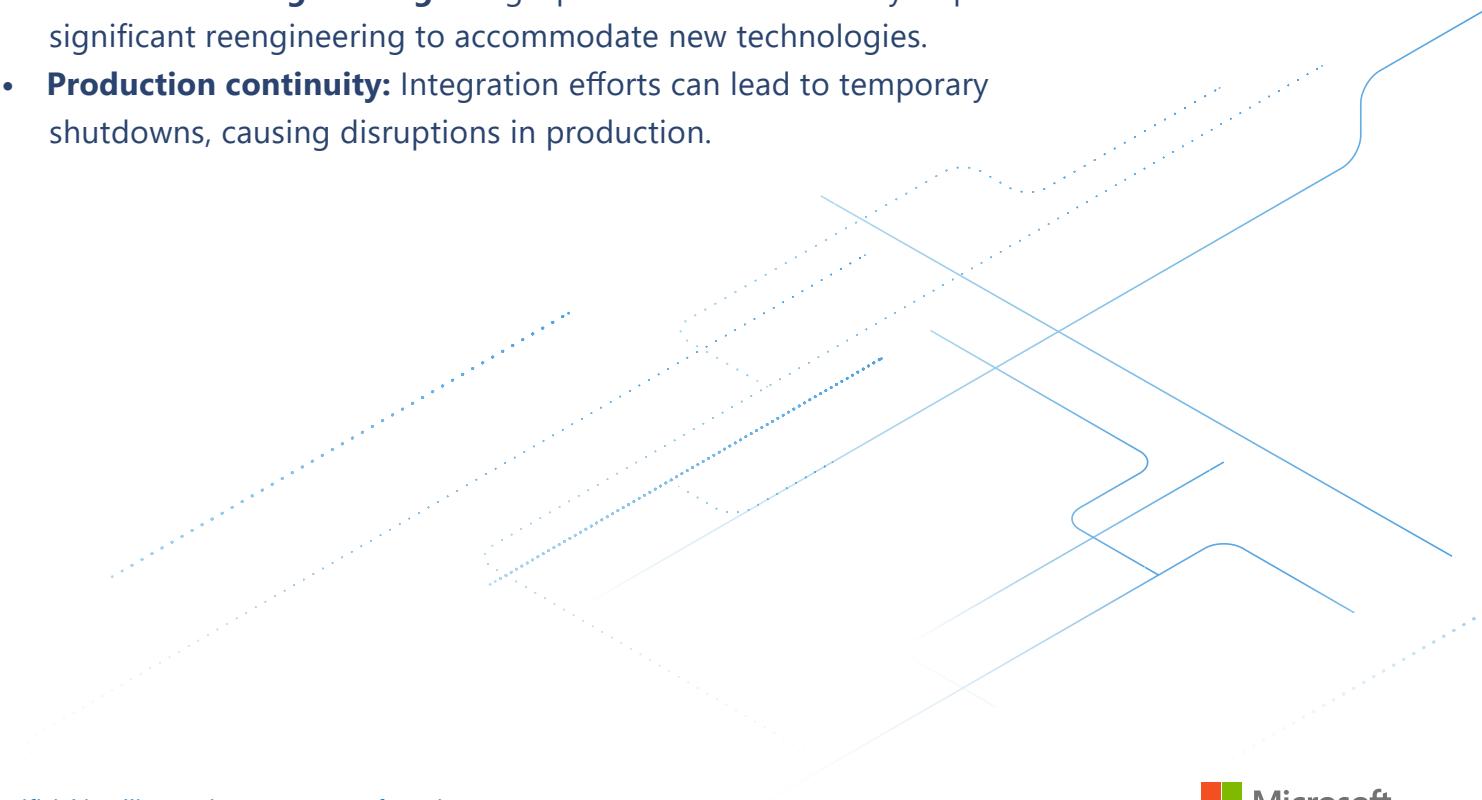
1 Data security challenges impact:

- **R&D operations:** Proprietary formulas and process data are at risk when shared across digital systems or external platforms.
- **Regulatory compliance:** Data breaches could result in penalties for non-compliance with regulatory standards.
- **Operational continuity:** Cyberattacks could disrupt production or compromise plant safety.

> "Concerns over data security and confidentiality are a major barrier to integrating external data in our R&D processes."
>
> —Head of operations, production at a petrochemicals company in the USA

2 New technologies integration challenges impact:

- **System interoperability:** Legacy control systems and connectivity solutions often lack standardization, complicating integration.
- **Workflow re-engineering:** Long-optimized workflows may require significant reengineering to accommodate new technologies.
- **Production continuity:** Integration efforts can lead to temporary shutdowns, causing disruptions in production.



2 Transforming process industry with AI

The potential of AI in process industries

AI is transforming process industries by driving value across the manufacturing value chain. From accelerating R&D with faster data analysis to optimizing operations through process efficiency and predictive maintenance, AI empowers workers with real-time insights, enhancing productivity and minimizing downtime. GenAI is gaining interest, but many companies struggle to manage expectations, often expecting it to solve problems better suited to traditional AI.

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AI plays a different role across the value chain

AI expected to transform the value chain in the process industry.

AI is expected to play a vital role across various stages in process industries. In the R&D phase, AI addresses challenges like the manual processing of large research datasets by enabling faster, more accurate analysis. In the plant operations phase, it enhances quality-focused applications by ensuring real-time defect detection and process optimization. Meanwhile, in the operate phase, AI empowers connected workers by providing real-time insights and diagnostics, enabling faster troubleshooting and minimizing downtime in critical equipment.

Top benefits of AI

R&D

1. **Reducing manual data processing**: AI automates data extraction and analysis, handling large datasets faster and more efficiently.
2. **Integrating data from multiple sources:** AI consolidates data from experiments, trials, and external databases into a unified, accessible format.
3. **Enhancing data analysis accuracy:** AI detects patterns, trends, and anomalies with greater precision, reducing errors in analysis.

Q: In your opinion, how impactful will adopting AI-assisted solutions in your R&D activities be in gaining each of the following benefits?

Intelligent plant

1. **Process optimization:** AI dynamically adjusts process parameters based on real-time data to improve efficiency and reduce waste.
2. **Quality control:** AI-powered vision systems and analytics detect defects and deviations in real-time for consistent product quality.
3. **Maintenance planning & asset mgmt.:** AI predicts equipment failures and schedules maintenance proactively, reducing downtime and improving asset reliability.

Q: How important do you regard data and analytics* in supporting the following operational decisions at your plant? *The question was presented in the context of leveraging AI to enhance operational outcomes.

Connected worker

1. **Troubleshooting equipment issues:** AI provides real-time diagnostics and guidance, helping workers identify and resolve equipment problems quickly.
2. **Optimizing task scheduling:** AI analyzes operational data and worker availability to dynamically schedule tasks, reduce bottlenecks, and prioritize critical activities.
3. **Ensuring consistent quality control:** AI assists workers with real-time quality checks, reducing variability and maintaining production standards.

Q: Which AI tools (AI chatbots for on-demand support, generative AI for contextual support, AI-based simulations) do you think will help overcome these challenges in the next 3–5 years?

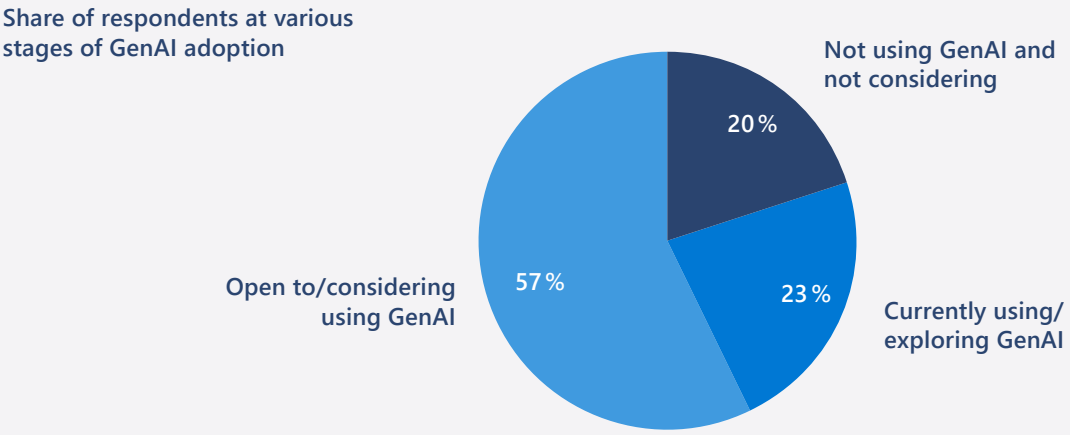
Increasing interest in GenAI

GenAI sees interest despite adoption barriers.

80% of respondents report they are either currently using GenAI or considering its adoption. Among those, use cases like process optimization were the most cited (see next page). Conversely, those not engaging with GenAI (20%) frequently attribute this to the immaturity of technology in their specific contexts or a lack of alignment with leadership priorities. As these tools mature and showcase tangible benefits, the plants not currently exploring GenAI are likely to reconsider and adopt it. Vendors are also actively addressing these gaps by integrating GenAI capabilities into their product offerings, focusing on tailored solutions for specific use cases.

Exhibit 9: GenAI adoption status

The majority of respondents are either using GenAI or planning to adopt it



"We are exploring generative analytics for understanding optimal conditions in our process manufacturing technologies. This will allow us to develop trends that will help with raw material decision-making when this is fully deployed."

—Director/head of division/head of a site of a general chemicals company in North America

"Generative AI is not of current interest because prior pilots have failed to show significant improvement and actually required more labor to double-check any possible mistakes. The pilot was disruptive to current operations due to limited personnel."

—VP of a general chemicals company in North America

Evolving GenAI use cases

GenAI drives interest through operational efficiency gains.

Respondents highlighted several use cases where GenAI could make a substantial impact. The top use cases emphasize operational optimization, including improving production efficiency, reducing waste, and preventing downtime. This suggests that the primary interest in GenAI lies in its potential to enable efficient operations and deliver measurable gains in productivity.

Exhibit 10: Top GenAI use cases

Process optimization is the top GenAI use case

Q: For what use cases is your plant currently using or considering using generative AI? Note: Respondents were allowed to mention multiple use cases, hence the total percentage exceeds 100%.

"We have already rolled out two GenAI-based chatbot solutions globally. One provides real-time guidance to operators, helping novice operators during startup and shutdown by giving step-by-step instructions on standard operating procedures (SoP), eliminating the need for multiple back-and-forth phone consultations. The other solution assists quality operators who may have forgotten the sample preparation process by instantly providing the required steps when prompted."

—Digitalization director at a large chemical company

"We are exploring GenAI to understand optimal conditions for our manufacturing, which will help with raw material decision-making."

—Head of innovation at a chemical company in the USA

"By using GenAI, we can create innovative designs for plastic products that are not only functional but also optimized for manufacturability."

—Senior mfg. manager at a rubber and plastics manufacturer in Europe

GenAI: Perception vs. Reality

Many respondents struggled to differentiate GenAI from traditional AI, leading to the inclusion of use cases that may extend beyond the capabilities of GenAI. For example, predictive analytics was cited as a GenAI use case, even though it is better suited to traditional AI. This shows a misalignment between expectations and technology fit, highlighting the need for education on GenAI's strengths.

Case Study:

How a global chemical manufacturer is adopting AI

European chemical company has tremendous success using AI to transform operations and R&D.

A European chemicals company is at the forefront of AI adoption. The foundation was laid way before GenAI reached mainstream status. The company invested in a solid data foundation early and built a culture where small and local innovations can become global hits. The company is now starting to reap the rewards from this strategy, with AI seen as the reason that the time-to-market of new products has more than halved, demand planning costs have significantly reduced, and GenAI tools that save hours of time have been rolled out.

1 How did the AI journey begin?

1. **Dedicated digital unit:** In 2019, the company created its own Digitalization & Information Services division to streamline digital investments.
2. **State-of-the-art digital capabilities:** The company has invested in state-of-the-art digital infrastructure like IoT sensors and cloud platforms for years.
3. **Fostered a local innovation mindset:** Over the years, the company has built a culture of innovation through training and idea generation, where local ideas count and can become a global initiative if successful. Cross-functional teams lead those digital initiatives.

> "When I came up with an AI-based chatbot for operator onboarding in 2023, I never imagined that this project would become so significant and viral within the company."
>
> **—ML/AI engineer at a local site in Spain**

2 How is data managed to support AI initiatives?

1. **Data streams are separated into control data and non-control data:** The company treats data in its control loop (e.g., data in the DCS system) that require real-time actions differently from sensor data that do not require real-time capability. The control loop flows continuously to DCS and historians and is eventually brought into the enterprise data lake (EDL). Non-control loop data (e.g., tank level data) is transmitted less frequently and mostly via a private 5G network or LoRa devices. Automation gateways sync this data automatically via Kafka to the cloud and into the Microsoft EDL, where the data lives as a single source of truth.
2. **Applications are fed from the enterprise data lake:** Data in the EDL can be accessed by various applications, most notably a data science platform (DSP), which is in use enterprise-wide.

> "We have integrated historian data, supply chain data, SAP data, IoT data, and third-party data into a sanitized and trusted structure. Through rigorous data quality assessment and cleansing, this data lake serves as the single source of truth of the organization's data. Whether it's a sales manager, R&D specialist, CXO, or supervisor, everyone accesses tailored datacubes, pre-configured or contextualized on the fly."
>
> —Digitalization director

3 What are some of the barriers to AI adoption?

1. **Integrating data from legacy systems is difficult:** Integrating AI with existing legacy systems has shown to be a key challenge throughout the journey, as older assets and so-called brownfield sites lack the ability to stream data into the EDL seamlessly.
2. **Data security is crucial, limiting direct data access to control loop data:** AI adoption is constrained by strict security protocols, especially regarding data flow between different network layers. Safeguarding sensitive operations requires complex measures like data diodes, VPNs with two-factor authentication, network segmentation, etc. Direct data access to control-loop devices is not allowed.
3. **Regulatory compliance for data privacy and sharing:** Navigating existing and upcoming regulatory frameworks, such as stringent EU data privacy laws and other regulations, presents hurdles. For example, the Data Act (Regulation (EU) 2023/2854).

> "In brownfield environments, legacy systems pose significant challenges. Take a water treatment plant, for example, where a PLC might lack an OPC server, making it impossible to integrate its data into EDL. Modernizing such systems is crucial, but business is not always willing to spend. In those cases, we rely on semi-automatic transfer, extracting data as XML or CSV and throwing it into shared services and repositories to bring the data into EDL."
>
> —Digitalization director

4 Where is AI successfully used today?

1. **AI is used to create new product formulations:** An AI-driven virtual experiment simulation platform is in place that is trained on real and experimental product data. When the need for a product enhancement arises—e.g., the viscosity needs to change—new isotope combinations can be simulated. By doing so, there is no need to perform hundreds of physical experiments, significantly shortening the time for a new formulation.
2. **An operator chatbot provides work instructions:** A GenAI chatbot guides novice operators through SOPs during startup and shutdown, reducing errors and ramp-up time and ensuring smoother operations.
3. **AI-based vision control allows for increased operator safety:** AI-powered vision systems (people positioning systems) detect safety violations like missing protective gear, improving safety compliance and minimizing workplace risks.
4. **AI is used in asset failure prediction:** AI-driven predictive analytics is used for high-value assets to predict failures before they occur.

> "We have a people positioning system (PPS) in place to ensure safety in hazardous areas. If someone enters a hazardous zone, the PPS alerts on their position. For example, if an untrained person enters Zone 1 multiple times in a month. Also, our AI-powered vision control for EHS detects safety violations, such as a contractor entering a hazardous zone without a life vest."
>
> —Digitalization director

5 Is AI truly a gamechanger?

1. **More accurate demand forecasting:** AI-driven models that rely on a multitude of external data have reduced the cost of demand forecasting by >90% of previous expenditure while increasing forecast accuracy.
2. **>50% faster time-to-market:** Time for molecular enhancements has dropped from 6 months to 6–8 weeks, while new molecule development timelines have been reduced from 12–18 months to 7–8 months.
3. **Knowledge retrieval in seconds instead of days:** The time to search for engineering data now takes about 5 seconds with a GenAI-based support chatbot, whereas in the past, it sometimes took operators two days to locate and read the respective manual.

> "AI-based molecular enhancement is phenomenal. The speed of our time-to-market is reduced from months to weeks. AI-driven models have also increased the demand forecasting accuracy while reducing costs."
>
> —Digitalization director

6 What is the future vision?

The company is only at the beginning of the AI journey. Executive management has laid out a plan to increase AI investments and achieve significant margin improvement as a result in the coming years. Key focus areas include:

1. **Optimized value management:** Encouraged by the demand forecasting results, the company envisions greater precision in general decision-making and resource allocation throughout the organization, transforming how value is managed across operations.
2. **Augmented customer experience and supplier collaboration:** The company is achieving deeper insights into customer needs and stronger supplier partnerships, paving the way for business growth.
3. **Accelerated innovation:** Leveraging the early successes of reducing time-to-market for molecule design, the company plans to expand the application of AI-driven R&D throughout the organization, with further time-to-market reduction expected.
4. **Enhanced production efficiency and safety:** The company plans further use of vision systems (where allowed) to achieve more efficient, reliable, and safer production processes, reducing risks and elevating operational standards.

3 Getting started with AI

A roadmap to implementing AI

Successfully implementing AI in process industries starts with a clear, structured approach. It begins by identifying business needs, forming cross-functional teams, and establishing solid data foundations. Integrating AI tools into daily operations enhances problem-solving capabilities, fostering a more skilled workforce and paving the way for scalable AI adoption.

Microsoft

Getting started with AI in process industry

Getting started with AI in process industries requires a structured approach.

To successfully implement AI, start by identifying a clear business need that AI can address, ensuring alignment with organizational goals. Build cross-functional teams that integrate AI experts, business stakeholders, and IT to drive collaboration and flexibility. Assess and improve data readiness, unifying repositories and addressing gaps in data collection and processing. Finally, leverage AI tools to upskill your workforce, enabling them to adopt and benefit from AI-driven innovations effectively.

4 steps to getting started with AI

1. **Identify business need**
   Focus on identifying the core business problem or challenge. Avoid starting with technology.
2. **Embrace structural flexibility**
   Build multidisciplinary teams integrating AI/data experts, IT, and business stakeholders.
3. **Get the data in order**
   Assess data maturity: how data is collected, stored, and processed. Unify data repositories and improve data quality.
4. **Use AI to develop skills**
   Use AI to enhance problem-solving capabilities across the workforce.

Step 1: Identify business need

Successful AI adoption requires clear business alignment.

AI adoption starts with identifying the right use case that is aligned with business needs and goals. Only 15% of survey respondents cited a lack of executive sponsorship or a clear business case as challenges, highlighting strong management support for AI initiatives. This places the onus on plant stakeholders to focus on the right business need and drive implementation.

Examples of business needs addressed by AI

- **Faster time-to-market.** Shorten long R&D cycles by using AI to screen millions of chemical candidates to identify the most viable options based on properties like solubility, bioactivity, and structural stability, drastically reducing time-to-market.
- **Reduced downtime.** Reduce costly unplanned downtime by analyzing equipment data with AI to predict and prevent failures before they occur.
- **Improved quality control.** Eliminate inefficiencies in quality control by automating inspections with AI, detecting defects in production processes, and minimizing waste.
- **Reduced energy expenses.** Combat high energy costs and inefficiencies by leveraging AI to analyze production schedules, equipment performance, and energy demand patterns.
- **Sustainable growth.** Meet sustainability targets while driving product innovation by using AI simulations to develop new products with reduced environmental impact.
- **Improved workforce productivity.** Overcome workforce limitations in data analysis by equipping non-IT staff with AI tools for complex data modeling and problem-solving.

Examples of business needs addressed by GenAI

- **Accelerated product design.** Address inefficiencies in product design cycles by leveraging generative design and real-time iterative processes, using CAD models.
- **Simplified application development.** Reduce complexity in application development by using AI-assisted coding and PLC programming to simplify lifecycle management and accelerate software development for connected products.
- **Enhanced operational visibility.** Overcome challenges in operational visibility by unifying facility and plant data with AI, enabling real-time production monitoring, root cause analysis, and improved worker collaboration.
- **Unified decision-making across operations.** Eliminate silos in decision-making processes by enhancing knowledge discovery across R&D, assets, processes, and supply chain information with AI-powered solutions.
- **Improved worker safety and efficiency.** Improve worker safety and task efficiency by providing frontline staff with AI-driven, real-time insights tailored to their roles and environment.

> "We bring our scientific expertise to bear on picking the most promising material candidates. In this case, we had the AI insights that pointed us to potentially fruitful territory so much faster."
>
> **–Karl Mueller, program development office director, Pacific Northwest National Laboratory**

Step 2: Embrace structural flexibility

Successful AI deployment thrives on cross-functional collaboration.

Nearly 73% of survey respondents identified the lack of internal expertise as having a considerable impact on their efforts to adopt digital technologies like AI, underscoring the need for collaboration. Breaking down silos by engaging AI experts, data scientists, site personnel, engineers, IT, and business stakeholders ensures use cases align with both operational realities and technical capabilities. Co-creating AI use cases with product owners and site teams increases the likelihood of practical and impactful deployment.

How to embrace structural flexibility

A **Build collaborative teams that align expertise with goals**

Pair AI specialists with domain experts to blend technical capabilities with business knowledge. Encourage AI experts, product owners, and IT personnel to actively co-create AI use cases, ensuring solutions are practical and impact-driven.

B **Pilot, learn, and scale AI use cases iteratively**

Start with high-impact pilot use cases that involve cross-functional input. Analyze results, gather feedback, and refine solutions.

"Any AI project requires a cross-functional team. For process optimization, it's essential to have material experts, process specialists, and operators with firsthand insights. These people have the knowledge to identify issues and improvements. Ultimately, a smaller team with 3 to 5 such experts and an external AI specialist considers these inputs to develop AI-based solutions. Without such cross-functional collaboration, running an AI project is simply impossible."

—Head of engineering & maintenance at a leading steel manufacturer

Step 3: Get the data in order

Effective AI relies on strong data foundations.

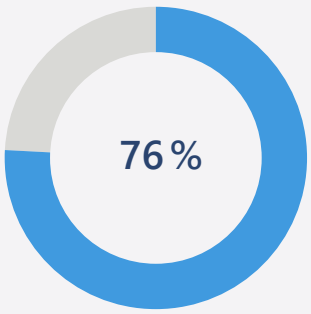
AI requires data maturity to be effective. Organizations must assess how they collect, store, and process data, addressing weaknesses before implementing AI use cases. Key steps include unifying data repositories for better accessibility and quality. 76% of companies prioritize improving data integration and analytics, while 39% have already adopted data lakes and unified data platforms, showing progress in data organization.

Exhibit 11: Companies are working to get their data in order

Companies are improving their data integration and analytics capabilities, with many adopting data lakes and unified platforms

Share of respondents pointing to the following action as the top priority

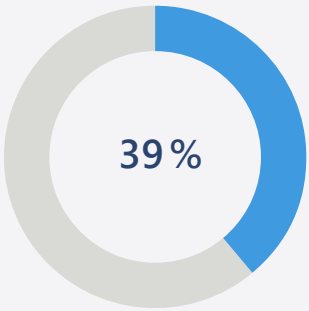
1. Prioritizing the improvement of data integration and analytics capabilities



Question: To what extent is each of the following a priority for transforming your org.'s operations over the next 3–5 years?

Share of respondents who are at the following stage of adoption

2. Fully or partially adopted data lakes and unified data platforms



Question: At what stage is your plant in adopting the following technologies?

Shining success stories of getting data in order

Bayer addressed fragmented and unstructured research data by adopting centralized platforms to unify their data repository. This allowed researchers to locate and reuse predictive models efficiently, saving months of duplicated effort and enabling faster product delivery.

Intertape Polymer Group adopted a data-first platform to centralize and organize data, creating a scalable foundation for capturing and contextualizing information across the plant. This provided a systemwide view of production processes, making data easily accessible to anyone.

Step 4: Use AI to develop skills

AI as a catalyst for workforce skill development.

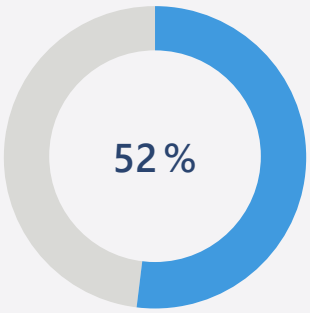
Organizations should leverage AI not only as a tool for operations but also as a means to bridge skill gaps within their workforce. GenAI can simplify complex processes, enabling engineers and non-IT staff to effectively engage with AI models. This is increasingly recognized, with 52% of respondents citing AI as very important for training and upskilling workers. Organizations should integrate AI tools into day-to-day operations to help production staff enhance their problem-solving capabilities, fostering a more skilled and adaptive workforce.

Exhibit 12: Role of AI in developing skills

AI is considered very important for training and upskilling workers

Share of respondents citing the role of AI* as very important for the following

Training and upskilling for workers



Q: How important do you regard data and analytics in supporting the following operational decisions at your plant? Select the level of importance for each decision. *The question was presented in the context of leveraging AI to enhance operational outcomes.

"[GenAI] can be used for in-depth report generation without any manual work, as well as for virtually training employees."

—Head of manufacturing IT at a paper company in the USA

"We use [GenAI] for RFP management, document preparation & review, addressing customer queries, and project management."

—Head of process engineering at a chemical products company in India

"Our company uses GenAI for screening candidates."

—Chief digital officer at a chemical company in the USA

Case Study:

Bayer's structured approach to AI adoption

Bayer accelerated innovation through AI-driven operational efficiency.

Bayer, a global life sciences leader, demonstrates how addressing specific business needs, fostering cross-functional collaboration, and prioritizing data readiness can drive impactful outcomes. Bayer improved productivity and accelerated product delivery, providing a replicable roadmap for AI adoption in process industries.

1 Identify business need

Bayer recognized that inefficiencies in managing unstructured research data impacted access to critical insights for R&D and operational decision-making. It focused on challenges such as collaboration and data access to accelerate product delivery timelines.

2 Embrace structural flexibility

Bayer deployed cross-functional teams comprising data scientists and laboratory researchers. It introduced an AI-powered platform that bridges communication gaps by enabling researchers to search, locate, and reuse predictive models efficiently.

3 Get the data in order

Bayer centralized its data using unified repositories to manage structured and unstructured data. Tools were used for improved access to decades of research knowledge, eliminating duplicated efforts and saving months of work.

4 Use AI to develop skills

Bayer enabled non-technical staff to use AI to quickly retrieve insights, analyze data, and focus on strategic activities. GenAI applications simplified tasks such as summarizing large documents, expediting email processing, and drafting reports.

"Our employees have more power to support farmers, help cure diseases, and see consumers healthier."

—Christoph Sieger, VP, head of global digital workplace at Bayer

"We are seeing a lot of curiosity in our HR, R&D, IT, Procurement, and Marketing groups. Already, people are saying they are getting more productive every day."

—Christoph Sieger, VP, head of global digital workplace at Bayer

How Microsoft can support your next actions

For numerous process manufacturers, adopting artificial intelligence presents a significant challenge due to the rapidly evolving nature of the technology and determining the optimal areas for its implementation to maximize business benefits. However, the opportunity and impacts are transformational for organizations to help drive efficiency improvements, quality control, cost reductions, and business growth. Given the highly competitive and dynamic environment, now is the time for action.

To learn more about how Microsoft can help your AI planning and strategies with a market leading industrial AI technology platform and real solutions to build the plant of the future, review these resources:

Learn how AI is driving a new era of industrial transformation

Microsoft Cloud for Manufacturing: Design, build, and operate with AI

3 practical ways industrial AI is reshaping manufacturing - Microsoft Industry Blogs

IOT ANALYTICS

This report is based on research by IoT Analytics.

IoT Analytics, founded and operating out of Germany, is a leading global provider of market insights and strategic business intelligence for the IoT, AI, the cloud, edge technology, and Industry 4.0.

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