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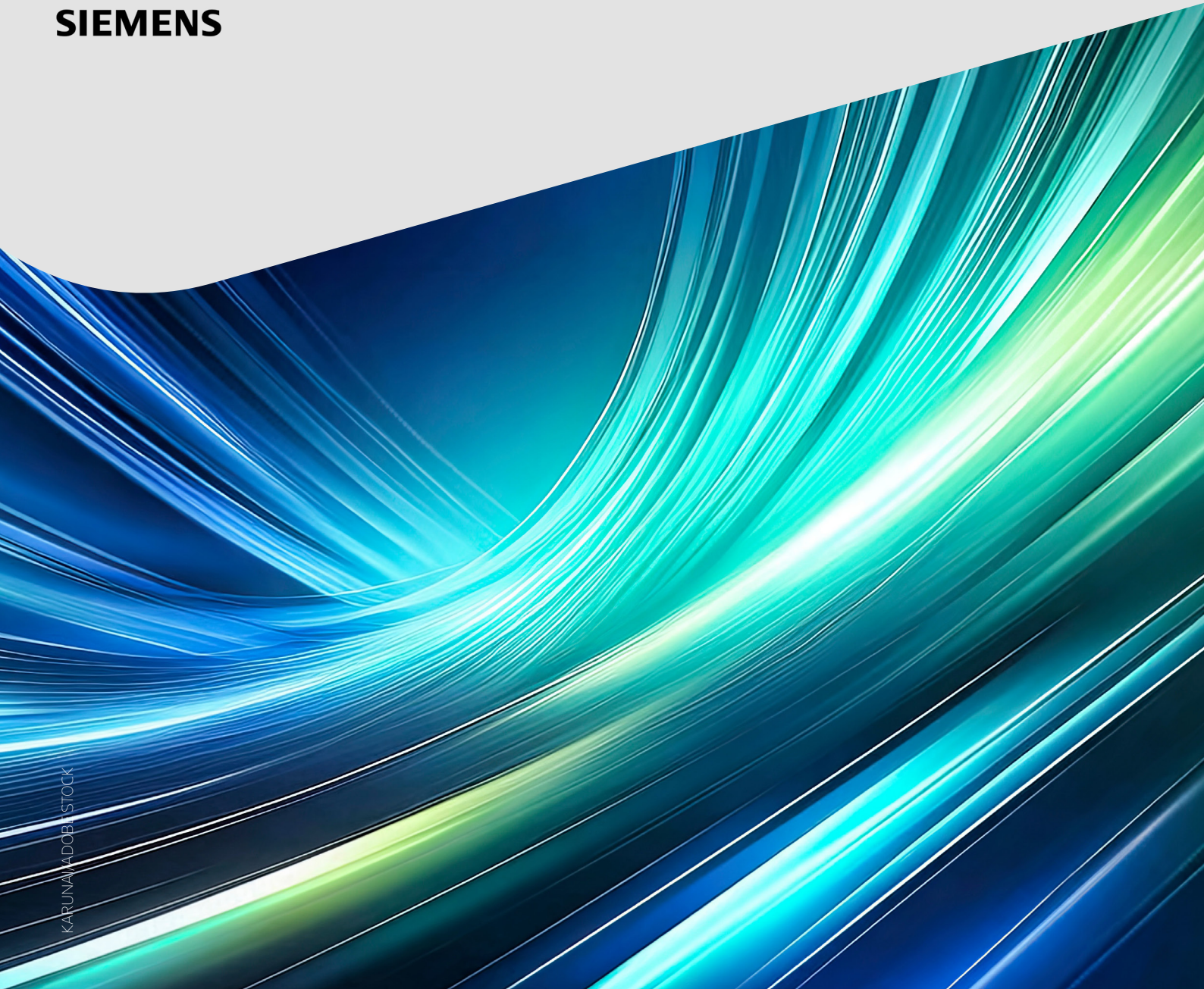
A NEW PACE OF CHANGE

INDUSTRIAL AI x SUSTAINABILITY

The Executive Perspective

In cooperation with

SIEMENS



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FOREWORD

A COMPLEX WORLD WITH COMPLEX CHALLENGES

Industrial organizations worldwide face similar challenges: societies are aging, we face skilled worker shortages, supply chains are strained, and geopolitical conflict is ever present. All these issues require unprecedented and transformational solutions. But it is the existential threat of climate change that unites us all in industry and beyond. We are in a race to decarbonize, and with around 30 percent of the global greenhouse gas emissions coming from industry, we have a responsibility to do the right thing.

Using digital technologies and by harnessing the power of data, industrial companies are becoming more resource-efficient, more productive, and more sustainable. Yet, while there has been progress, enterprises of all sizes are nevertheless grappling with the dual transformation of digitalization and sustainability. Whereby the progress of one determines the progress of the other. Many find managing the pace, scale, and complexity of the transformative change required to meet net zero targets and mitigate environmental impacts to be extremely challenging.

OUT OF TIME? WE NEED TO DO THINGS DIFFERENTLY

But time is running out. Or as Bill Gates put it in his book "How to Avoid a Climate Disaster": "We need to accomplish something gigantic we have never done before, much faster than we have ever done anything similar." So, urgency is essential but so is precision.

Think of it like the classic slot car game; digitalization is the accelerator, pushing the car – your business – faster on the track ahead. In the real world, this enables quicker production, market agility, and sustainable transformation. But at some point, you will hit a speed limit or fly off the 'track' at a curve. In business, progress stalls, strategy gets diluted, efficiency drops.

> ***"ARTIFICIAL INTELLIGENCE SYSTEMS HAVE THE POTENTIAL TO HELP US UNDERSTAND THE WORLD IN ALL ITS COMPLEXITY AND OPTIMIZE INDUSTRIAL PROCESSES"***
>
> - James Cole, **Chief Innovation Officer at the Cambridge Institute for Sustainability Leadership**

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Here's where AI comes into play: it acts like the elevated curves of the track keeping the vehicle grounded despite its speed. Every variable impacting that car – velocity, friction, timing – is under control. All data within the organization is harnessed to push the limits; mastering sharp turns in markets, resource management, and strategic vision without losing momentum.

AI can make the difference. It lets you go faster while ensuring you stay on the track. It helps turn a race to transform into a finely tuned victory lap.

AI: THE HYPE AND THE HOPE

As consumers, AI based tools have become a feature in daily lives, from helping us write better copy to translating languages in real time. However, we have not yet reached the checkered flag in the AI race. There is great talk about AI's gigantic potential, but it has yet to materialize in supporting tangible societal progress and large-scale development, significant GDP growth, or broad economic gains outside of a small group of tech players.


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This raises the questions: is AI overhyped? And should we therefore deprioritize it and turn to other technological developments? The answer to the first is "yes" but to the second, "no"! Undoubtedly there is a level of hype, but the technology behind this is real and will have a transformative impact.

In fact, industry has been steadily developing AI since the 1970s, making it reliable, secure, trustworthy, and suitable for industrial use. 'Industrial AI' now meets the requirements of the most demanding environments, enabling us to communicate with software, equipment, or machines in natural language, and helping us to design processes or even entire plants.

Crucially, industrial AI is making a difference in the one area where we cannot afford any hype: sustainability. It enables us to leverage all the data that sits in our Digital Twins to do things faster in the virtual world first, improving efficiency and reducing waste so that we can do more with less.

AS VITAL AS HAMMER TO NAIL – DATA AS THE FOUNDATION FOR INDUSTRIAL AI

Industrial AI enables us to harness the one vital thing we have in abundance across industries: huge amounts of data. We've all heard it. Data is the new oil – but with far greater potential for sustainable good. AI gives us the means to transform that data into meaningful information, turning numbers into actionable insights.

In the future, we will be able to develop new industrial AI solutions much faster thanks to the power of data. The next powerful models will be trained around industrial environments, with industrial data – Industrial Language Models. Today the modalities –the types of input and output data an AI system can interpret – are pictures, texts, video, or code. Soon these will also be 3D/CAD data, 2D/complex diagrams, time series, and industrial business data.

ACCELERATING THROUGH THE CURVES – HOW DO WE DRIVE AI FORWARD?

What this Reuters report shows us is that the real value and potential benefit of AI lies in the industrial world – the backbone of our economies. Our opportunity is to extract the most useful parts of industrial AI and to combine them with data and other technologies like Digital Twins or software-defined automation. It will be a supercharger for digital and sustainability transformation – and we have only scratched the surface.

Reaping the full benefits of industrial AI will largely depend on whether we as industrial companies can master the complexities, fully adopt, and scale this technology, and jointly drive it forward. We also need to heavily invest in the enablers of AI – chips, compute, and people. Without the compute powered by chips and the AI experts creating the smart algorithms, AI will not reach its full potential.

Now is the time for boldness; to scale the development and application of industrial AI – both bottom-up and top-down – at speed.

THE WHY OF AI – TECHNOLOGY TO DO MORE WITH LESS

We always need to come back to the 'Why of AI.' We must not use AI – or indeed any other technology – just for the sake of it. Technology can only ever be our 'How' in making an impact and transforming the everyday.

To win the race against climate change, we are going to need every bit of creativity we can get. Not just human creativity. AI will enable us to do more with less in our industrial world. It's our duty to make sure we use it for good.

Cedrik Neike
Managing Board Member and CEO Digital Industries
Siemens AG

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FOREWORD

Welcome to the Industrial AI x Sustainability report, produced by Reuters Events in cooperation with Siemens.

This study has been conducted to chart the role of industrial AI in sustainability-focussed operations and initiatives, reflecting both how organizations are implementing industrial AI today and how they expect to integrate it in the future. We have explored the benefits experienced by organizations integrating industrial AI, specific use-cases for the technology and the challenges faced.

We have used a mixed-methodology research approach to inform the contents of this study. Qualitative interviews with senior executives and thought leaders within the space have supported quantitative analysis of survey data.

In total, more than 200 senior company executives participated in the survey, with respondents filtered to ensure sufficient seniority and relevance to their organization's AI and/or sustainability strategies. Further detail on the breakdown of participants can be found in the methodology section of this report.

We would like to take this opportunity to thank all that participated in the survey, alongside those who helped with our qualitative research. This report would not have been possible without their valuable contributions.

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Liam Stoker
Market Insights Lead
Reuters Events

ONE ROAD AHEAD: THE GLOBAL RACE AGAINST CLIMATE CHANGE

The world is today facing a period of unprecedented and transformational change. Driven by overarching megatrends such as demographic change, urbanization, glocalization, climate change and resource efficiency, and digitalization, how we respond to this change promises to shape our collective future.

The pressure of time intensifies each of these trends, yet the pressure becomes existential regarding the threat of climate change. The world faces a race against the clock to sufficiently decarbonize and avert human-induced environmental impacts. To achieve what's required, within a timeframe compliant with the Paris Climate Agreements, requires swift, large-scale, effective, and collective action.

Encouragingly, there are the technologies and approaches to enable and accelerate the required sustainability transformation. Digitalization is proving to be a key enabler, empowering organizations to fast-track their sustainability goals along key impact areas, including but not limited to:

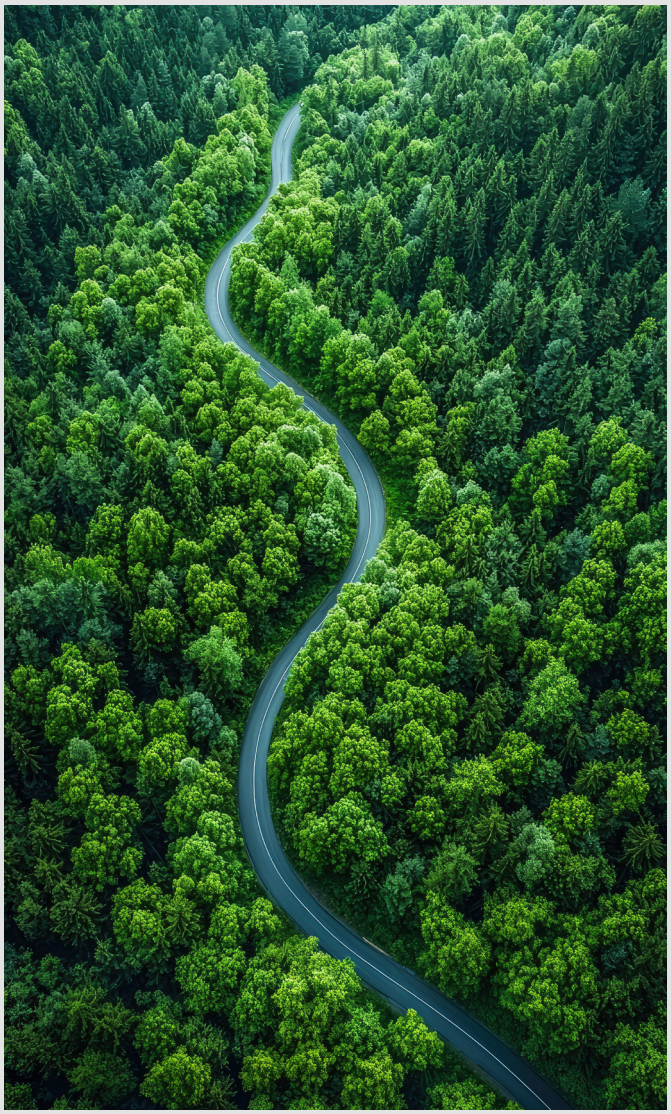
1 **DECARBONIZATION AND ENERGY EFFICIENCY:** prioritizing carbon footprint management, renewables integration, electrification, and energy efficiency

2 **RESOURCE EFFICIENCY AND CIRCULARITY:** enabling greater circularity through products, services, and software across the entire value chain

3 **PEOPLE CENTRICITY AND SOCIETAL IMPACT:** ensuring secure and equitable access to essential resources, for example mobility, electricity, food and water, as well as safe and comfortable built environments

Within this context, Artificial Intelligence (AI) holds promise to be a game-changer. Its application within the industrial world is transforming our ability to master complex multidimensional problems at unprecedented speed and scale. It is, for example, supporting end-to-end grid management amidst growing distributed energy resources, enhancing supply chain-wide insights to help lower emissions, expanding design capabilities to reduce environmental impact and risk, and more, as this paper will explore.

Now is the time for opportunity to be translated at speed and scale into the required action. Afterall, climate change is perhaps unique in that we all face the same threat and must



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cross the same finish line to avoid it: humanity is united in this race.

Yet, within this race demanding unity, the reality is a divided picture. Just over half (54%) of our survey respondents, for example, said their organization is either meeting or ahead of reaching their interim energy transition goals. That leaves 46% of respondents indicating the opposite – that their organization is at risk of missing interim targets. In fact, 14% admit their organization is currently lagging behind by a wide margin or has yet to make any progress towards its goals.

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These findings align with those of the 2023 edition of the Siemens Infrastructure Transition Monitor, which revealed a similarly divided landscape: in which fewer than half of organizations (44%) expect to meet interim decarbonization targets by 2030.

With time being very much of the essence, it is imperative that obstacles to collective progress are understood and overcome.

A COLLISION OF COMPLEXITY

One clear challenge is that the context in which organizations are managing their sustainability transformations is indeed complex.

46%

of respondents said their organization is at risk of missing interim energy transition goals

In discussing this, James Cole, Chief Innovation Officer at the Cambridge Institute for Sustainability Leadership (CISL), citing the recent report Navigating low carbon disruption, identifies the need for 'systems thinking' in the decision making of businesses and governments.

This is "embracing the complexity and interconnectedness of whole real-world systems, rather than attempting to distil out individual parts or phenomena in isolation." It conveys that the feedback and interaction emerging from this interconnectedness is crucial to delivering the level of transformation climate change demands.

In practice, Cole outlines, the level of change required necessitates disruption, bringing existential challenges and opportunities to organizations across technological, economic and cultural domains. Environmental progress at the scale required is not insurmountable but the complexity of it must be embraced and navigated.

Pina Schlombs, Sustainability Lead, DACH, Siemens Digital Industries Software, reinforces this context of complexity in which organizations are managing their sustainability goals. "Sustainability is interconnected with all other business objectives, simultaneously influencing and being influenced by them. These relationships can either compete with or reinforce progress, meaning businesses must develop a thorough understanding of the cause-and-effect chains. This is a complex feat, but mastering it allows organizations to leverage the right strategies and technology stack at the right time and maturity, to scale progress fast."

Breaking this down further, our survey respondents highlight the challenge of driving their own sustainability transformations across a number of levels: a lack of necessary funding to reach energy transition targets, technological and skills hurdles, and the complexity of decarbonizing operations and processes themselves.

Such intertwined challenges are felt across industries. The question becomes how organizations can conquer the complexities of their own sustainability transformations to help accelerate and scale holistic progress in the race against climate change?

HOW (AND WHEN) TO MOVE FASTER: UNPACKING INDUSTRIAL AI'S POTENTIAL

With complexity identified as one of the primary obstacles to sustainability transformation, industrial AI holds significant promise as a solution. "We've never had such powerful tools to solve the challenges we face in sustainability," continues CISL's Cole. "Artificial Intelligence systems have the potential to help us understand the world in all its complexity and optimize industrial processes not only for strong business outcomes, but also for holistic social and environmental outcomes."

Our research indicates that this potential is not lost on the global business community. More than two-thirds (69%) of respondents consider industrial AI as "essential" in helping simplify the complexity of climate change for their respective organizations.

While there is a more measured response for industrial AI's application today – 42% of respondents consider the technology having a 'high' or 'medium' impact – the verdict was almost unanimous for the role of industrial AI in the near future. Some 91% of respondents said industrial AI would have a 'high' or 'medium' impact on accelerating the energy transition in their industries within three years' time.

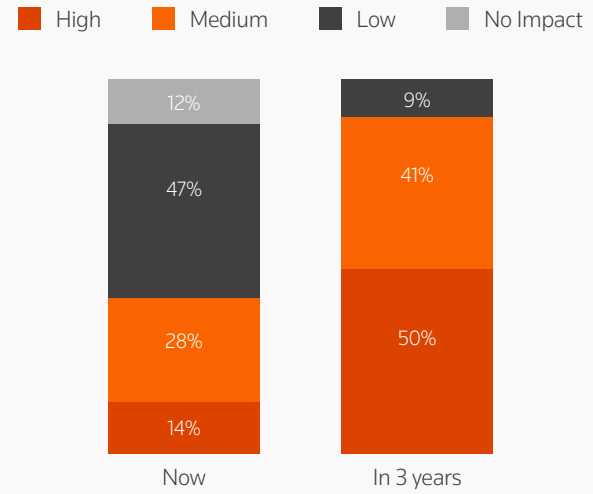
IDENTIFYING SPECIFIC OPPORTUNITIES FOR INDUSTRIAL AI

To unpack this further, our research focused on the potential use cases for industrial AI, across both sustainable operations and products. Respondents indicated priority

Figure 1

Industrial AI is set to have a significant impact on accelerating the energy transition in industries in the next three years

Share of survey respondents indicating the level of positive impact industrial AI applications will have on accelerating industry energy transitions, ranked by both today and in three years



**Note: The percentages might not add up to 100 per cent due to rounding error.*

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Role of Industrial AI in Sustainability Study, 2024

WHAT IS INDUSTRIAL AI?

Within the accelerated digitalization of our economies, Artificial Intelligence (AI) represents one of the transformative technologies of our time. AI refers to software that can learn and adapt, that can solve tasks requiring it to interpret the meaning of input data and adapt to the requirements. Typically, these are tasks that previously could only be solved by natural intelligence.

Industrial AI refers to the application of artificial intelligence within the industrial world. AI that is reliable, secure and trustworthy; designed to meet the requirements of the most demanding professional environments.

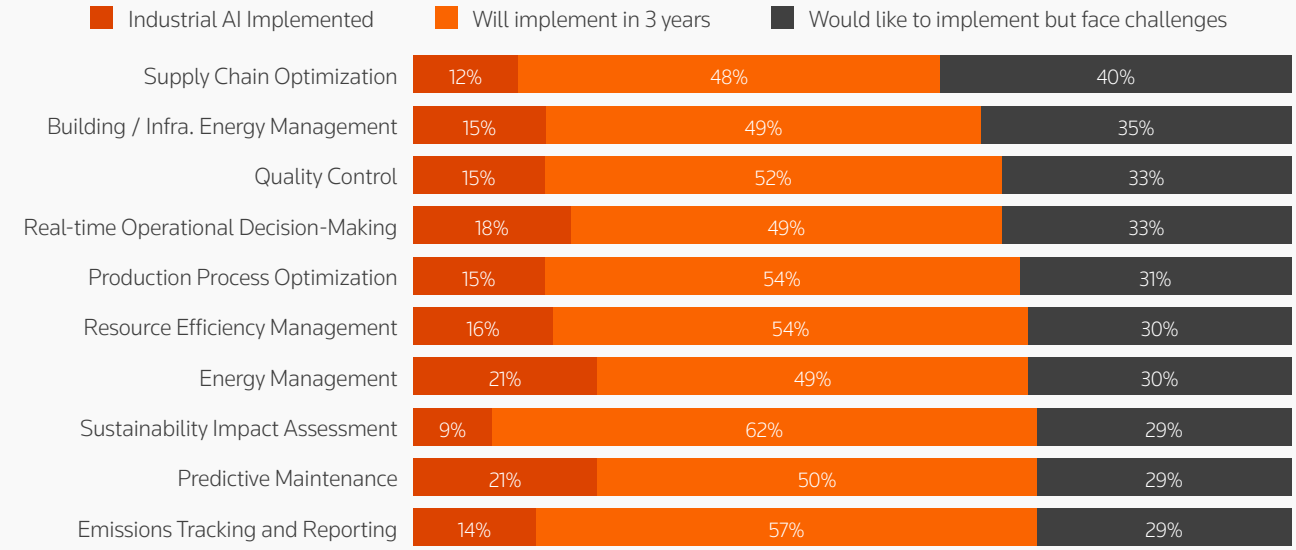
Applying AI in an industrial sense can help assess, predict and optimize the design, production, sourcing and operation of products and processes, to supercharge the transformation of industries.

Examples include; dynamic and intelligent cooling management for use in data centers to help improve plant sustainability; predictive maintenance that analyzes runtime-data and forecasts issues before they arise, reducing downtime and prolonging asset lifetimes; robots capable of autonomously picking any "unknown" or unpredictable item, helping address labor shortages; generative AI assistants that can quickly create, optimize and debug complex automation code on an engineer's instruction.

Figure 2

Operationally, industrial AI is more frequently applied to energy management and predictive maintenance today, with broader applications to grow over the next three years

Share of respondents indicating the implementation and planning for industrial AI to be applied in operations, ranked for both today, in the next three years, and with challenges



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Role of Industrial AI in Sustainability Study, 2024

focus areas and intended timelines for the implementation of industrial AI, which are highlighted in figures 2 and 3.

These provide an indication as to where industrial AI has already been implemented, where it stands to be implemented over the next three years, as well as use cases wherein implementation may be more considerably beset by challenges.

Sustainable operations

Operationally, industrial AI holds relevance across a range of use case areas. Greater shares of respondents have already implemented it in the likes of energy management and predictive maintenance. Elsewhere, higher proportions of respondents said that industrial AI will be implemented in sustainability impact assessments and emissions tracking and reporting in the next three years – with relatively low-levels of challenges expected.

Supply chain optimization emerges as one area of significance here; it's where our respondents suggest they are most likely to face challenges in implementing industrial AI but also, answered elsewhere in the research, the area in which they expect the technology to have the greatest impact. Currently, it is one of the most advanced in terms of multiple use-case implementations that organizations are looking to scale further *(see figure 4)*.

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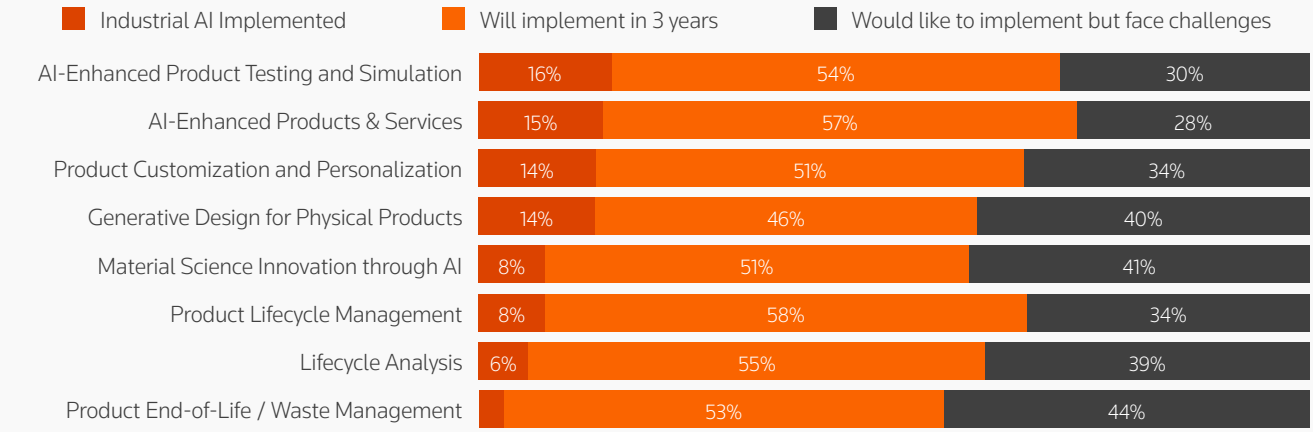
Figure 3

Implementations of Industrial AI are set to grow across product-relevant use cases, noting challenges in areas such as product end-of-life and material science innovation

Share of respondents indicating the implementation and planning for industrial AI to be applied in sustainable products, ranked for both today, in the next three years, and with challenges



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Sustainable products

Meanwhile, with regards to the implementation of industrial AI in sustainable products, there is a similar story to be inferred: relevance across the range of use cases and with higher levels of expected implementation to follow in the coming three years.

The above figures indicate an appreciation of how transformative industrial AI could be, both operationally and at the product level, for sustainability initiatives. Additionally, there are significant cases where industrial AI, already today, is not just implemented as a single-use case technology, but as more integrated and holistic uses.

Figure 4

Industrial AI is most often applied across multiple use cases to optimize supply chains, production processes and sustainability impact assessments

Share of respondents indicating the scale of industrial AI implementation across sustainable operations, individual or small-scale use case versus multiple use cases

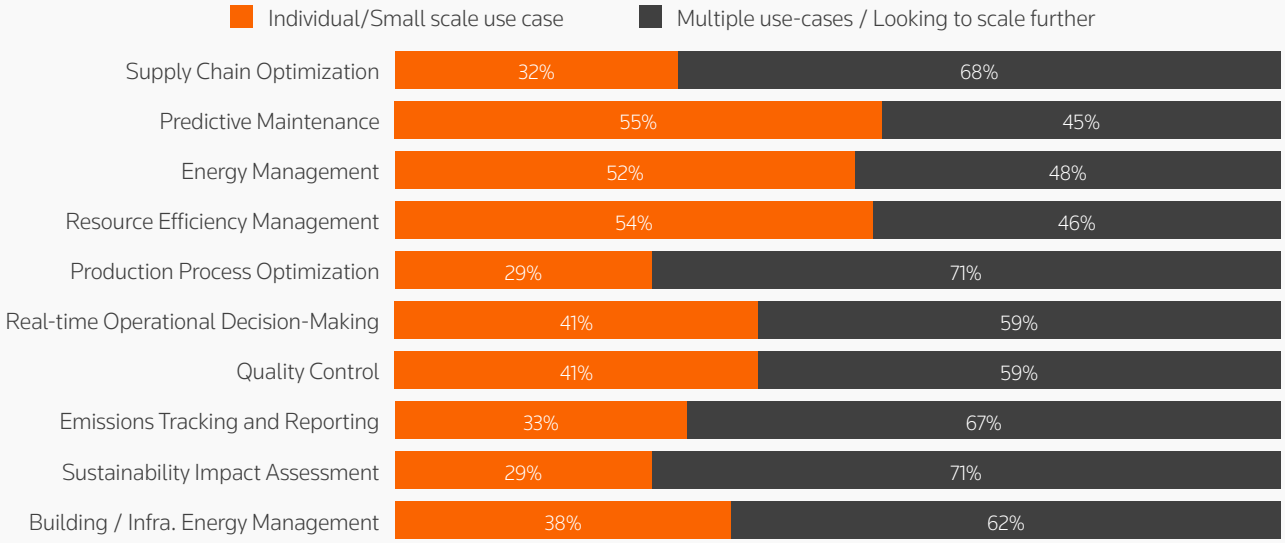

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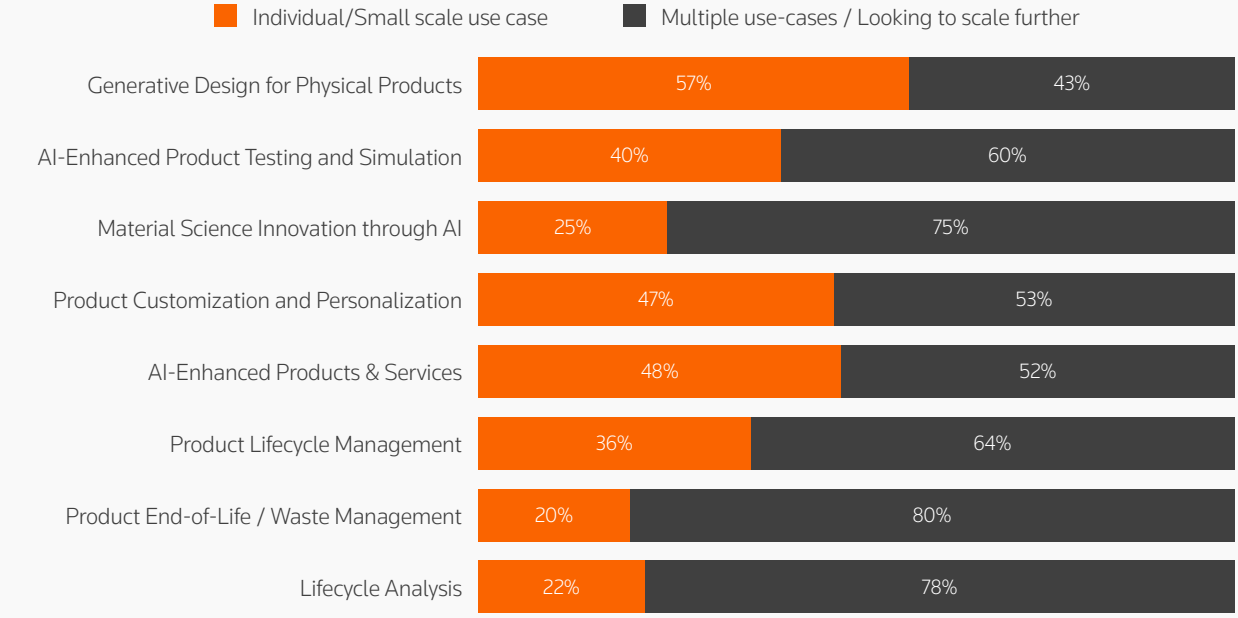
Figure 5

There are potential wide-scale use cases for industrial AI in product end-of-life, lifecycle analysis and material science innovation

Share of respondents indicating the scale of industrial AI implementation across sustainable products, individual or small-scale use case versus multiple use cases



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Role of Industrial AI in Sustainability Study, 2024

It becomes apparent that over the next three years, it is the ambition of organizations to integrate industrial AI across their businesses, and that by addressing certain implementation challenges, the adoption of industrial AI can be embraced further.

ELIMINATING THE 'BURDEN OF TIME'

While there is value in identifying particular uses cases of relevance to industrial AI, this should ideally be aligned to a more integrated vision for both the technology and its potential impact.

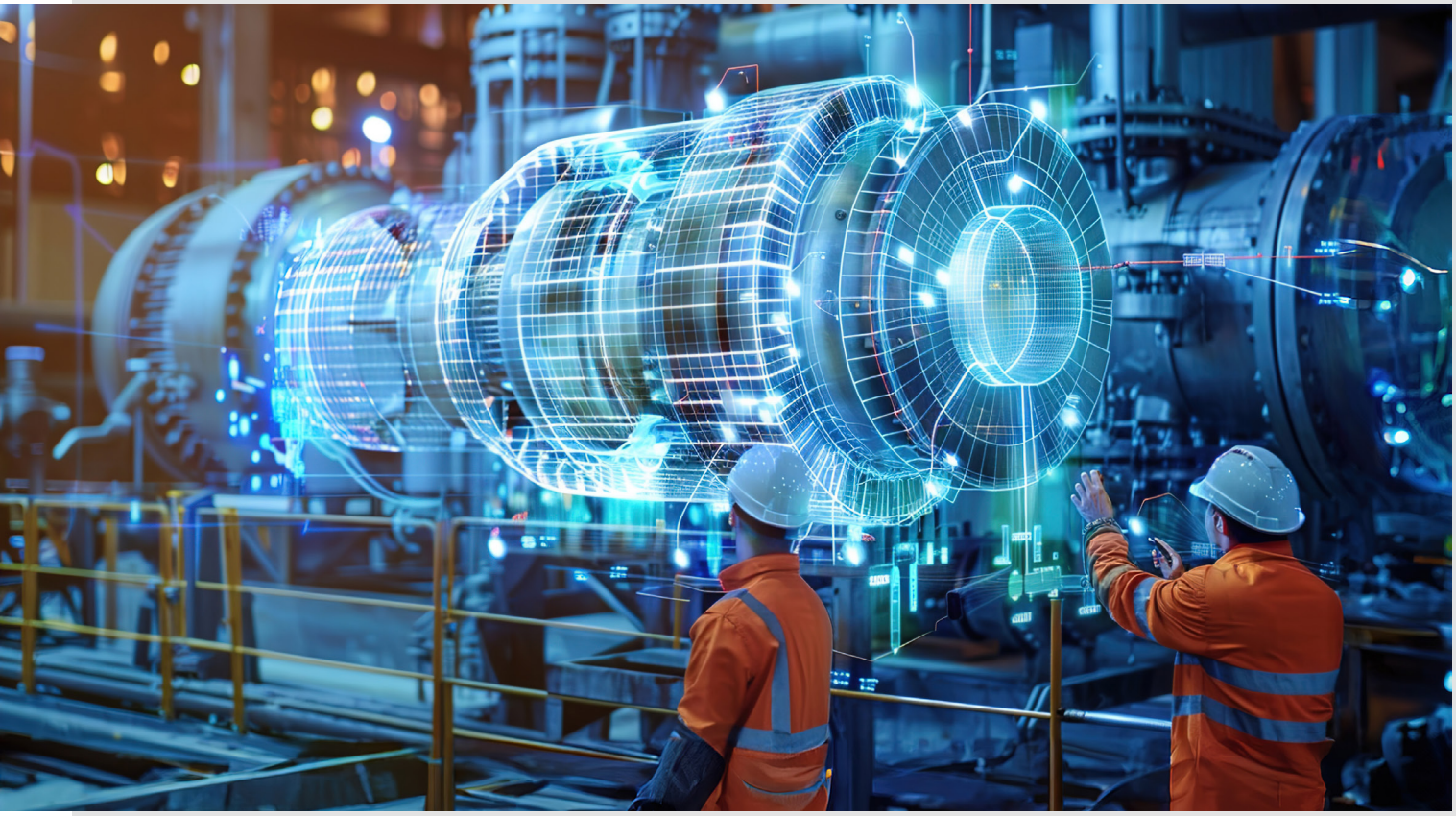
As Schlombs states; "Impact comes not just from AI in isolation but the convergence of AI with other technologies; it's unique ability to enhance the likes of digital twins, 3D printing, IoT, AR/VR and many more. As Jamie Metzl outlines in his book Superconvergence; it is often the combination of technologies that creates more value than each technology by itself, and at a much faster pace, accelerating the rate and scale of value creation."

Thomas Kiessling, Chief Technology Officer at Siemens Smart Infrastructure, relates this to the worlds of buildings and grid infrastructure, outlining how "the evolution toward truly intelligent buildings isn't just about making a substantial leap into what we might perceive as advanced AI. It instead revolves around taking the data and systems we have and infusing them with the intelligence required to realize smarter decision-making." Through an integration of AI with building and grid systems, for example, "we've seen potential savings of up to 5 percent on total grid upgrades—a big step towards reducing carbon footprint and achieving net zero targets."

> ***"IMPACT COMES NOT JUST FROM AI IN ISOLATION BUT THE CONVERGENCE OF AI WITH OTHER TECHNOLOGIES"***

Such potential is supported by first-hand experiences from those who are at the cutting edge of the AI's development, such as Professor Hanno Gottschalk, Professor for Mathematical Modelling of Industrial Life Cycles at TU Berlin.

Gottschalk says that industrial AI can enhance the traditional modelling approaches that are often pivotal to improving the



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overall efficiency of industrial sites. Consider, for example, classical simulation methods or building a digital twin of an entire factory manually, on which adjustments can be modelled and tested. This can be a very complex and time-consuming endeavor, something that industrial AI can make easier. It's ability to remove complexity, to process and analyze data at speed, can remove "the burden of time" of such tasks, redressing the balance between investment and output, to deliver greater returns.

CISL's James Cole reinforces this opportunity. CISL's work in this field has included working with startup organizations that are harnessing AI to process large datasets that may be too complex to understand by traditional means. One example is the start-up Monumo, which is leveraging AI to do "rapid prototyping" of electric motors to make them more efficient.

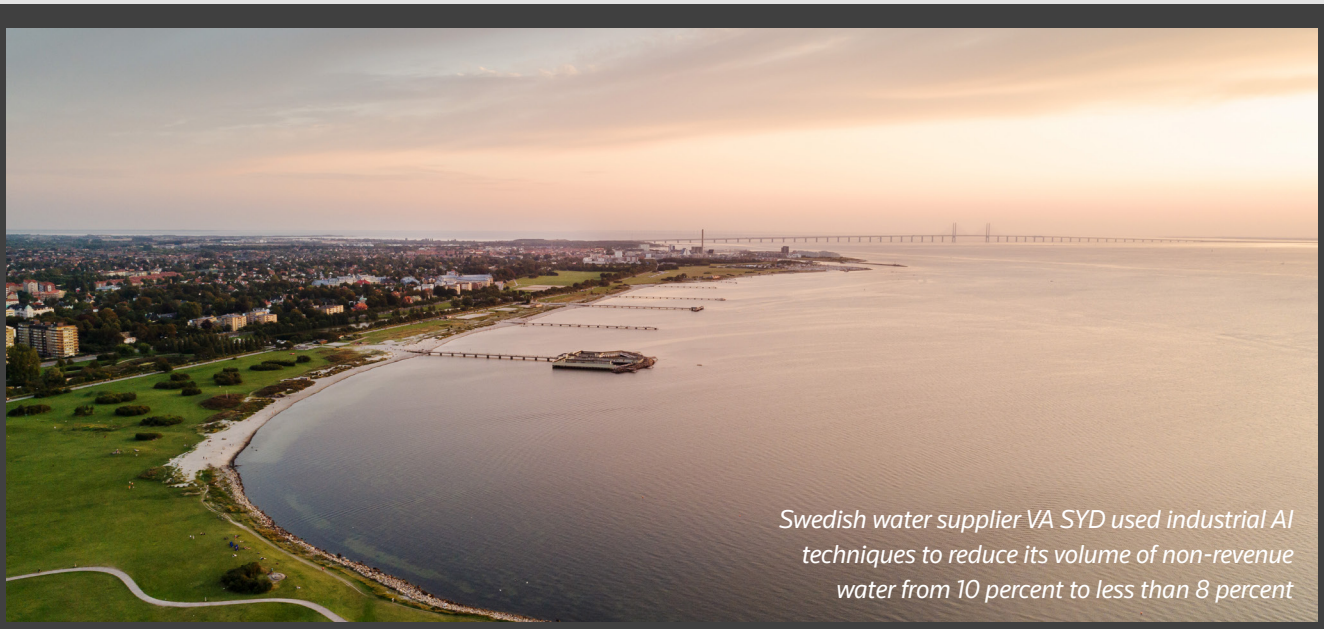
Rather than going through the manual process of testing designs and change pieces sequentially, a developed AI is capable of running ten million motor design simulations in one day – 200 times faster than the industry standard, Cole says. In addition to the productivity enhancement, the potential sustainability impact is huge in the context of the electric vehicle transition.

69%

of respondents consider industrial AI "essential" in helping simplify climate change complexity for their organization

Finally, Antonis Kyrkos, Chief Digital & Strategy Officer at cement producer Titan Cement, says that the implementation of industrial AI has been "fundamental" for its industry, holding the promise to be transformative across product development, manufacturing, material use and customer relationships.

Titan Cement, recently just one of three cement companies to be recognized in TIME magazine's World's Most Sustainable Companies list, first focused its industrial AI efforts on models used to optimize its manufacturing operations in the US and reduce their energy consumption by 5 – 10%, something Kyrkos says has been transformative in terms of both cost and carbon savings for a cement manufacturer. Predictive maintenance and machine learning models are now being utilized to optimize manufacturing plant productivity, while other models and demand forecasting are being deployed to make Titan's distribution and logistics operations more efficient.



Swedish water supplier VA SYD used industrial AI techniques to reduce its volume of non-revenue water from 10 percent to less than 8 percent

INDUSTRY FOCUS: HOW INDUSTRIAL AI IS TRANSFORMING WATER'S APPROACH TO SUSTAINABILITY

The water industry is facing a number of distinct challenges as it bids to become more efficient and sustainable.

One of the challenges is the energy intensive nature of distribution and management: energy can account for up to 30 – 50% of a water system's total costs, while globally the sector contributes to around 4% of global energy consumption.

Equally, non-revenue water – effectively drinking water that is produced but lost during distribution – is a significant drain on a water system's efficiency. On average, around 30% of drinking water is lost during distribution, however some regions can see non-revenue water rates of even up to 70%.

With water operators facing such unique challenges – and with infrastructure improvements costly - AI-powered technology that can make systems more efficient and less energy intensive, for example by accurately detecting leaks, is proving vital to the industry's future sustainability.

"The existing OT and IT device landscape is complex, skilled workers are in short supply, and the business benefits of many digital applications have often been unclear. We are addressing these conditions by enabling water companies to perform AI-based operational analyses", explains Anja Eimer, General Manager, Global Water Industry at Siemens. "[It's] a perfect playground for software that is based on artificial intelligence."

Siemens' industrial AI-powered offering helps to reduce losses attributed to non-revenue water. Using sensors installed across a water network, data points such as flow rates and water pressures are analyzed to identify leaks in a timely fashion. Intelligent leak detection capabilities powered by AI have been found to reduce leaks by 50% and cut the detection time to within two hours. Additionally, the system is self-learning, becoming more effective over time.

In the future, Eimer sees the scope and responsibilities of industrial AI-powered tools in the water sector expanding, potentially acting as an overarching monitor for the entire water cycle. This would mean that the self-learning nature of AI could be leveraged against other data to better time water production and pump cycles to coincide with renewable energy generation.

Building on this, her colleague Adam Cartwright, Siemens' Industry Strategy Director for Software in Water and Waste Water, outlines how "pumping and treating water accounts for 2-3% of a country's power use. As we move to an era with intermittent renewable and distributed generation, this demand can be used more intelligently to reduce costs for water and increase resilience for both sectors." This complex integration of operating critical national infrastructures and market prices can only be managed and optimized with industrial AI.

NAVIGATING ROADBLOCKS: CHALLENGES AND OPPORTUNITIES

Like many transformative technologies, the implementation of industrial AI is not without its challenges. These challenges differ in nature, be they internal, financial or even regulatory, but they all must be addressed in order to allow the technology to affect sustainable change to its fullest potential.

THE 'SUSTAINABILITY' OF AI

Before anything else, it is critical to address one growing concern of AI; its computer processor power usage and, in turn, the amount of energy that can be consumed by AI itself.

This is only likely to become more prominent as further use cases for AI emerge, perhaps best typified by the mainstream introduction of generative AI. With AI applications becoming more integrated among workforces and organizations, many of which require more energy than the status quo, is AI at risk of undermining its own potential to advance and scale sustainability impact?

Considering this, it is important to differentiate between the types of AI being deployed and the context of these deployments. As Pina Schlombs articulates; "Judging the environmental impact of AI solely on the raw compute power needed falls short of the sustainability benefits it can bring. We need to take the positive impact that the solutions applying AI allow us to realize into the equation. This is especially true for industrial AI.

"Consider the potential sustainability benefits, for example, of an AI model that empowers multiphysics simulation in the industrial space - helping to speed up innovative product design for optimal environmental lifetime impact, increasing resource and energy efficiency, selecting durable materials, improving asset performance in operations and increasing their longevity; all to strive for sustainability. With a holistic perspective, we can assess whether the sustainability benefits of the strategic use of AI outweigh the invested resources to train and run it."

"Think of putting your hand on a car's motor or on your computer when the fan is working hard", says Gottschalk. "I wouldn't recommend either but the heat you could feel is proportional to the energy that's wasted in things today. There is, generally, the opportunity to improve efficiencies by

PECTOR/ADOBE STOCK

orders of magnitude, and the appropriate application of AI can play a potential role in this."

Schlombs and Gottschalk also align on how the outlook of AI computing efficiency is increasing drastically, thanks to innovation already underway targeting LLM efficiency, how the infrastructure architecture is designed, the hardware the models run on, and more. The latter mentions the "quite stunning" developments in computer efficiencies for large GPUs, which will also stand to improve the energy or resource intensity of AI.

Looking ahead, there are certain principles to consider, to help realize the potential of industrial AI's positive sustainability impact:

The net balance must be positive
The energy used to train and run the AI should be more than balanced out by the reduction of environmental impact achieved through the product or end process optimization.

Green data centers are the future
Smart infrastructure that propels decarbonization and energy efficiency, alongside tailored financing that enables cost-friendly technological upgrades, will drive the sustainability of data centers and thus – sustainability of AI development.

AI itself must - and can - become greener
Given developments improving the footprint of AI, we expect the efficiency of AI compute per power unit to increase significantly. Transparency remains a key lever: in order to use AI most efficiently, carbon footprint data should be collected and made available. At the same time, energy consumption can be reduced, for example by using pre-trained models.

INDUSTRY FOCUS: DATA CENTERS UTILIZING INDUSTRIAL AI FOR SUSTAINABILITY AND EFFICIENCY GAINS

The data center is the unsung hero of our increasingly interconnected world. They play a crucial role in our digital activities, business operations, and indeed the global economy.

Yet they can consume significant energy, particularly for cooling purposes. With demand for data processing and storage only set to soar in the future, sustainability transformation within the industry is critical to net zero ambitions.

Toomas Kell, CTO at Greenergy Data Centers, says his organization has approached this sustainability journey from the very start, ensuring that all services offered by its data centers have as minimal an ecological footprint as possible. This has required a laser-focus on areas such as power usage and efficiency, heating and cooling and water usage, amongst other metrics.

Aside from the organization's geographical location – Northern Europe, which helps control data center temperatures naturally – Greenergy Data Centers uses AI and machine learning-powered systems to help optimize its cooling systems.

AI, Kell says, is already contributing "hugely" to data center energy efficiency, optimising when, how much and for how long cooling systems need to be used to maintain a center's operating temperature. "By using AI and machine learning to enhance the cooling system, you get immediate, tangible efficiency," he says. "When we first launched the system, it improved our efficiency by approximately 30% at the push of a button."

The application of AI is also having further, knock-on benefits. In automating many of the decisions required in areas such as cooling, and when looking ahead to further operational efficiency gains, members of staff can do less of the "routine tasks" and concentrate on more essential and strategic work.

"It's like a big domino effect," Kell says. "When you start with AI from one end, you will also benefit parts of the whole chain." Having experienced success with its first foray into industrial AI, Greenergy Data Centers is now exploring further works, including the possible addition of a solar-powered microgrid to help further decarbonize its operations, one which could also utilize AI to optimize self-consumption.

MIKKI ORSO/ADOBE STOCK

OVERCOMING THE CHALLENGES OF AI ADOPTION

Our research indicated that the most prevalent or distinct challenges holding back the adoption of industrial AI within organizations could be categorized into three specific areas; **financial, partnerships, and internal capabilities and skills**.

The most cited challenge from our survey respondents was a difficulty in projecting or measuring a specific return on investment (ROI), identified by 38% of total respondents. A further 26% of respondents highlighted costs associated with implementation. Organizations, it would appear, are experiencing difficulty with the perceived investment of AI-powered solutions, or at least translating that initial investment into a payback figure that would give a financial department confidence. Around one-third (33%) of respondents, meanwhile, stated that they had experienced difficulty in finding reliable solutions, vendors or partners. A further 22% suggested there was a lack of maturity in solution providers for their respective industries, indicating that organizations are having trouble finding the right partner, or partners, for their projects even if they can secure financial backing internally.

38%

of respondents said the biggest challenge for AI's further adoption is the difficulty in projecting or measuring ROI

Our research also found that more than a quarter (26%) of respondents said a lack of appropriate skills within their respective organizations was a distinct challenge that was holding back the adoption of AI.

But while not insignificant, these challenges are neither insurmountable – as outlined by the below guidance.

1 FINANCIAL: SCALE STRATEGICALLY, CHANGE MINDSETS

"AI is not optional, it's out of the bag, it's going to happen and it has the potential to transform business models," CISL's Cole says, adding: "So, companies that are assuming everything is broadly going to stay the same except for their investment in AI risk missing the point."

Therefore, the lens of consideration should be broader than simply seeking short-term ROI or one key metric to justify an investment.

The benefits of industrial AI are expected to be realized in productivity, efficiency and sustainability gains, as our research has indicated. The opportunity, Cole says, is considering this at the highest level of a business's strategy, rather than just at a product level. Avoid the danger of treating AI has a "hammer looking for a nail. We don't need AI to open a tin of beans, but you can guarantee someone will propose it to". Rather, be thorough in identifying the relevant business cases – some will be obvious, others less so – to match AI and its capabilities to.

Successful integrations of AI rest on how organizations approach these projects.

Here, Hanno Gottschalk says that integrations are often a result of process, and with industrial AI in mind that process should be to start with smaller evaluations of data that can really contribute to or benefit the company at large: instances where tangible value can be seen. The broader implementation of industrial AI can then in effect "grow with the task" and engage further stakeholders – including those who may not initially be with the company, such as in-demand data scientists – as required.

Kyrkos explains how Titan Cement's early pilots focused on its operations with the highest profitability, with the organization choosing to do proof of concept in areas with particularly high payback opportunities. "It convinced our management that [industrial AI] is not just a fashionable thing to do, but this had a really important impact on our operations," he says.

> ***"[WE'VE] SEEN ENTIRELY NEW PRODUCTS CREATED FROM SCRATCH IN MINUTES, WITH MODELS TRAINED IN LESS THAN THREE MONTHS"***

EWASTUDIO/ADOBE STOCK

The 'speed' of impact largely aligns to levels of both digital and cultural maturity

According to Schlombs, she's "seen entirely new products created from scratch in minutes, with models trained in less than three months". Priority one is ensuring the groundwork is done in establishing a robust data strategy and data backbone that AI can leverage: without this digital maturity, it's an uphill challenge to implement successful use cases, let alone scale their impact. Then, "simply because something is technologically available doesn't mean it will be widely used. Leaders need to consider incentivization, because ROI also demands a growth mindset centered around a constant curiosity to learn and change."


BUSINESS PICS/ADOBE STOCK

2 THE RIGHT PARTNERSHIPS: AN ECOSYSTEM CENTRIC APPROACH

As respondents highlight difficulties in locating appropriate partner support, Mateja Kramar, Partnerships Success Manager at the ETH AI Center, underlines the priority of addressing this. From her experience, "the successful use of AI in the sustainability transformation of industries often relies on partners filling gaps in skills and developing collaborative processes. The ideal is that mutual goals are completed and scaled faster, together." In order to support this:

Certain prerequisites are necessary for a successful relationship

Clear communication and definitions (certainly around AI and its implementations), ensuring expectations are robustly aligned upfront, and that the time is taken to identify the most pressing knowledge gaps.

Kramar also notes that concurrent developments are providing greater collaboration possibilities and partner support for organizations. These include;

An increased acceptance from solution providers and end-user communities that this is a journey of collaboration

No one can tackle our great challenges or opportunities alone. And AI – that is ensuring AI is industrial-grade, suitable to adopt, develop and/or scale within critical industries – is proving to be, like digital transformation, rarely a one-company show.

The growing recognition of the benefits of an ecosystem-centric approach to innovation

With this, businesses, developers, and innovators can come together to cocreate and leverage the interoperability of industrial AI to other technologies.

It is via this ecosystem-centric approach that often rapid technological developments and domain knowledge best come together, to apply innovative solutions across industrial scenarios and use cases. As Adam Cartwright says, the 'move fast and break things' approach to certain technology innovation doesn't quite apply to something like critical national infrastructure. While there is significant potential for AI to transform the water industry, for example, there must be the deep domain knowledge to marry the model of a continually evolving digital technology with the ways in which a big, regulated asset base like a water network is operated. As specific applications and use cases of AI continue to grow and evolve, this combining of the real and digital worlds is becoming better understood and pursued.

This is the rationale behind the design principles of the digital business platform Siemens Xcelerator; interoperability, flexibility, and openness. Whether it's regarding AI or AI-enabled technology, this offers a growing open ecosystem and evolving marketplace to make digital transformation and sustainability outcomes easier, faster and more scalable for companies of all sizes.

The ask from Cole is that this open approach to collaboration, across expertise and skillsets, translates to more companies, big and small, governments and academia collaborating in the pre-competitive space. This would help provide further clarity as to the solutions needed, the associated market dynamics and the role of individual companies in commercializing those products.

ANDREY POPOV/ADOBE STOCK

3 CAPABILITIES: RESKILL AND UPSKILL

After demonstrating the effectiveness of industrial AI in delivering returns, Titan Cement's Kyrkos says attention turned towards investing in skills and capabilities, recruiting data scientists and engineers into the business to help rollout the technology further. This was not, however, as simple as having data science capabilities to develop algorithms, nor was it a case of giving new tools to frontline operations stuff and hoping they adapt. "It was the combination of skill sets working together to create high-impact use cases," he says.

This required data scientists to create and develop the algorithms, data engineers to help capture the right data and store it properly, domain experts to work on the problem being solved on the process or customer side and change management to address any process or management issues. "Unless you have all of this together, a lot of pilots fall flat," Kyrkos adds.

There is no escaping the need to align appropriate skills to match the speed of AI's development

There is not a silver bullet to this scenario, rather, as Gottschalk outlines, the requirement for more and ongoing training around, for example, data awareness throughout businesses. Alongside demonstrating the value of initial evaluations or AI use-cases, this can help foster a general understanding of AI, its capabilities and requirements to permeate throughout the workforce.

Cole emphasizes the importance of having individuals who understand both the technology and its broader business and societal contexts. This understanding is crucial not only for developing AI use cases but also for governing them effectively, particularly given the potential for unintended consequences. And it is often business leaders that must develop new capabilities to successfully incorporate AI into business models and product deployments.

Elsewhere, AI itself is providing opportunity from a skills perspective

It is reducing the barrier of 'appropriate' capabilities to using technology. Here, generative AI is making human-machine interaction easier and more effective. With the Siemens Industrial Copilot, developed together with Microsoft, for example, maintenance staff can chat in natural language with a faulty machine's Copilot – asking for details and discussing solutions for the problem as if they were doing so with colleagues. This helps democratize the interaction with industrial machinery, eliminating the need for workers to learn complex machine languages. Meanwhile, the ability to automate repetitive tasks that require expert knowledge, such as generating standard automation code, also helps address the skilled worker shortage.

Siemens' collaboration with Amazon Web Services further enhances accessibility by integrating generative AI into the low-code development platform, Mendix. This enables

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users to create applications without or with low-level coding knowledge, incorporating, for example, AI features such as summarizing and analysing documents, translating content, and recognizing images. Elsewhere, startups such as SUMM AI. are using AI to make complex information accessible for everyone by translating text resources to be easily understandable and concise.

The opportunity – largely pioneered by advancements in generative AI – is putting the power of AI at everyone's fingertips. It is a rewiring of the industrial innovation cycle, where traditional barriers to engagement are overcome. This can accelerate the 'integrations' of AI Gottschalk mentioned earlier, helping build more applications and use cases to increase momentum and help lay the path for further adoption within organizations.

In its entirety, this section points to the view that, while there are unquestionably challenges or barriers to implementing and scaling industrial AI – complex and significant – they are also far from insurmountable.

Strategically selecting projects to help change mindsets and scaling mindfully; working collaboratively across ecosystems; marrying technical and domain expertise; reskilling employees and leveraging AI itself to address skill gaps; all will be pivotal to unlocking the potential of this technology.

With this in mind, we can transition to the next focus; what's possible for future innovation in sustainability supported by industrial AI?

ALICE_PHOTO/ADOBE STOCK

BUILDING ON FOUNDATIONS: FUTURE INNOVATION AND INDUSTRIAL AI

Our research reveals a clear confidence in overcoming the potential complexity challenges associated with industrial AI. Respondents to our survey were overwhelmingly supportive of the notion that future innovation in sustainability will be driven by industrial AI applications and solutions. Just 4% of our sample disagreed with this, with 70% stating their firm agreement with the sentiment.

Applications such as methane emissions monitoring and quantitative reporting of greenhouse gas emissions, breathing intelligence into robotics, wind power generation management control, building performance modelling, increasing reliability of grid operations were all cited.

Predictive maintenance was highlighted as an ongoing priority application for industrial AI from a sustainability impact perspective. This is already being realized in certain sectors, as it helps transform the way complex systems are managed and maintained. It involves using AI to analyze runtime-data and predict potential issues before they arise, effectively reducing downtime, enhancing efficiency and prolonging the lifetime of assets.

70%

of respondents agreed that future innovation in sustainability will be driven by industrial AI applications and solutions

Leveraging the predictive capabilities of AI and ML in buildings is transforming their efficiency. Anomaly detection algorithms applied to energy data, for example, can now identify high energy-consuming assets, while forecasting algorithms are helping improve the understanding of energy consumption trends. As a result, applications like Building X Comfort AI can better balance energy consumption with occupant comfort. Predictive cooling services, for instance, can learn that the occupancy of a co-working space on a building's seventh floor peaks between 2pm and 3pm and plan for the respective cooling load.

Design was another area identified by respondents where industrial AI is expected to have a continued and significant impact – from identifying environmentally friendly material & chemical substitutes to assessing trade-offs between carbon footprint and cost in design.

Again, this vision for impact is building on a proven technological reality. Today, generative design, which utilizes AI to explore a vast design space, can offer a broad range of solutions while also narrowing down those most effective to save time and resources in testing. This design freedom can

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directly lead to notable reductions in cost, environmental impact, and risk – as evidenced by the AI-driven redesign of an industrial robot gripper, which led to an 80% reduction of assembly time and an 82% reduction in CO2 emissions per robot.

Tomorrow's opportunity comes with scale

In the above instance, for Pina Schlombs: "The potential that I see is that such savings are relevant to one industrial robot gripper. But what about the entire robot or the production line that the robot is part of, or the entire plant that the robot is part of?

"The complexity rises but the upside is we have the technology today to be able to do this. We can think about all the different aspects, parts, products, manufacturing, equipment, machinery that come together in a line but then also include the products that are manufactured on it and bring this together in our AI-enhanced world. So it becomes ever more integrated but also ever more holistic in the perspectives we can take."

One small step to the industrial metaverse: from accelerating the pace of progress to defying time

> The superconvergence of industrial AI with numerous technologies will eventually result in the industrial metaverse; an immersive digital environment that mirrors and simulates real-world systems. But unlike gaming, for example, this environment is not a means to escape and play away from the real world; it's rather one to engage and interact with the real world, based on the universal laws of physics. To improve it – faster, with fewer resources, and at less cost
>
> **Peter Koerte,**
> *Managing Board Member, Chief Technology Officer and Chief Strategy Officer,*
> **Siemens AG**

Rather than gaming, the Industrial metaverse could be considered through the lens of general relativity and theoretical physics. Take, for example, the concept of closed timelike curves (CTCs), a theoretical construct that suggests the possibility of time loops in spacetime. A CTC allows for a timelike path that loops back on itself, theoretically enabling an object to revisit a moment in its own history: essentially, time travel.

While this remains speculative in physics, a similar idea is taking shape in the Industrial metaverse. Here, AI-powered digital twins, sophisticated simulations of real-world assets, do more than replicate and monitor current states of real-world assets and systems – like entire factories, railway systems or even coral reefs. They enable 'time travel' for engineers; allowing them to analyze past data and forecast future scenarios to drive progress in the present day. For example, the environmental impact of products can be simulated, enabling data-driven optimization decisions that minimize real-world footprints.

In this environment, we can transition from accelerating our pace in the race against climate change to defying time

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> ***"USING GENERATIVE DESIGN AND SUPPORTED BY THEIR AI COPILOTS, PEOPLE CAN TRY OUT NEW CONCEPTS AND SOLUTIONS WITHOUT INCURRING ADDITIONAL COSTS, CONSUMING RESOURCES, OR RISKING DAMAGE TO PHYSICAL OBJECTS"***

itself. Because in the real world, the trial and error approach to innovation is costly – it's bound by the laws of physics; often intensive when it comes to cost, time, material and environmental impact.

In the digital world, enhanced exploration through human-machine collaboration becomes not only a possibility but one that is liberated from traditional constraints. Using generative design and supported by their AI copilots, people can try out new concepts and solutions, without incurring additional costs, consuming resources, or risking damage to physical objects.

A gigafactory, for example, could be built in the industrial metaverse first, to optimize the design and build and ensure it functions in the right way. And once there is the real factory, the metaverse version runs in parallel, learning faster than the real world, to continually inform and help optimize operations.

All the while, in this digital playground of innovation, AI copilots will continuously explore and navigate the digital twins on their own, tirelessly seeking innovative ideas and solutions to improve various aspects of the system. Their 24/7 presence ensures a constant stream of fresh insights and recommendations to help shape sustainable operations, processes and, ultimately, impact.

UNITED IN THE RACE: A MORE INTEGRATED 'SYSTEM OF SYSTEMS'

The race against climate change represents one of the most profound challenges we face globally. It is a challenge that, as outlined at the start of the paper, can be defined by complexity, and the speed and scale with which this needs to be addressed.

Within this context, organizations have a responsibility to advance their own sustainability transformations. They must balance environmental and social imperatives with their fundamental need to be productive and profitable; balancing carbon budgets and bottom lines will be a critical challenge in the years ahead.

It is within this specific environment – cumulative, organization-wide sustainability transformations as a vital contributor to broader societal change – that advanced digitalization, and industrial AI within this, holds particular value.

Ninety five per cent of organization foresee industrial AI helping them achieve their sustainability goals, whether that's as a tool to realizing these, the most important digital technology available driving progress (21%), a key element of their sustainability strategy (25%), or one of the defining factors in reaching their goals in time (11%).

As Cole concludes; "the meta challenge of businesses is how to balance productivity and commercial outcomes with the imperatives of social and environmental outcomes." By facilitating the better sharing and processing of data across industrial systems, he sees tools like industrial AI having the potential to help drive both organization-wide and more holistic societal goals. "Via big data and AI, there's the opportunity to not just optimize operations but drive symbiosis across entire industries where there's historically been a disconnect, to align increasingly digital systems and make sense of a broader 'system of systems'."

> ***"VIA BIG DATA AND AI, THERE'S THE OPPORTUNITY TO NOT JUST OPTIMIZE OPERATIONS BUT DRIVE SYMBIOSIS ACROSS ENTIRE INDUSTRIES WHERE THERE'S HISTORICALLY BEEN A DISCONNECT"***

BUSINESS PICS/ADOBE STOCK

Cartwright supports this line of thought; outlining an ideal vision where digitally mature utilities have their data structured in a way that enables silos to collaborate with each other. Here, AI optimizes both design and operation phases, while also supporting the organizations with their integrations into the wider ecosystems in which they play. This enhances organizational performance while also promoting better cross-industry collaboration, fostering alignment in our efforts to achieve a sustainable future.

ACTIONABLE INSIGHTS

- In the race against climate change, businesses must accelerate their sustainability transformations with urgency and precision. This necessitates aligning commercial goals with critical pillars such as decarbonization and energy efficiency, resource efficiency and circularity, and people centricity and societal impact.

"Industrial AI has the power to fundamentally transform manufacturing to make it safer, smarter and more sustainable," says Peter Koerte, Managing Board Member, Chief Technology Officer and Chief Strategy Officer, Siemens AG. "Its implementation will require complex and often deep-rooted changes, alongside an awareness of how this transformation applies to businesses, industries and society together. But it can be realized."

- Within this context, industrial AI is already considered pivotal by organizations:

69%
see it as "essential" in simplifying climate change complexity

91%
believe it will significantly accelerate their energy transition within 3 years

70%
agree it will drive future innovation in sustainability

- To leverage the full potential of industrial AI and scale its impact, removing the "burden of time" from sustainability transformations, redressing the balance between investment and output, businesses should consider the following:

Scale strategically to change mindsets

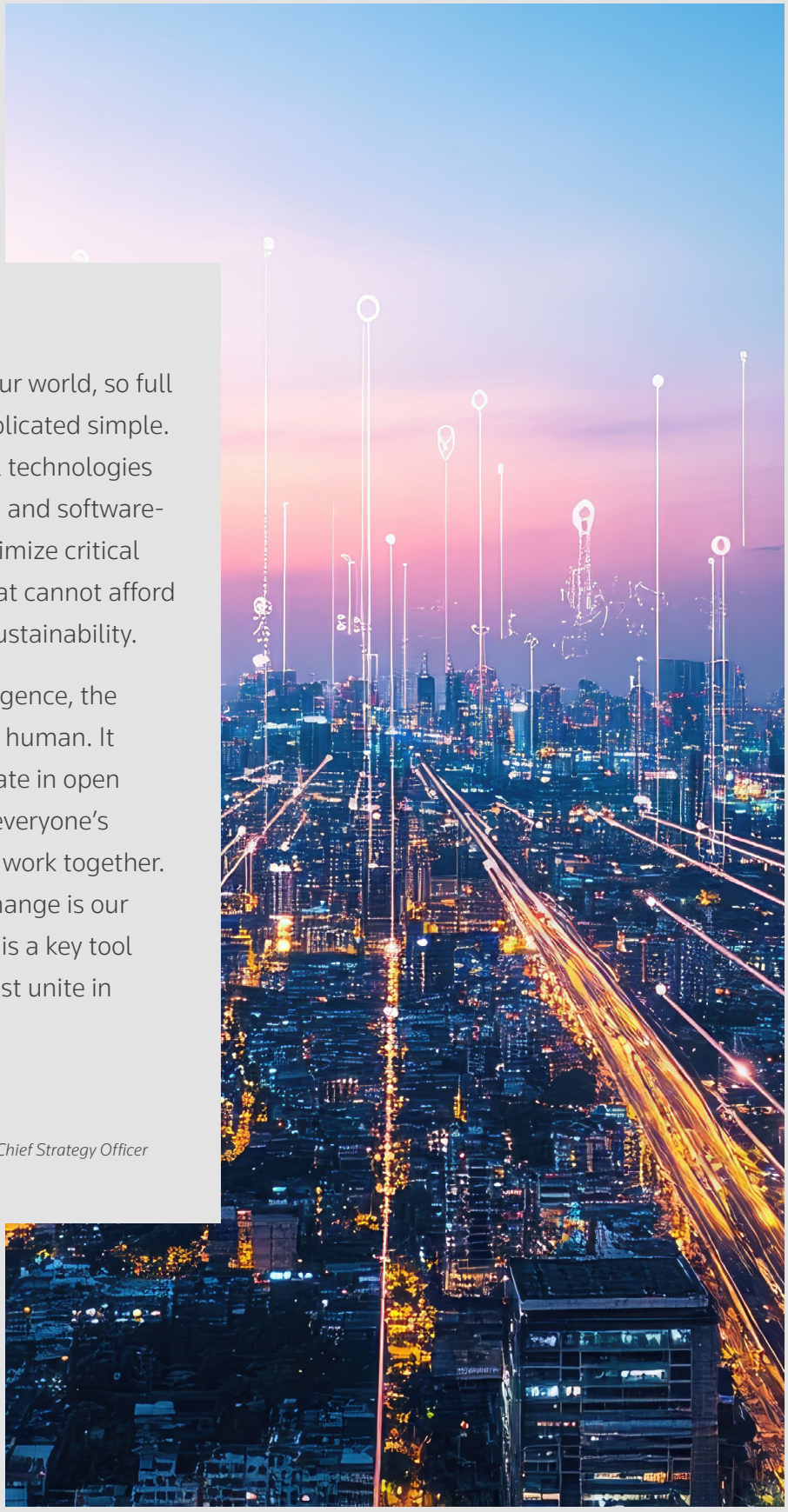
- Establish or progress a robust data strategy and data backbone that AI can leverage
- Prioritize early pilots, smaller data evaluations, that easily demonstrate value
- Have broader implementations "grow with the task", to engage more stakeholders
- Incentivize: impact demands a growth mindset of curiosity and adoption

Partnerships: embrace an ecosystem-centric approach

- Industrial AI's adoption, implementation and scale is rarely a one-company show
- Clarify essentials upfront: definitions, expectations, skill gaps, industry knowhow
- Combine technological and domain knowledge to apply innovative solutions across multiple scenarios

Reskill and upskill capabilities

- Impactful use cases don't stem from isolation. Different skillsets must collaborate
- There's no silver bullet: ensure ongoing training around key issues like data awareness
- Leaders: pursue new skills to integrate AI into business models and product deployments
- Embrace AI's opportunity: enhanced human-machine collaboration, supporting the demand for specialist skills



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It comes back to the 'why of AI'. In our world, so full of complexity, it can make the complicated simple. Its convergence with other powerful technologies – like digital twins, edge computing and software-defined automation - is helping optimize critical systems across industries. Those that cannot afford to fail. Those crucial to advancing sustainability.

Yet, while we discuss artificial intelligence, the opportunity before us is also deeply human. It requires our willingness to collaborate in open ecosystems: to put innovation into everyone's hands, learn from one another, and work together. Winning the race against climate change is our collective mission, and industrial AI is a key tool to helping us achieve it - but we must unite in purpose and action.

Peter Koerte
Managing Board Member, Chief Technology Officer and Chief Strategy Officer
Siemens AG

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METHODOLOGY

A New Pace of Change: Industrial AI x Sustainability, 2024 is a new study from Reuters Events and Siemens surveying senior executives in the industry specifically chosen for their direct involvement in shaping their organization's technology and sustainability strategies.

For this study, 'sustainability' has been defined in the context of energy savings and carbon reduction that can be addressed via production and operational efficiency. 'industrial AI' refers to the application of AI within the industrial world (industries such as manufacturing, infrastructure, transport and healthcare) to help drive efficiencies and sustainability in and across industries. Industrial application of AI helps monitor, produce, optimize and scale products and processes.

The study was conducted in the second quarter of 2024 engaging technology and sustainability practitioners across industries including oil and gas, renewables, energy storage, power generation, manufacturing, infrastructure, construction (including commercial buildings), transportation, supply chain, pharmaceutical, healthcare, food, agriculture, and data-center services, among others.

A total of 204 respondents from regions across the globe participated in the survey with a high share of respondents (89%) in leadership, board, or senior management roles, with the rest in mid-management roles. Thiry-seven per-cent of companies surveyed have revenues of less than $50 million, 35% have revenues between $51 million and $1 billion, and around one-third (28%) have revenues over $1 billion. Fifty-six per-cent of the respondents reported their employee headcount to be under 1000. Twenty-three per-cent were mid-sized at 1,000-10,000 employees and less than quarter (21%) reported over 10,000 employees.

The data for the study was gathered through web surveys which were designed and implemented following strict market research guidelines and principles.