Warsaw 2021

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No decarbonisation without digitalisation

Sustainability needs digital technology

Partnered by
Accenture in Poland

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ORLEN

Editorial Team

It is the fourteenth report authored by experts from PKN ORLEN aimed at sparking extensive discussion on the key economic and social challenges faced by the contemporary world. The previous reports are available at ffbk.orlen.com. This report has been prepared by the Strategy & Innovation and Investor Relations Department and by the Corporate Communication Department of PKN ORLEN S.A. in partnership with Accenture Poland.

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Patrycja Klarecka
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Digital transformation acts as a catalyst for industry decarbonisation

The world is undergoing a series of social, economic and environmental changes. One of the key elements of the ongoing industrial revolution is energy transition. The existing model of economic growth powered by fossil fuels, supported by highly concentrated energy generation sources, is being replaced by distributed energy generation, with renewable energy sources playing a key role.

Digital transformation is driving this change. IT solutions are no longer treated as serving a purely instrumental function, but they lie at the very heart of new business models. Moreover, developments like the ongoing pandemic have accelerated the pace of change by at least a decade. But our report looks beyond the simple aspects of digitalisation, such as digitisation of documents and automation of processes. Rather, we address the impact of digital tools in transforming industry towards improved environmental sustainability and a lower carbon footprint.

With digital tools, we are already streamlining production processes, more accurately predicting future events, minimising raw materials and energy consumption and, consequently, reducing carbon emissions from production processes. Thus, digital transformation reconciles business and environmental goals, which may have seemed at odds for some until now. In 2020, the ORLEN Group launched the Digital Transformation Programme as a joint initiative of its IT and Strategy & Innovation and Investor Relations teams. The Programme's objective is to promote solutions based on emerging technologies across the organisation and to support projects showing the greatest economic and environmental potential. Seamless project execution largely depends on our employees, therefore we deliberately help develop their competencies in advanced analytics, agile working methods, and other fields. We take a broad-based approach to digital transformation, encompassing projects, processes and competencies.

This report aims to provide a new, shared perspective on two key trends taking place in the world today: sustainability and digitalisation. We believe these two themes are inextricably linked and will drive each other in the years ahead.

Patrycja Klarecka
Member of the Management Board, Retail Sales,
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Investors look favourably at the companies improving their efficiency and supporting the idea of sustainability based on digital transformation

Progressing climate change is increasingly affecting the future of our planet. One way of stopping it is undoubtedly decarbonisation, which is also the greatest challenge facing the economy and society at large. Time is running out to combat climate change, and the road to a meaningful reduction in CO_2 emissions leads through a deep transformation of the energy sector. Fortunately, it is achievable, and digital technology will play a critical role in this formidable process.

We are pleased to present a report prepared by PKN ORLEN together with Accenture. We paint a comprehensive picture of the links between technology and sustainability. We explain how digitalisation helps solve zero-carbon challenges and how it is becoming a growth driver for the green industry. The report also presents examples of implementations carried out by PKN ORLEN and other global companies which, by changing their business models and applying technologies such as artificial intelligence, cloud, advanced analytics and digital twins, are successfully transitioning to decarbonisation pathways. The awareness of decision-makers and investment in renewables, coupled with the digitalisation of businesses, are key to achieving sustainable development goals.

The final chapter of the report focuseson Accenture's survey of senior executives, which confirms that corporate executives are turning to digitalisation to drive sustainable business strategies. This trend is bound to gain momentum, especially as investors look favourably at the companies improving their efficiencyand supporting the idea of sustainability based on digital transformation.

Change is needed like never before, and it may become a remedy for the ills of the contemporary world – including the worsening climatic conditions. Because technology can and should be used to protect the environment. I am confident that it is innovation that will enable European businesses to achieve their ambitions so that the needs of the current generation can be met without compromising the chances of future generations to live in affluence and a healthy environment.

I encourage you to read on and be brave in your digital transformations!

Jarosław Kroc
Country Managing Director,
Accenture Sp. z o.o.

Introduction

This year, the topic of sustainable business development has become particularly relevant. In this report, we address a well-defined scope of the term. We want to focus primarily on its environmental aspect and the ways in which digital technology can drive decarbonisation of industry.

The advancement of a zero-carbon economy is propelled chiefly by renewable energy technologies. Digital tools will step up the decarbonisation process. It is digitalisation that will accelerate the growth of green, zero-carbon industry. In this report, we describe how digital solutions of Industry 5.0 are supporting decarbonisation.

Global greenhouse gas emissions from fossil fuels could be reduced with digital tools by as much as 15% by 2030. Given the transformative impact of technology on business models and consumer decisions, digitalisation can support emission reductions of up to 35% in total. This would be done by changing the way businesses operate, for example by moving from car ownership to car sharing.

Digital technologies drive decarbonisation in three ways:

Digitalisation helps to more accurately monitor equipment operations and raw material, energy and asset usage. With digital tools, the carbon footprint can be tracked and reported.

Through process optimisation and automation, energy and raw materials are used more rationally, leading to improved financial performance and reduced greenhouse gas emissions.

Greater process knowledge means greater ability to anticipate incidents and avoid unplanned downtimes, accidents and failures. This minimises raw materials and energy waste and reduces the risk of leaks and spills. Thus, digitalisation improves process safety and lowers the environmental impact of companies.

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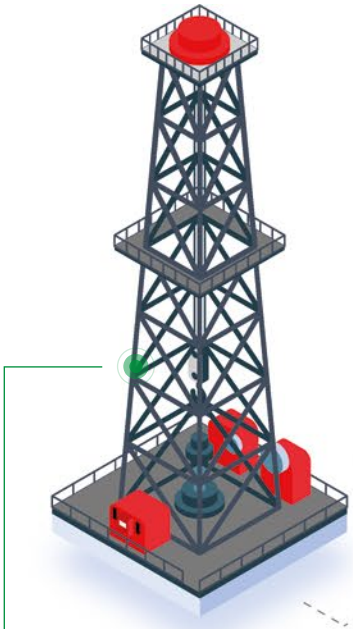
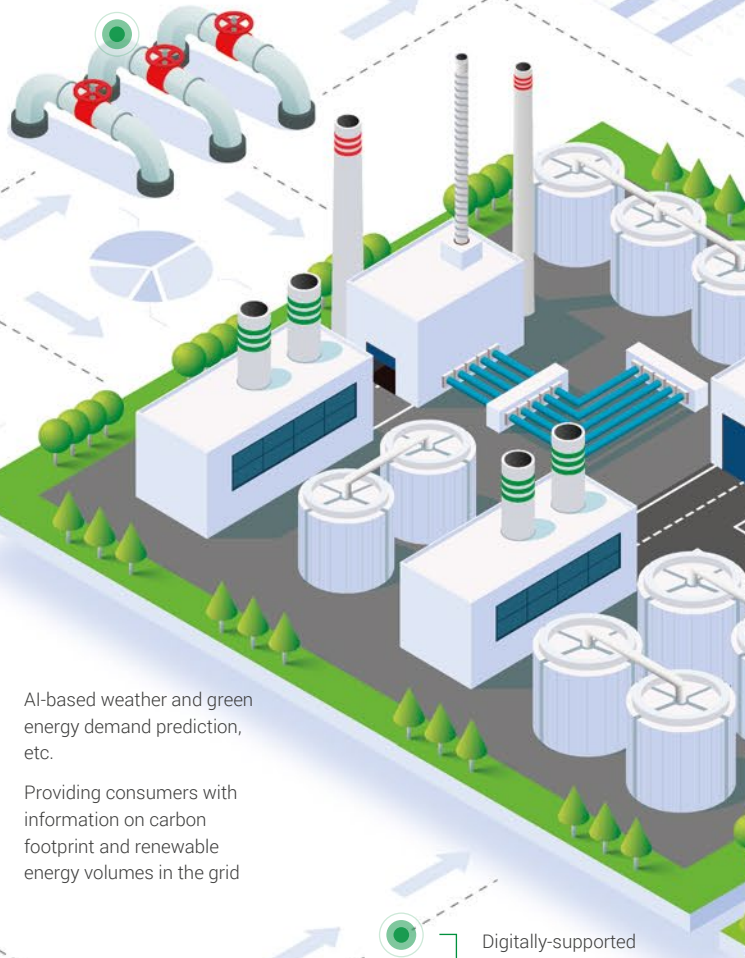
AI-based simulations of various scenarios of the field production process make it possible to increase the efficiency of hydrocarbon production and to reduce drilling work and media consumption

Machine vision aids detection of leaks, corrosion or altered feedstock composition



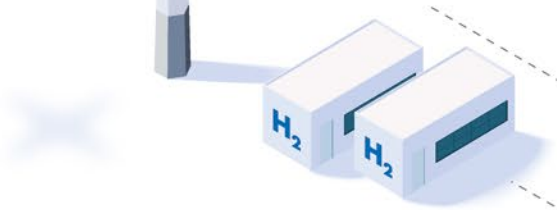


Analysis of large geological data sets and artificial intelligence algorithms help to identify the optimal drilling location, making the process more economical and environmentally friendly

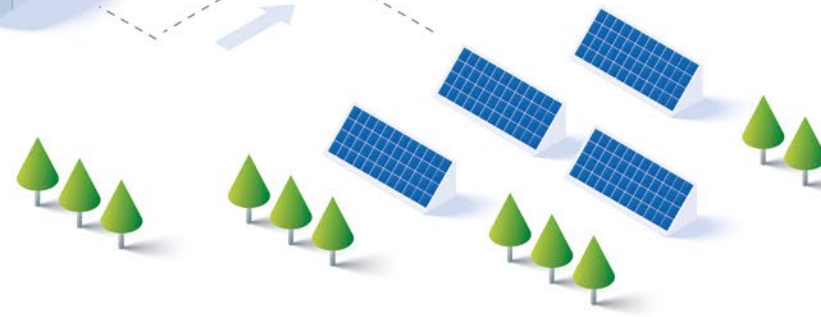
Autonomous drones inspecting equipment for early detection of malfunction and failure

AI-based weather and green energy demand prediction, etc.

Providing consumers with information on carbon footprint and renewable energy volumes in the grid



Digitally-supported smart grid management and balancing



Green and digital transformation

Online process monitoring to detect process inefficiencies or excessive consumption of feedstocks and materials

Product demand prediction and flexible production adjustment leading to feedstock savings

Remote diagnostics using real-time sensor data for early detection of equipment failures

Energy efficiency enabled through rapid detection of energy loss sources

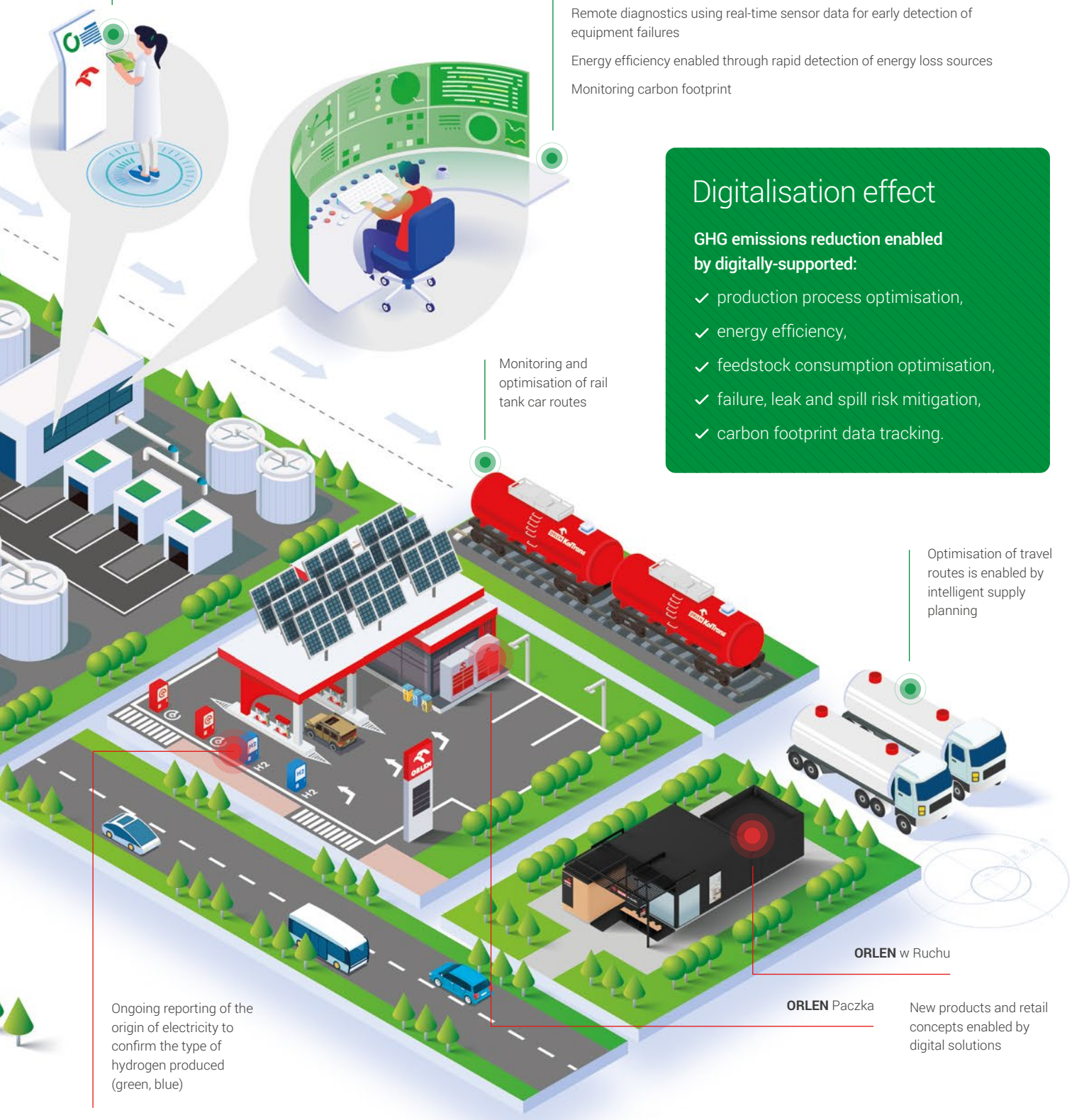
Monitoring carbon footprint

Digitalisation effect

GHG emissions reduction enabled by digitally-supported:

- ✓ production process optimisation,
- ✓ energy efficiency,
- ✓ feedstock consumption optimisation,
- ✓ failure, leak and spill risk mitigation,
- ✓ carbon footprint data tracking.

Monitoring and optimisation of rail tank car routes



Optimisation of travel routes is enabled by intelligent supply planning

ORLEN w Ruchu

ORLEN Paczka

New products and retail concepts enabled by digital solutions

Ongoing reporting of the origin of electricity to confirm the type of hydrogen produced (green, blue)

01

Sustainability is a megatrend of the future

We need to step up efforts to protect our planet

Critical indicators and climate challenges for the years ahead

There is a 40% chance that, by 2025, temperatures will be by even 1.5°C higher than in the pre-industrial era

Sea level rise has accelerated, threatening plant and animal life

Global energy consumption is growing steadily

Greenhouse gas concentrations continue to rise to new record highs

The risk of extreme heat, drought, torrential rains and flooding will increase due to climate change

Source: Accenture

Global development is gaining momentum. We are witnessing far-reaching technology advances that are improving our quality of life. Communication is more convenient, doing everyday work requires less effort, and access to learning and information has become easier. The healthcare sector is now more efficient and medical advances have extended life expectancy. The climate is changing just as rapidly, exerting a growing adverse impact on our lives. With time, the effects of global warming are taking an even greater toll on our lives. We are more and more affected by heat waves, forest fires, floods and melting glaciers. The record of major climate disasters, whose cost was estimated at billions of dollars, was established in the U.S., in 2020, with as many as 22 events. This is far above the long-term average of seven per year. In the previous record years of 2011 and 2017, the number of climate disasters was 16.

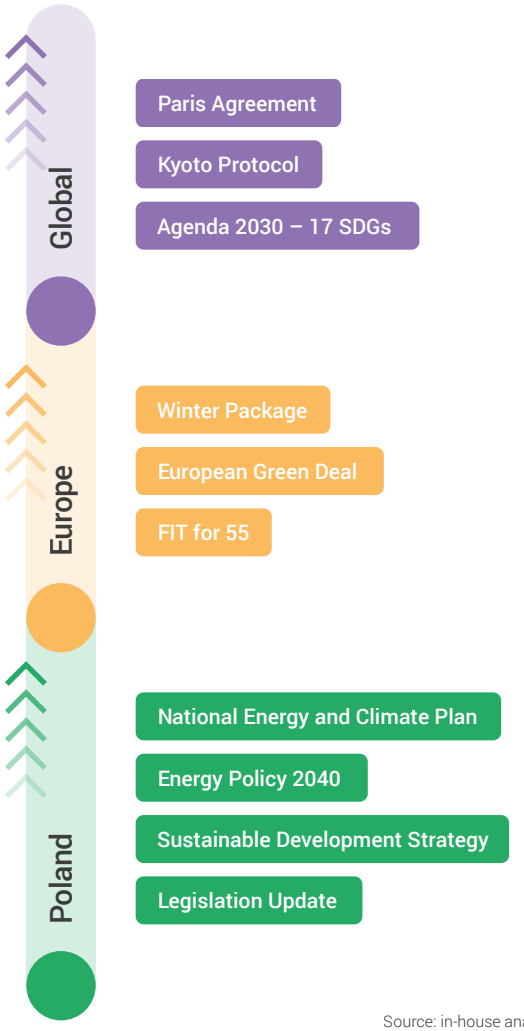
Climate transformation requires adequate investment, access to technology and support for the most vulnerable sectors that are not capable of adapting quickly to the changing environment. Commitment and motivation to change is required of all market participants.

Global temperature is already 1°C higher than it was in the pre-industrial era (1850–1900), and taking action to limit the rise to 1.5°C appears to be quite a challenge. It requires global cooperation that translates climate action into initiatives at the local level. To deliver green transformation, leaders need to drive an effective effort to combat climate change. The success of this common effort will depend on the ability to understand all stakeholders and combine technology, innovation and business value creation to accelerate technology-driven transformation.

We see a world that is open to change and responsible and sustainable recovery, ready to transform our environment into one that works for everyone. To make this a reality, businesses, governments and society alike must seize the moment to make a change by acting in new ways to meet the challenges the world is facing. This requires innovative thinking, bold action and extensive collaboration.

Climate goals can be achieved by coordinating legislative activities at the global and local level

The development of a common strategy and effective multi-level coordination of efforts are supported by a number of regulatory and organisational agreements. Over the past few decades, increased efforts have been made in the field of climate protection worldwide, at the levels of the European Union and national legislation. This has resulted in a significant increase in legislation, reflecting the importance of achieving climate transformation goals.



Source: in-house analysis

At the global level, the key legal document is the United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992. It was operationalised by the Kyoto Protocol signed in 1997 at the Third Meeting of the Conference of the Parties (COP3). However, the commitment to reduce greenhouse gas emissions only applied to developed countries and economies in transition. Another binding document on climate protection was the Paris Agreement concluded at the Paris Climate Conference (COP21) in December 2015.

To date, some 190 countries have joined the Paris Agreement, including the European Union and its Member States. The overarching goal is to limit the increase in global temperatures to below 2°C and work to keep it at 1.5°C. The agreement also aims to achieve carbon neutrality by 2050.

Agenda 2030, embodying the global strategy for sustainable development until 2030, was adopted in the same year. It contains 17 Sustainable Development Goals (SDGs) and was embraced unanimously by 193 member states that committed themselves to achieving sustainable development in its three dimensions – economic, social and environmental.

The Paris Agreement commitments were incorporated into the legislation package forming part of the European Green Deal. Its main objective is for the European Union to achieve carbon neutrality by 2050. The level of reduction of greenhouse gas emissions in 2030 should be between 50% and 55% compared to 1990, which is a much more ambitious goal than the previous target of 40%. The European Green Deal identifies digital technology and digitalisation as important tools to achieve the defined goals.

To align current legislation with the ambitious 2030 and 2050 targets, the EU is working on a package of legislative updates and new climate, energy and transport initiatives to be launched under the so-called 'Fit for 55' package.

In July 2021, the European Commission also adopted a package of regulations aimed at streamlining the flow of funds to finance the transition towards a sustainable economy. The package comprises three elements: a new sustainable finance strategy, an updated version of the European Green Bond Standard (EUGBS) and an approved final version of Article 8 of the EU Taxonomy Regulation on information to be disclosed by financial and non-financial companies.

All Member States must implement the same rules under EU law. Some of them have already been adopted in Poland, while others are still in the legislative process. The process involves amending laws and updating national plans and strategies, including the National Energy and Climate Plan and Energy Policy 2040.

Efforts supporting sustainability should encompass all key dimensions: environmental, economic and social

Sustainability means building an economic model in which societal needs would be met without compromising the resource needs of future generations.

This definition addresses limitations to growth posed by availability of resources to humans on Earth. Sustainability is pursued in the environmental, social, and corporate governance (ESG) dimensions.

Environmental

- The environmental aspect refers to our planet and the challenges we are facing today, such as global warming, water usage, waste management, soil/land use, resource use and air pollution.
- For companies, the environmental imbalance on the planet translates into resource scarcity and business disruptions, which hamper business activity and generate increased operating costs.

Social

- The social aspect relates to wellbeing and health, issues relating to inequality in its many forms, health and safety challenges as well as inclusivity and diversity.
- In the case of companies, this aspect covers employees, workforce in the supply chain, local communities and society as a whole.

Corporate governance

- The governance aspect refers to how a company is managed and how transparency, ethical standards and oversight are ensured.
- For companies, this may include processes and data security, supply chain and risk management as well as organisational and governance structures.

ESG is a term that has become embedded into everyday business practice and is often used in capital markets. The ESG framework makes it easier for companies to categorise and measure sustainability practices. As a result, ESG measures not only the environmental aspect, but also strongly influences the rating of investments and the ability to obtain preferential financing or access certain financial instruments at all.

ESG is also a factor underlying stock market ratings and investment decisions. The environmental, social and corporate governance aspects are directly reflected in a company's valuation, long-term value creation, stability and financial performance.

As demand for transparent, standardised data on corporate sustainability metrics grows, so does the importance of ESG rating agencies. ESG rankings are compiled by such agencies as Bloomberg, S&P, and Thomson Reuters.

Global investors are relying more and more in their investment processes on ESG rankings produced by those agencies.

Companies and projects that fail to meet ESG sustainability criteria face an increasingly limited access to financing or are forced to raise funding on less favourable terms.

Setting science-based targets helps with the transition to a carbon-neutral economy

Recent years have brought a radical change in global finance. Companies are no longer evaluated based solely on financial indicators. Instead, it is becoming increasingly important how business activities affect the climate and the environment. Financial institutions are required to apply ESG standards to report both their environmental impact and their approach to managing risks arising from climate change. As a result, environmentally friendly projects are favoured, have access to cheaper financing and receive better ratings. They are also regarded as less risky.

Investors are paying more and more attention to sustainability when deciding where to invest their money. Growth of the sustainability industry has made it easier for investors to build portfolios with sustainable funds. The Global Sustainable Investment Review 2020 report shows that sustainable investment across the global financial markets has grown to USD 35.3 trillion (up by 15% in two years) and now accounts for 36% of all assets under management in the US, Canada, Japan, Australia, and Europe.

In Poland, most commercial banks have stopped financing companies relying on coal as their core business. In July 2021, Poland's largest state-owned bank, PKO BP, announced its commitment to that effect.

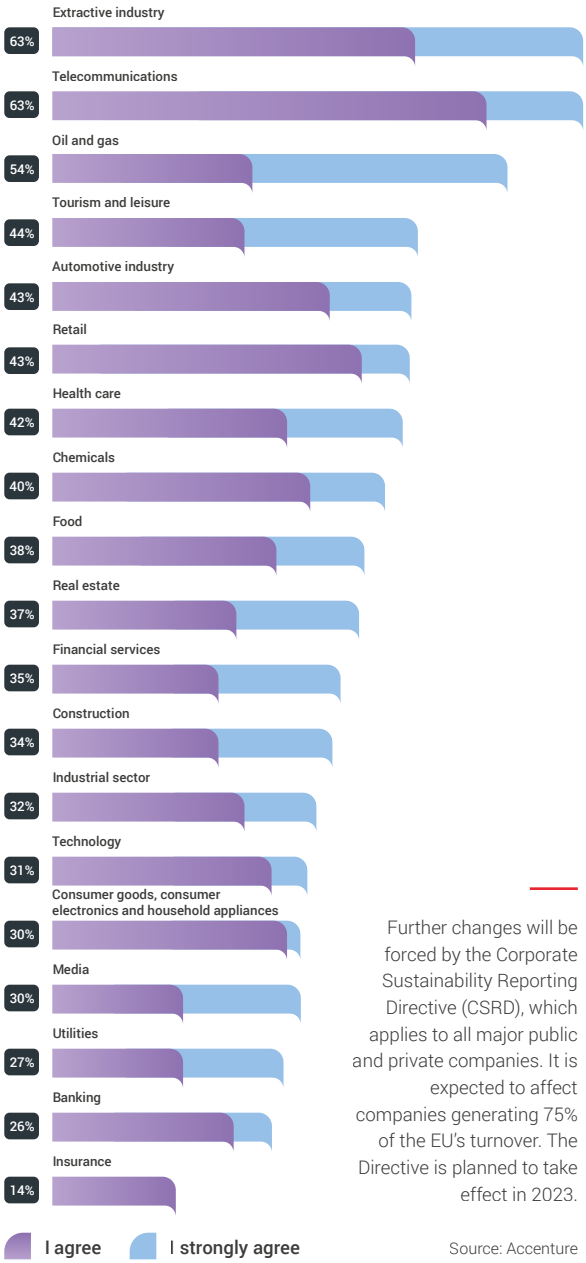
Setting a carbon neutrality goal is no longer enough for investors. The market and investors expect companies to publish short-term and medium-term targets and have a clear pathway to achieve them.

In an effort to get businesses to actually manage the transition and continuously reduce their adverse climate impacts, the global Science Based Targets initiative (SBTi) was established in 2015. It helps companies set quantifiable greenhouse gas emission reduction targets and transition to a low carbon economy of the future in line with the Paris Agreement goals. SBT defines and promotes best practices in setting targets consistent with climate science, provides resources and eliminates implementation barriers, and objectively evaluates and validates climate targets adopted by companies. The targets are then communicated to stakeholders and reported across the company, and progress against them is monitored periodically.

To what extent do you agree with the following statement

"My company has already set science-based targets or plans to introduce them next year"?

According to data as at the end of August 2021, over 1,700 companies worldwide have already undertaken SBT-compliant activities.



Further changes will be forced by the Corporate Sustainability Reporting Directive (CSRD), which applies to all major public and private companies. It is expected to affect companies generating 75% of the EU's turnover. The Directive is planned to take effect in 2023.

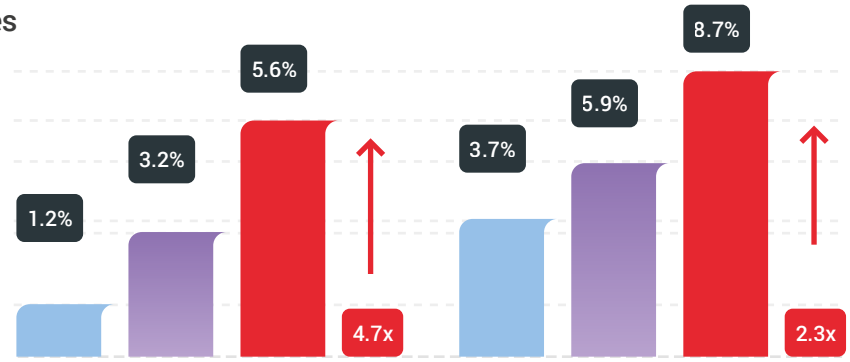
Source: Accenture

Companies that embrace sustainability improve their profitability and build value for their shareholders

Accenture has evaluated metrics that determine business success of companies. According to the analysed data, companies that deliver strong sustainability performance generate shareholder returns that are two to three times higher than those of companies which leave out sustainability in their business strategies. Companies that are already running sustainable businesses perform better financially and receive better ratings from global rating agencies.

Profit margins of companies with high ESG scores vs companies with low ESG scores (in percentage points)

Annual average | 2013–2019



Source: Accenture

Examples of companies that have embraced sustainability and are thriving today

Ørsted is the world's largest offshore-wind power producer, with a 25% share in the global offshore wind market. Despite its roots in the oil and gas industry, it wins rankings for the most sustainable energy companies in the world. Over the last decade, the corporation has radically changed its business model. In 2009, Ørsted derived 85% of the energy supplied to its customers from 'black' sources (powered by coal, oil and gas), with 'green' sources accounting for a mere 15%. But then the company announced it would reverse this ratio within one generation. However, the transformation happened much faster than expected – by 2018 the energy generated by Ørsted was already 75% 'green'. Transformation of the company's business does not end with just moving away from fossil fuels. Ørsted has also bet heavily on artificial intelligence (AI) and cloud solutions. These advanced analytical tools help optimise the operation and maintenance of offshore wind farms, improving business profitability. Ørsted's operating profit for 2018 was USD 2.3bn.

Deutsche Post DHL has developed the GoGreen Carbon Dashboard to help consumers choose low-emission shipments. With this interface, companies using logistic services can view analyses of carbon emissions associated with their shipments, mapping emissions along their supply chain. The resulting transparency allows users to compare and set targets, identify contributors to carbon emissions and develop strategies to reduce them.

Siemens minimises the environmental impact of its products and services throughout their life cycle by investing in solutions to simulate and build 'digital twins'. They enable products to be designed, simulated and manufactured faster than in the past, with an eye to improving cost savings, performance, durability or environmental compliance.

Companies that combine digital transformation with transformation based on sustainability goals stand a greater chance to succeed in business

The COVID-19 pandemic and the economic rebound seen in global markets in 2021 have clearly changed the previous growth trajectories for many companies. The coronavirus-induced unprecedented economic crisis is creating new market winners and losers.

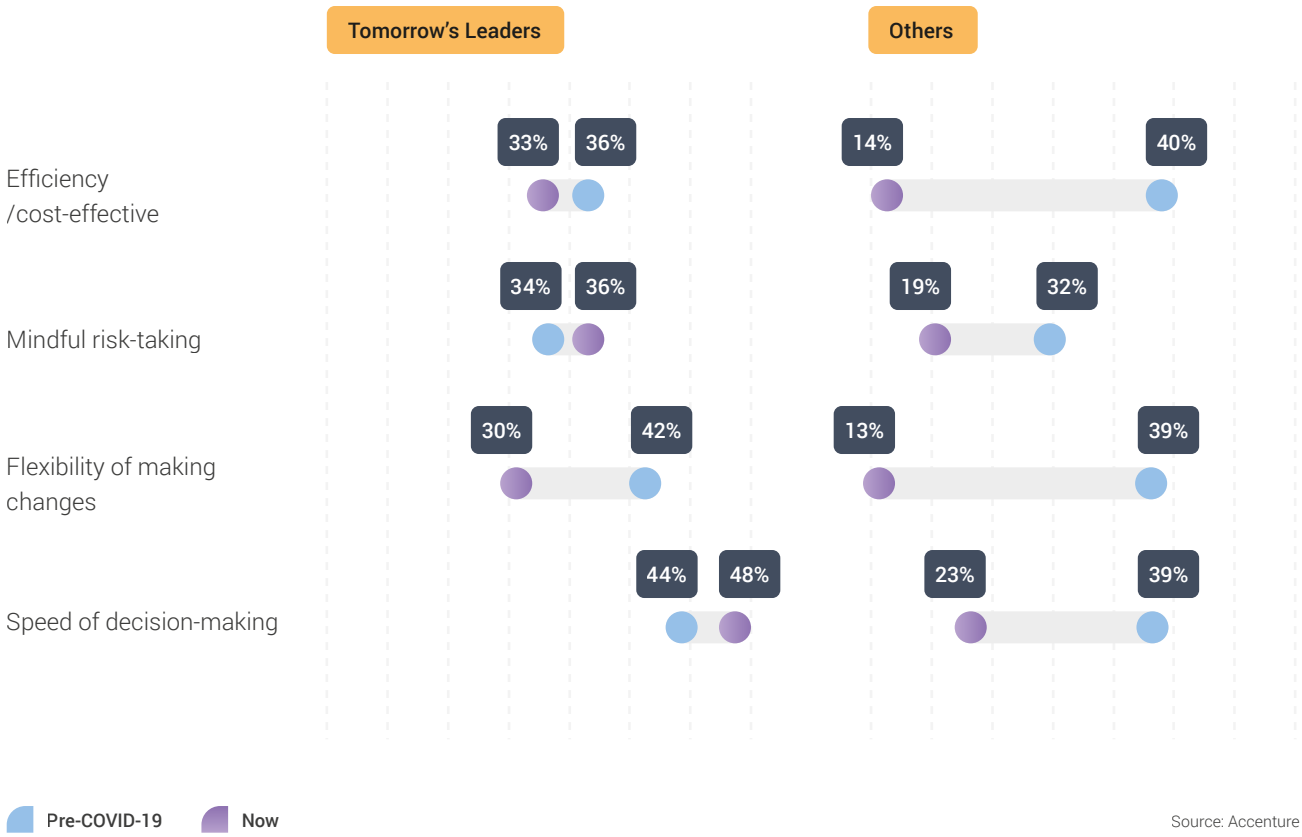
Accenture analysis suggests that only 32% of European companies in recovery after the COVID-19 pandemic are positioned for profitable growth. This group is referred to as Tomorrow's Leaders. They are companies that have a positive operating profit calculated from the 'fragility' phase (second half of 2020) until the rebound phase (first half of 2021), with a stable or improved operating profit between each phase. At the same time, as many as 19% of the companies surveyed, called Falling Angels, face serious problems in returning onto the pre-pandemic growth path.

What makes the two groups different? Tomorrow's Leaders are companies with an agile approach to organisational management. They are highly competent in quick decision-making, flexibility of making changes, mindful risk-taking, and economic efficiency, as was demonstrated during the crisis. Sustainable transformation strategies make business models more resilient to both climate change and market crises, such as the COVID-19 pandemic.

Combining digital transformation with sustainability transition (Twin Transformation) will enable efficiency gains while supporting delivery of the carbon neutrality goal.

Tomorrow's Leaders have demonstrated more resilience during the crisis than others, thanks to their agility across capabilities

% of high-level agility



Source: Accenture

Businesses are taking a new direction, and Twin Transformation pays off double

Based on Accenture's research and experience, companies embarking on Twin Transformation are 2.5 times more likely to be among Tomorrow's Leaders. Twin Transformation is a process that combines the shift towards sustainable business with digital transformation.

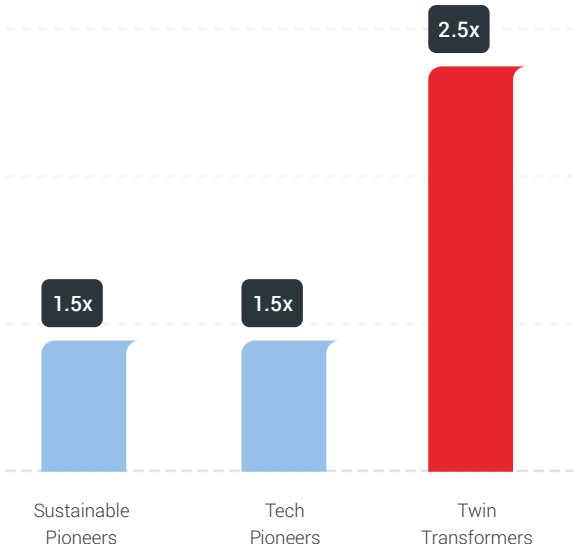
The leading business trend in the 2010s was digital transformation. The key development since 2021 has been building business models that are in line with sustainability priorities. There is a growing number of examples around the world of companies combining digital transformation with sustainability transition – Twin Transformers.

Section 4 describes a survey conducted among over 4,000 corporate executives worldwide, including Poland. The top strategic priorities for them over the next three years will be to step up digital transformation and sustainable business growth.

Most European companies are well prepared to join the Twin Transformation but they need new business models to get ready to tackle the challenges beyond 2030, such as transition to carbon neutrality.

Likelihood of being among Tomorrow's Leaders

Odds ratio for Tomorrow's Leaders among companies being pioneers of sustainable transformation, pioneers of technology adoption and of both versus those meeting none of these criteria.



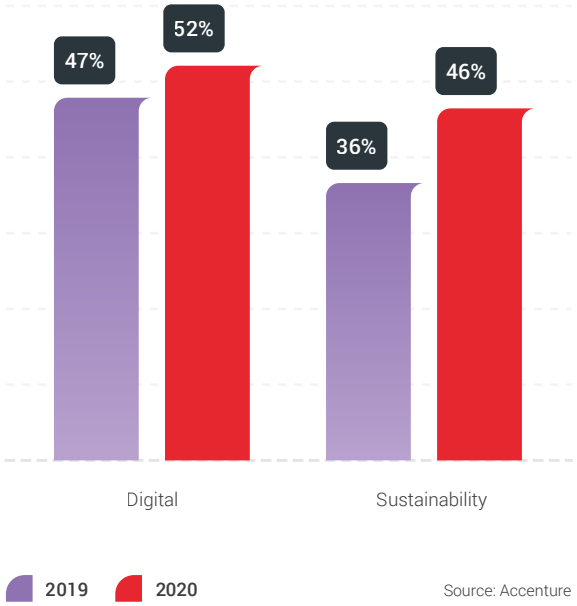
Source: Accenture

The key to success in energy transition is digitalisation. Ambitious climate goals cannot be achieved without it

Companies around the world are increasingly focusing on sustainability efforts. They do so for different reasons, though. Some industries are acting under the pressure of customer expectations. Others are motivated by investors or regulatory pressure. European companies engage in sustainable activities primarily driven by personal conviction and growing environmental and social pressures. The challenge for European companies remains to fully exploit the business opportunities that come with sustainability, with only few focusing on the importance of digital technology in driving sustainability. In Chapter 2, we discuss how digitalisation supports the development of low-carbon industry.

The coverage of digital and sustainability has risen fast during the COVID-19 crisis

Share of 2,000 largest companies located in Europe that mention digital and sustainability in earnings calls



Source: Accenture

European businesses are facing a huge transformation challenge. In response to the accelerating climate change, there are and will be more international and national policies forcing companies to take greater care of the environment and strive to reduce greenhouse gas emissions, among other things.

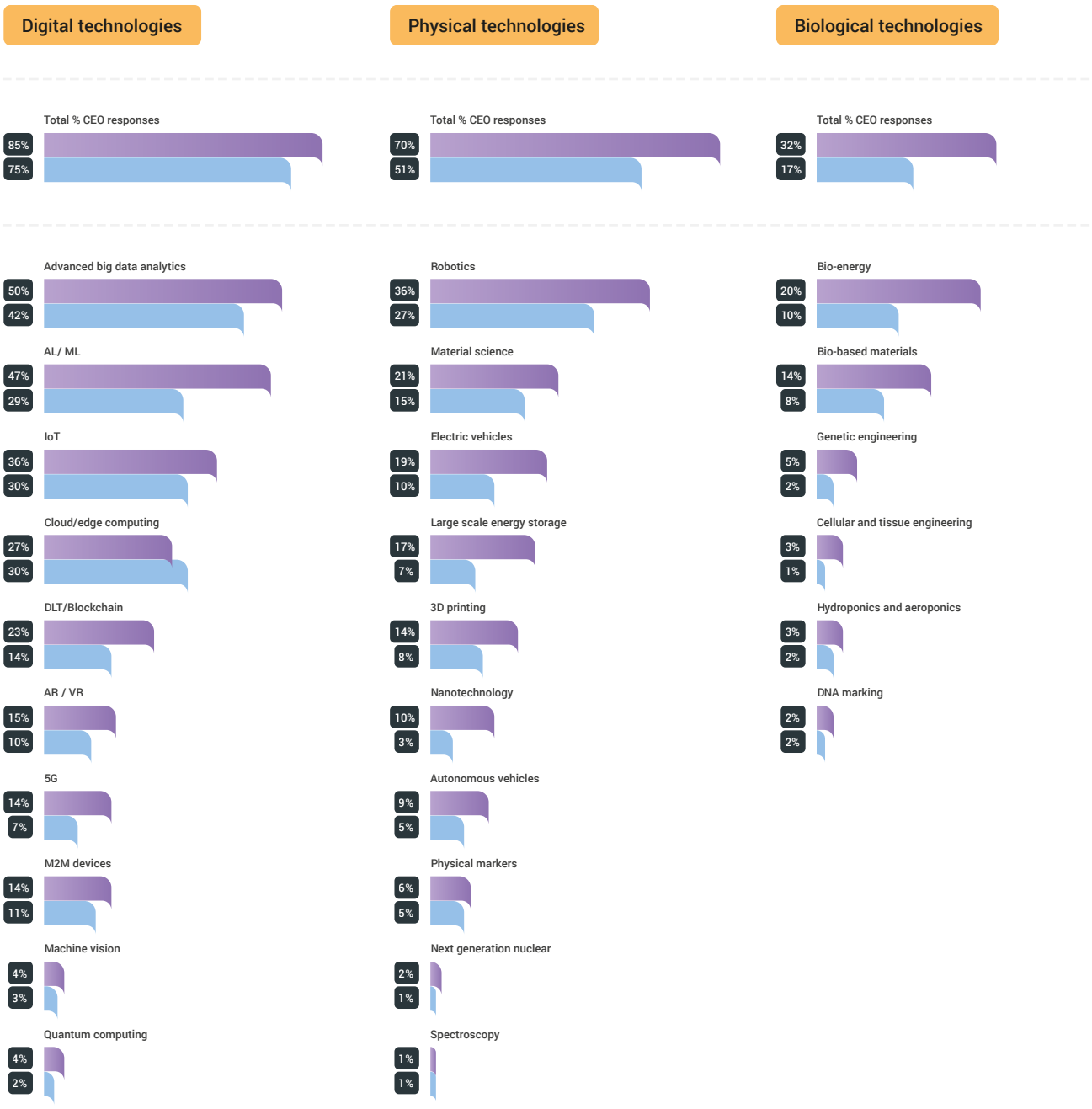
The climate and environmental commitment is necessary while striving for GDP growth and maintaining competitive advantage. All this makes companies develop and implement entirely new business models. They can be created with the support of digital technology.

Advanced technology can play a key role in the efforts to accelerate progress toward a more sustainable future. In a joint UNGC-Accenture Strategy CEO study, three-quarters of respondents indicated they are investing in digital technologies to address sustainability challenges. The five most important ones are: big data, AI, IoT, cloud technologies, and blockchain.

The technologies that CEOs see as most transformative toward sustainability and in which they are investing the most

Which technologies will help your industry meet its sustainability challenges?

Which technologies is your industry investing in the most today?



Source: Accenture

Sustainability leaders engage customers and business partners to deliver ESG goals

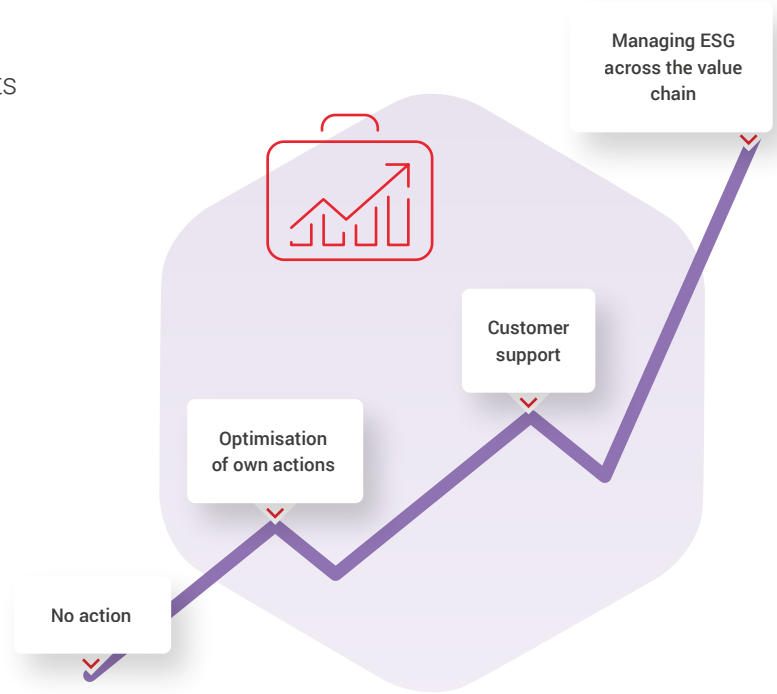
European businesses are facing a huge transformation challenge. In response to the accelerating climate change, there are and will be more international and national policies forcing companies to take greater care of the environment and strive to reduce greenhouse gas emissions, among other things.

Source: in-house analysis

We identify four levels of excellence in the efforts to support sustainability

- No action to support sustainability
- Sustainability supported solely through optimisation of own actions
- Sustainability supported through optimisation of own and customer actions by offering sustainable products that help customers implement ESG strategies
- Sustainability supported through optimisation of own and customer actions by integrating ESG goals in the supply chain and among other stakeholders

In practice, we also see companies partially implementing actions at different levels of excellence.

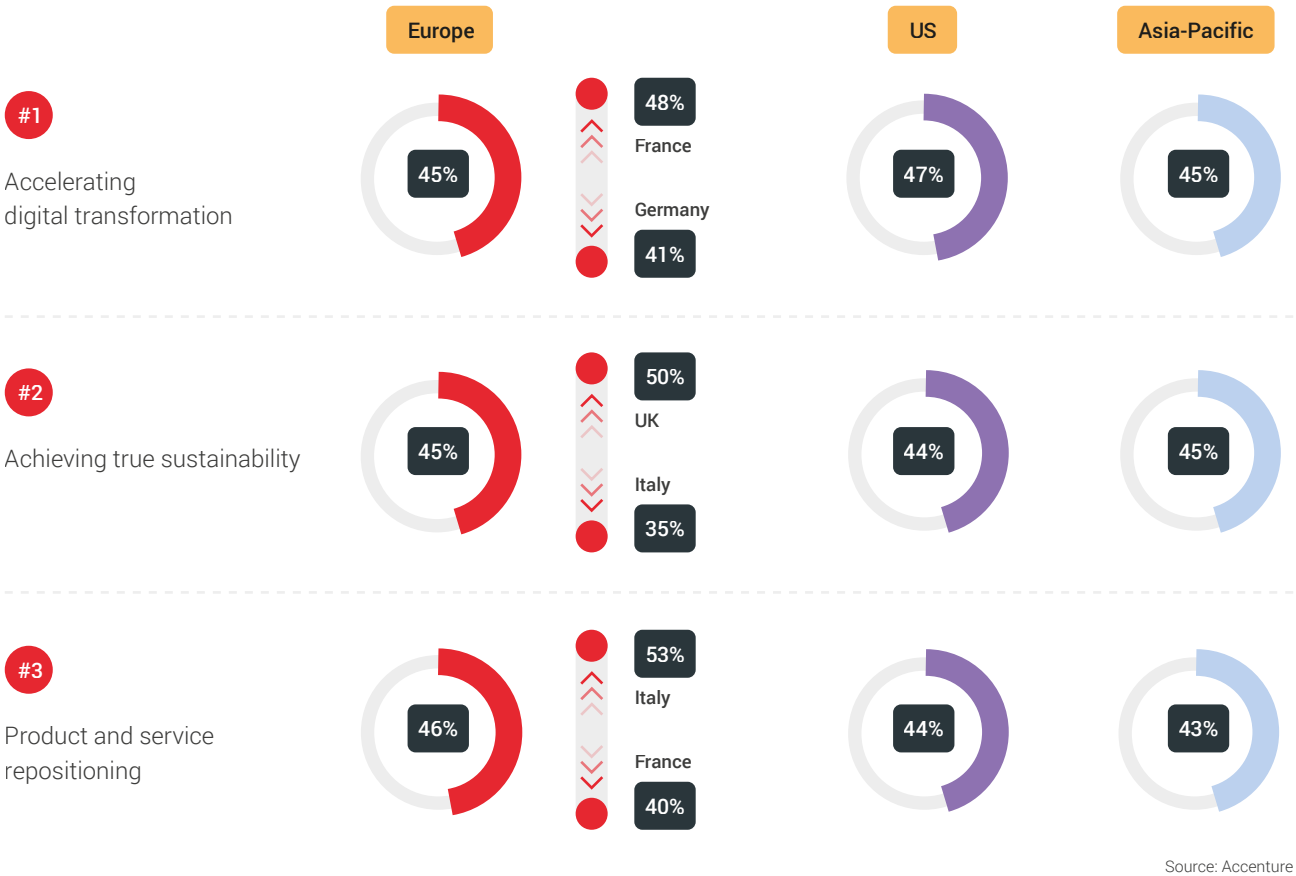


A growing number of companies in Poland link their key strategic goals to enabling sustainability and build sustainability-based value

Polish companies and Poland's economy are driven by similar trends and regulations as is the case in the rest of Europe. In the home market, we can see that digital business transformation is gaining momentum. In addition, there is an emerging paradigm shift in measuring the progress of society: it is no longer based solely on GDP growth and consumption, but increasingly on the environmental impacts of human activity.

Polish companies are ramping up sustainability efforts and competing for attractive financing sources on international capital markets. European companies are already prioritising sustainability and digitalisation in their strategies for short-term recovery and medium-term competitiveness. To gain a competency advantage, they focus on three main priorities: accelerating digital transformation, achieving a truly sustainable business, and repositioning products and services for a growing group of conscious customers who are more likely to choose sustainable products.

Share of responses from executives in each region voting for each priority



Source: Accenture

European companies plan to invest heavily in cutting-edge technologies

% of European and non-European respondents

	Europe	Others
#1 Artificial intelligence	40%	44%
#2 Cloud-based ERP	37%	39%
#3 5G	36%	35%
#4 Internet of Things	35%	39%
#5 Big data	35%	35%

Source: Accenture

Adapting to environmental requirements will be a key challenge for Polish businesses in the coming years. In addressing the challenge, digitalisation will play a vital role, especially in technologies such as AI, cloud, 5G, IoT and big data.

The rapid pace of regulatory change in climate policy is creating additional pressure to adapt. Businesses are also concerned about high penalties for exceeding emissions limits or failure to meet environmental standards and report the required ESG metrics.

Polish companies are increasingly motivated by actions towards achieving sustainability goals rather than fear of environmental restrictions. More and more conscious businesses are opting for digital transformation that enables them to optimise their operations in a sustainable way. Data management technologies will provide insight into databases and will help improve decision making, increase profits and deliver environmental and social goals.

02

Digitalisation and zero-carbon challenges

> Artificial intelligence has the potential to deliver enormous benefits to society, but only if used responsibly
>
> **Klaus Schwab**
> Founder and Executive Chairman of the World Economic Forum

Key digital technologies

Artificial intelligence

Artificial intelligence (AI) is the ability of machines to display human-like capabilities such as reasoning, learning, planning, and creativity. It enables systems to understand a lot of available data (for instance from sensors at an industrial plant or from a camera). Based on this data, action patterns are created. AI increases business efficiency and productivity by automating processes or tasks that used to require a lot of manual effort and analysis. Artificial intelligence can also make sense of data on a scale no human can.

Examples include virtual assistants, image analysis software, search engines, voice and face recognition systems; autonomous driving systems, drones, and the Internet of Things.

5G

5G is a mobile communications technology standard and the successor to 4G. Its expected parameters will enable data transmission with low latency and significantly higher data rates compared with current mobile technologies.

Blockchain

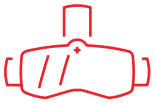
Blockchain is a distributed ledger containing data stored in a way that makes data manipulation impossible. Blockchain can be used to store and transfer information about online transactions. Importantly, in the context of sustainability, blockchain makes it possible to track and record the product development process at all stages in a transparent and reliable manner.

Internet of Things

The Internet of Things (IoT) is a system of interconnected devices that are equipped with sensors, have the ability to process data and exchange information with other devices, for instance via the Internet.

Communication

A family of technologies that process, collect and transfer information electronically.



Augmented reality

Augmented reality is a technology that combines the real and virtual world. Typically, 3D graphic content is superimposed on a camera image.

Cloud computing

Cloud computing is the provision of computing power and related services by an external provider. Data is not stored on own hard drives, but in external resources. Usually, the service recipient pays only for the services actually rendered, which reduces operating costs and facilitates more efficient use of the infrastructure. It eliminates the need to manage own servers and install or administer own software. The technology provides access to large computing power at a fraction of the cost of the infrastructure.

The ongoing industrial revolution is about greater human-machine collaboration and about using technology to protect the environment

As mentioned in Section 1, the global economy is undergoing an inevitable change driven by major climate regulations, forcing the transformation of traditional business models.

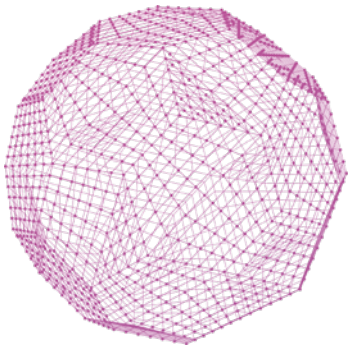
The previous industrial revolutions (1.0–4.0) involved exploitation of deposits and an unsustainable approach to protecting the Earth's climate and resources. Revolution 5.0, supported by powerful normative legal acts, has the potential to become the first to bring about significant technological progress while respecting the planet's resources.

Slowly becoming a thing of the past, the 'extract-make-use-dispose' business model is being challenged particularly within the EU – given the awareness of the mounting economic, social and environmental challenges Europe is facing.

The starting point for Industry 4.0 was the third industrial revolution, and its main achievement was the robotisation of production. But what sets it apart is that it connected the world of industrial automation with the physical and virtual world through sensors. The two realities began to intertwine, exchanging information continuously. The Internet of Things has enabled communication between devices without human intervention.

However, the dehumanised image of industry, where fully automated production networks are operated by autonomous robots, is becoming out of date. Industry 5.0 emphasises the restoration of humans in highly automated processes. The mutually beneficial human-machine interaction, where people and machines complement each other, is gaining prominence. An example of Industry 5.0 technology are co-bots – collaborative robots used in factory settings to automate processes, allowing for greater interaction with humans.

It is worth noting that in the ongoing revolution, digitalisation is not an end in itself, **but a fundamental tool serving the goal of sustainable development of our planet.** This topic will be elaborated on later in our report.



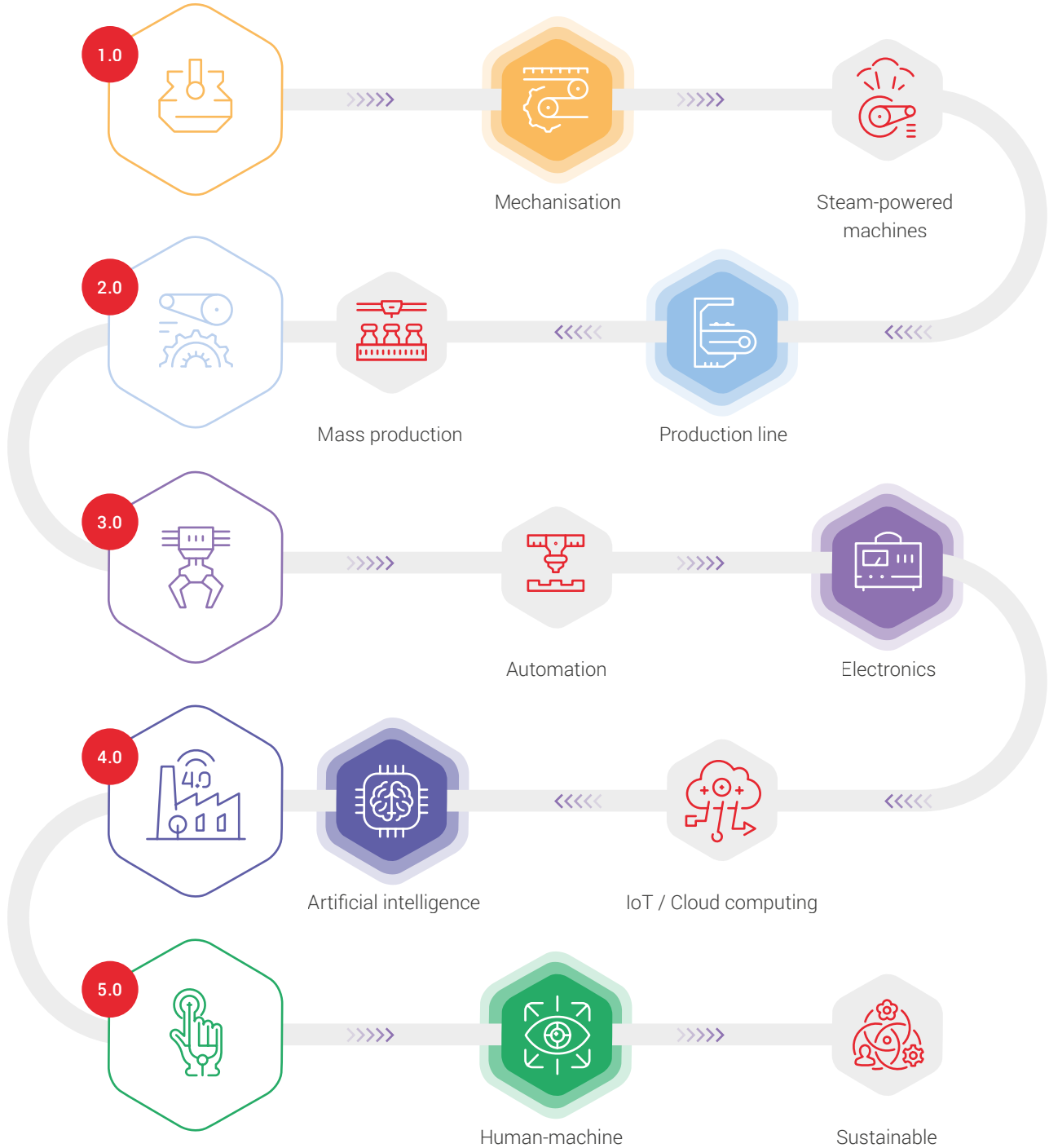
Over
60 trillion
web pages

The total number of web pages exceeds 60 trillion. That's almost 10,000 pages per person alive on Earth today. The rapid development of the virtual world is leading to equally dynamic changes in the physical world.

"Today, living in a world of technology, which has become an accelerator of change, an accelerator of change, involves and will involve the constant emergence of newer versions, including new versions of ourselves, forcing us to change our attitudes and behaviours. This process is also about self-adaptation and self-renewal."

Kevin Kelly
writer, editor-in-chief of *Wired* magazine

Successive industrial revolutions: Industry 1.0–5.0



Source: in-house analysis

> At least 40% of all businesses will die in the next 10 years if they don't figure out how to change their entire company to accommodate new technologies
>
> **John Chambers**
> Former CISCO CEO

Technology development is progressing at a pace faster than most of us think. Elon Musk said: "The pace of progress in artificial intelligence is incredibly fast. Unless you have direct exposure to groups like Deepmind, you have no idea how fast – it is growing at a pace close to exponential." Peter Diamandis and Steven Kotler, American technology experts, have presented the theory of technological convergence, or the intertwining of technologies that accelerates their development. The convergence of technologies will soon entirely transform many industries. You can respond to these changes in two ways – either by defending your existing business models or by adapting by creating new products or services.

Among the myriad of market, technological and social trends, worthy of note are the forces influencing contemporary business models:

- Climate regulations are putting increasing pressure on businesses to move towards zero carbon. The Corporate Sustainability Reporting Directive (CSRD) requires carbon footprint transparency. Projects helping to halt or reduce climate change have a greater chance of receiving funding as the lifeblood of business growth.

- Businesses are also strongly impacted by changing customer behaviours and expectations. Quick-commerce and hyper-personalised products and services tailored to customer needs are on the rise.

- Business growth is also driven by trends associated with decarbonisation – the emergence of new technologies and the rapid evolution of renewable energy sources. New fuels and storage technologies are being brought to the market. New mobility is changing transport, which has relied on oil for decades. Digital technologies further accelerate this progress by supporting the development of trade, energy, transport, communication. Once limited to selected sectors, digitalisation processes are becoming increasingly universal and global. As a result, there is a shift in the way we produce, consume and organise the market.

- In addition to the above forces, business is also influenced by expectations of investors, who continue to attach importance to investment returns. Expected levels of return will be provided by those initiatives which ensure a low carbon footprint of the business – not only that created by its own operations but also by its suppliers and customers ('Scope 3').

Existing business models are running out of steam. The effect of the forces affecting business, as described above, is the emergence of new business models. These factors put a lot of pressure on companies, but at the same time they create new development opportunities. Sustainable business models will be more flexible and crisis-proof as digitally-enabled businesses will be able to adapt to market expectations faster and better. The interrelations between manufacturers, distributors and consumers are changing. The context of economic viability is broadening. Companies that do not meet ESG requirements will find it more difficult to access finance.

New game-changing business models are emerging owing to digitalisation – new markets are being created that require regulation and new business models are being developed in traditional markets, for instance in the energy market. In the energy sector, we are seeing a shift in the roles of consumers, distributors and producers. Electricity generation is moving from centralised to ddistributed generation systems. Distribution system operators will cease to act as neutral energy market facilitators and will become leaders in many areas, including energy storage and smart grids, and, first and foremost, integrators between prosumers, renewable energy sources and energy consumers. Also, the role of energy consumers will change into micro-producers and consumers at the same time. They will sell surplus energy to a neighbour or store it in the battery of an electric car. Such new business models will keep emerging from green transformation.

Sustainable and technology-driven business models

Change in project financing methods

Projects to reduce or halt climate change will receive funding

Carbon footprint transparency requirement

CSRD Directive: non-financial reporting requirement

Moving towards zero-carbon

Green Deal
Paris Agreement
Agenda 2030

Digitalisation

Blockchain
Internet of Things
Augmented reality
Artificial intelligence
Cloud computing

Industry and transport decarbonisation

Renewable energy
Energy market decentralisation (energy storage, prosumers, smart grids)
Electric mobility
Hydrogen
Biomethane

Fast delivery and personalisation

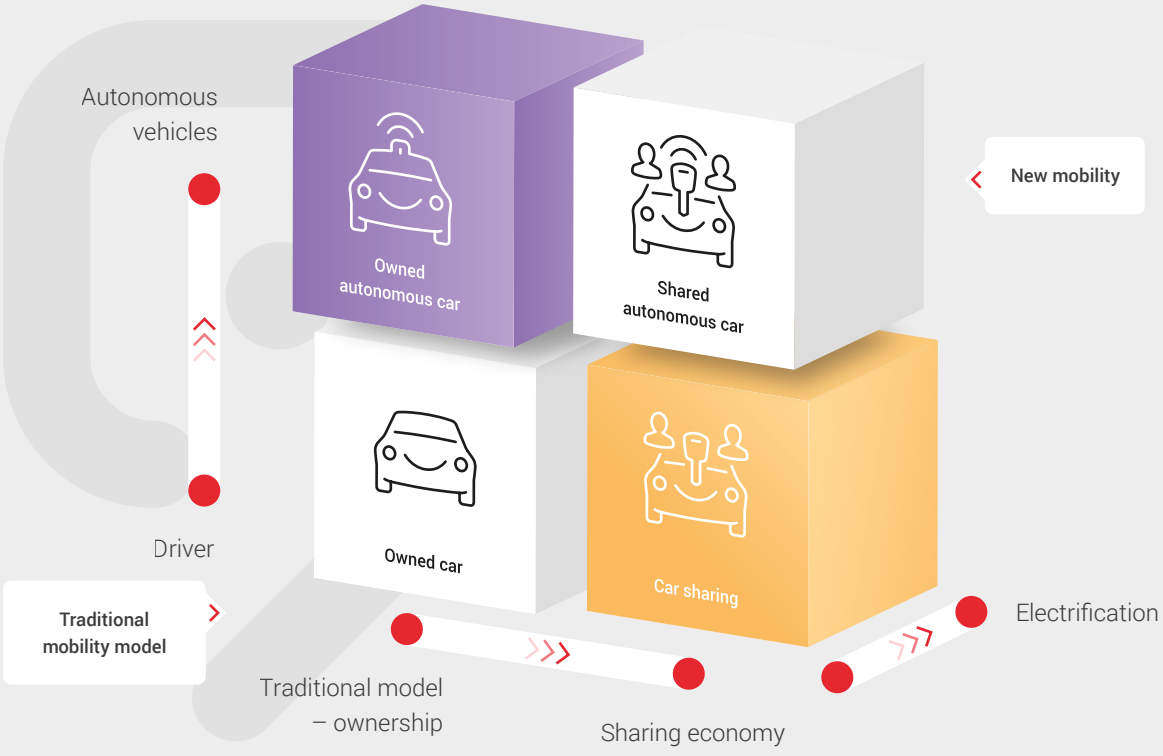
Quick commerce
Hyper-personalisation
Consumers as prosumers – demanding products and services with a low carbon footprint

New sharing economy business models

Big data and fast communication technologies have led to new sharing economy business models. The ongoing transformation of the automotive market is a manifestation of the evolution in our thinking about what a product is. Products are increasingly offered as a service. Instead of buying a car, people can use a car-sharing service. Cars used to be purchased from car dealers. Today, the purchasing process is conducted online, has become personalised, and offers a full car configuration without the need to visit the showroom.

The new mobility model is a shift from one in which a car with a combustion engine and manual transmission is driven by its owner, to one in which an autonomous electric vehicle drives passengers on demand while the passengers can engage in work or leisure activities. This model requires cooperation and communication between people and between people and vehicles (machines). The sharing economy is also, perhaps more importantly, about resource efficiency, particularly with regard to raw materials and labour. Moreover, shared products and services are available on demand. As in the example provided above, resource sharing is not an act of goodwill by a market participant but a business proposal involving a product offered as a transport service.

Example of a new business model in the automotive market



Source: IHS Markit mobility cube

Digitalisation as a driver of the transition to a circular economy

Linear economy

Circular economy

Take, use, dispose	Reuse, repair, refurbish, recycle
Single-use products, materials and energy	Infinite flow of raw materials and materials
Products become obsolete but are still usable	Extended product life cycle achieved through rebuilding the product or breaking it down into components

Technology also drives the circular transition. Circular economy is a response to the growing demand for raw materials. It is a development strategy increasing prosperity while reducing and optimising resource consumption by:

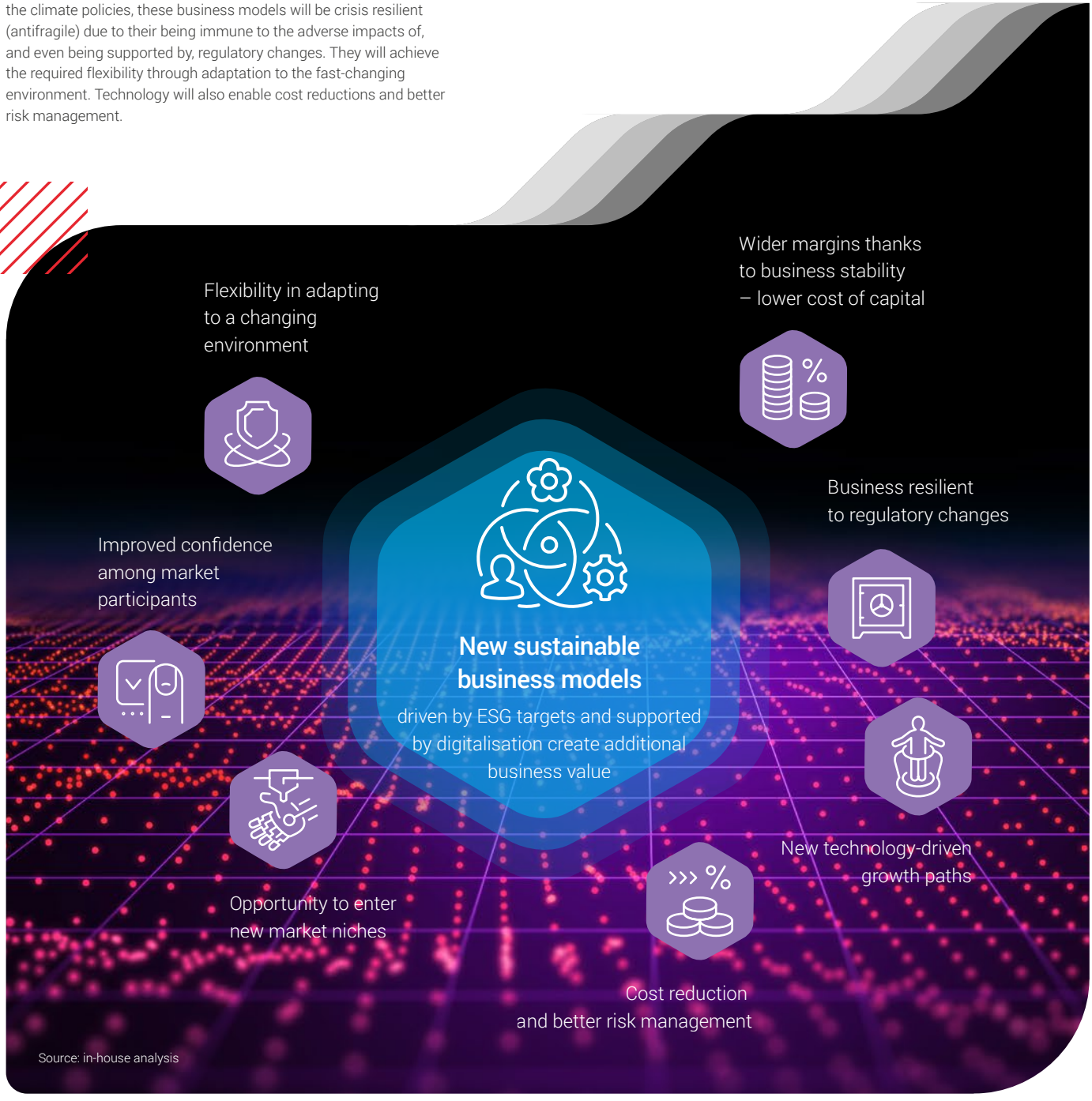
- reusing materials
- extending the product life
- exploiting the potential of the waste stream and driving a deep transformation of production chains and consumption
- creating new, highly innovative business lines

The circular transition may prove to be one of the far-reaching and most beneficial revolutions of the modern world.

What is the transformative role of digitalisation? Industry 5.0 is driving an evolution of the traditional model of resource consumption towards a circular economy. Business has so far been locked-in to the linear model of production and consumption. But increasingly demanding environmental standards, limited access to raw materials and changing customer expectations are forcing businesses to transform their strategies and implement solutions enabling them to track the life cycle of their products. Similar to the evolution in the mobility sector, consumption of other services, previously satisfied only through the purchase of durable goods, will follow models of product sharing and shared product responsibility. As product owners, companies will be responsible for their products from design to final disposal.
The obligation to recycle now falls on the producer and the consumer. Product-as-a-Service (PaaS) facilitates recycling and fits into the circular economy model, while additionally lowering the cost of satisfying needs. Instead of buying durable goods, we will pay to use them.
And technology will be a driver of the transition to a circular economy.

Sustainable business models will be more resilient to market changes

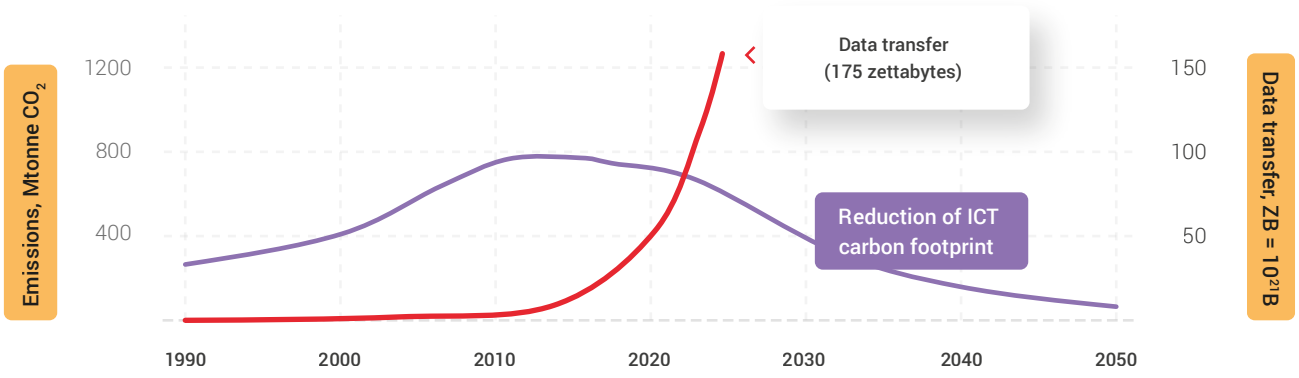
With digital support, new sustainable business models will be geared towards delivering profit margin targets but also ESG targets. Fitting into the climate policies, these business models will be crisis resilient (antifragile) due to their being immune to the adverse impacts of, and even being supported by, regulatory changes. They will achieve the required flexibility through adaptation to the fast-changing environment. Technology will also enable cost reductions and better risk management.



The development of digital technologies in itself generates greenhouse gas emissions, but their application is even more effective as a leverage to counteract adverse environmental impacts

Projected reduction of digital carbon footprint

Source: in-house analysis based on Ericsson Mobility Report



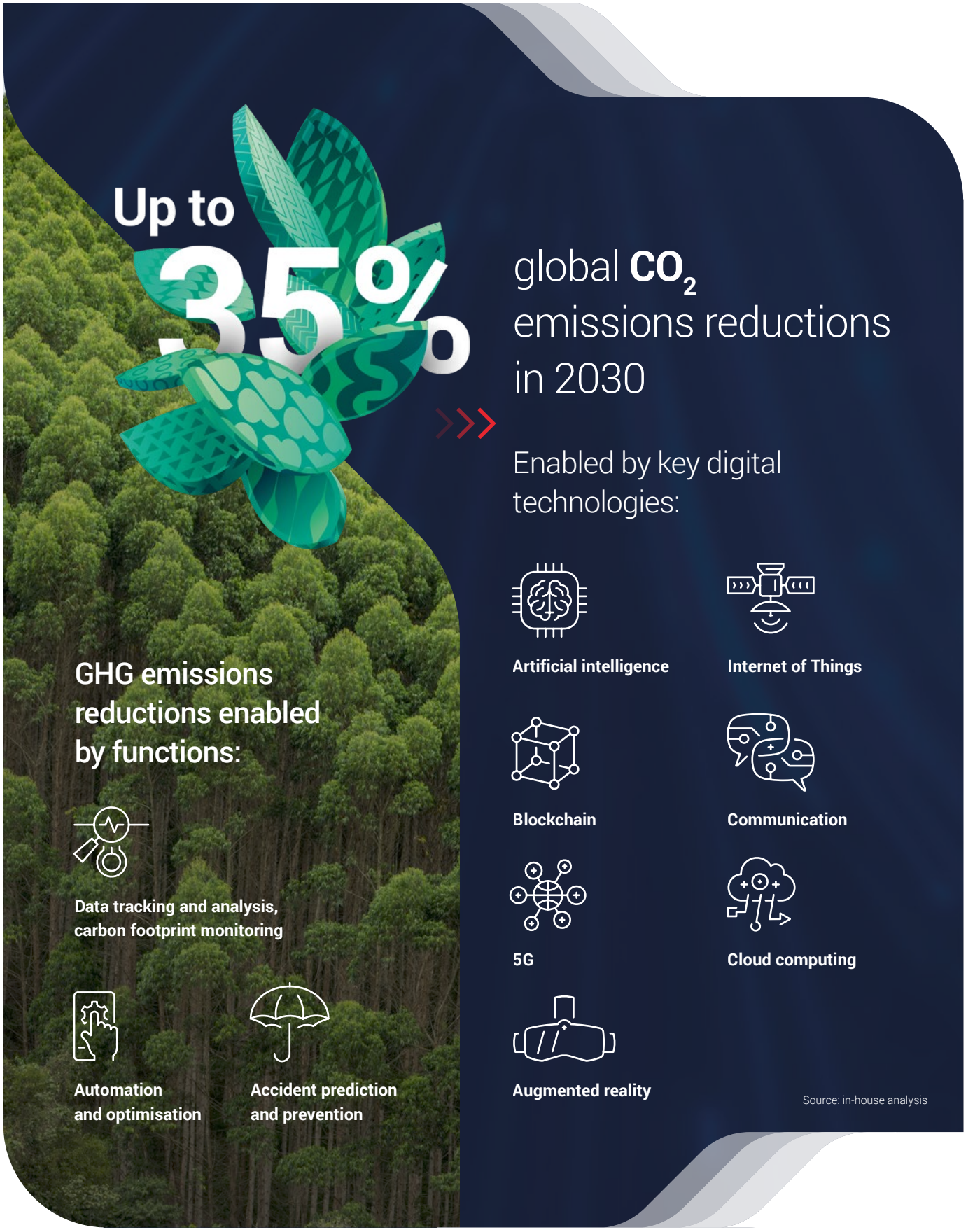
The world is gathering pace. International Data Corporation (IDC) predicts the datasphere will grow from 59 zettabytes (ZB) today to 175 zettabytes by 2025, with 90 ZB created on IoT devices. One zettabyte is one trillion gigabytes. For comparison, if you could store 175 ZB onto BluRay discs, you would have a stack of discs that could get you to the Moon 23 times. Every online interaction increases server usage and generates more carbon emissions. Estimates show that demand for computing power, and thus energy demand, will continue to grow.

The exponential growth in digitalisation translates into rising electricity consumption. The ICT sector accounts for around 5% of global CO_2 emissions. But the benefits of using digital tools outweigh the adverse impacts of digital carbon footprint. It is important to stress that progress of the information and communications technology (ICT) should also be sustainable and achieved responsibly. Every successive generation of wireless technology increases the efficiency of data transmission while stimulating demand for network services. With the progress of digital transformation, the world will become increasingly connected. This could lead to the so-called Jevons paradox, in which the use of digital technologies causes electricity and raw materials consumption to rise (just as more efficient use of the energy contained in coal led to rising demand for coal). However, digital technologies, through energy efficiency improvement, inbound optimisation and pollution prevention, are making a real contribution to reducing greenhouse gas emissions and minimising the occurrence of leaks and spills of hazardous substances. Hence the need to raise the awareness of digital tools being capable of reducing carbon footprint on a scale larger than before.

After a period of rapid growth, ICT emissions peaked around the year 2010, to start falling in subsequent years despite further continued progress and rising data transfers, chiefly on the back of significantly faster data processing capabilities and more energy-efficient data transfer networks.

In order to serve sustainable purposes, digital tools must be used sustainably and the energy that powers them should come from renewable sources. These are the two critical conditions. Responsibly implemented and efficiently used, digital solutions are a prerequisite for achieving most of the Agenda 2030 and Paris Agreement goals, and they may reduce greenhouse gas emissions by as much as 35%.

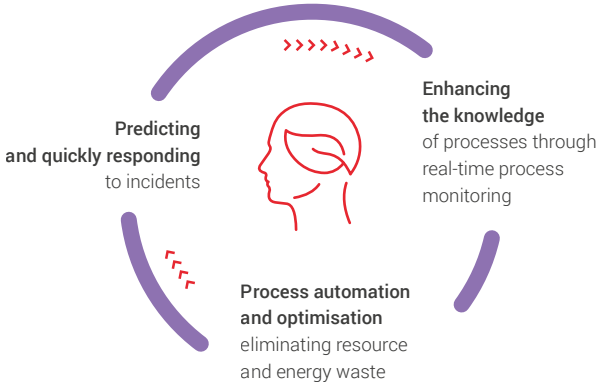
It is imperative that digital implementations are coordinated across various sectors of the economy. For example, the rollout of green generation sources, such as solar PV, should be integrated with expanding networks capable of receiving extra power. Smart tools should be deployed to combine micro-source distributed power data with information on current prosumer demand so that the flows of generated energy can be properly managed.



Source: in-house analysis

Digitalisation helps understand the consequences of actions and adapt them to minimise environmental impacts

> Decarbonisation and digitalisation are two strongly correlated trends that are transforming business models and the life of entire societies. They create synergies, driving each other to become the engine of sustainable economic growth



Source: in-house analysis

Europe targets net zero emissions by 2050. What this means for businesses in practice is reduction of emissions within three scopes: Scope 1 – own emissions, Scope 2 – emissions associated with the purchase of utilities, and Scope 3 – emissions related to the carbon footprint of products and services used by customers. To achieve the ambitious reduction targets, equally ambitious action is called for. Simply transforming technology to 'green' or low-carbon sources is not enough. Therefore, it is vital that digital tools are employed as an accelerator for decarbonisation.

Digital technologies support decarbonisation across all sectors of the economy, particularly in agricultural, fuel, energy, services, transport and construction industries. Global emissions from fossil fuels could be reduced through digitalisation by as much as 15% by 2030. This is a whopping one-third of the 2030 reduction target (and more than current EU and US CO_2 emissions combined). Taking its indirect effects into account, digitalisation could help curb emissions by a total of up to 35% by influencing consumer decisions and transforming business models. However, the pace of technological progress is so fast that the reduction potential, today estimated at 35%, may prove to be much higher.

Digital technologies drive decarbonisation in three ways:

- **Improving process knowledge through data monitoring and tracking –** analysis of raw material and energy consumption data provides a better insight into environmental impacts. It enables carbon footprint tracking and reporting.
- **Optimisation and automation** – improving production efficiency through more rational use of resources needed for production. This saves energy and raw materials, boosting earnings and reducing greenhouse gas emissions. Production resources are used more efficiently, which improves energy efficiency.
- **Predicting and preventing incidents** – predicting failures and accidents minimises the risk of machine downtime and raw materials and energy waste. It also reduces the risk of leaks and spills, prevents water, air and soil contamination and improves human safety.

These three functions form part of the technology-driven growth engine. A deeper understanding of processes enables companies to fine-tune them and predict equipment failures, generating even more data to analyse. With technologies such as Internet of Things, artificial intelligence, cloud computing and 5G, the understanding of industrial processes can be taken to the next level.

Decarbonisation is achieved through data tracking and monitoring processes geared towards reducing carbon footprint

Tracking and reporting reliable data is at the heart of investigating and reducing the environmental impact of industry. In view of current regulations (including the Green Deal), challenges arise in reporting the carbon footprint of products. Digital tools serving to collect and analyse emissions data may prove particularly important for reporting Scope 3 GHG emissions, that is emissions generated by customers.

Other exciting digital solutions that may support reporting activities of companies interested in monitoring their GHG emissions and reducing their climate impact are all kinds of carbon footprint calculation tools. They must be tailored to meet the specific needs of the company and its production process. Artificial intelligence can help crunch data from multiple sources and identify the most emissions-intensive areas. Digitally-assisted monitoring of the carbon footprint facilitates ongoing measurement of progress towards reduction targets.

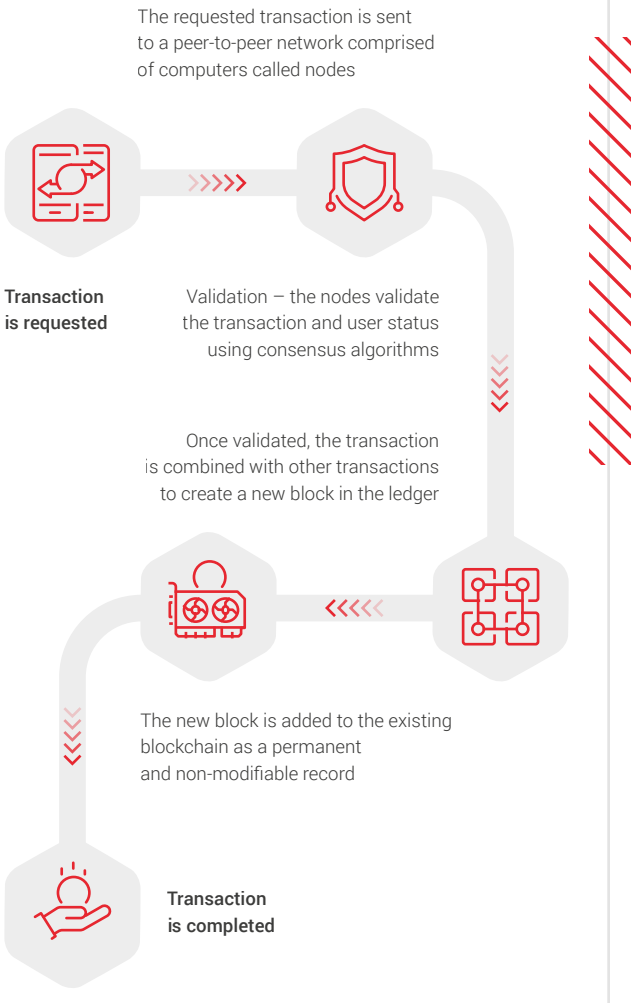
One technology that enables advanced traceability of product sourcing at every stage of production is blockchain (distributed data ledgers). The key advantage of blockchain is that collected data is reliable and cannot be manipulated. In blockchain, no single person has control, and data is copied and stored on multiple computers. This allows users to interact peer-to-peer without any intermediary, which reduces transaction costs and increases efficiency. Blockchain thus permits transactions to be tracked and verified without any centralised authority (such as a bank).

Some areas where blockchain can create positive impacts

- **Product carbon footprint** – Blockchain can be used to track the carbon footprint of products, allowing it to be monitored from manufacturer to point of sale. It also helps to prevent unethical practices such as 'greenwashing' (misleading carbon footprint information) by providing greater transparency in the supply chains. Historical data regarding the development of a product is often unavailable and difficult to verify. Products pass through many hands before reaching the customer. Blockchain prevents dissemination of false information about a product – how it was made, what materials and chemicals were used, which components were recycled, etc. Customers gain the ability to make more environmentally-conscious choices.

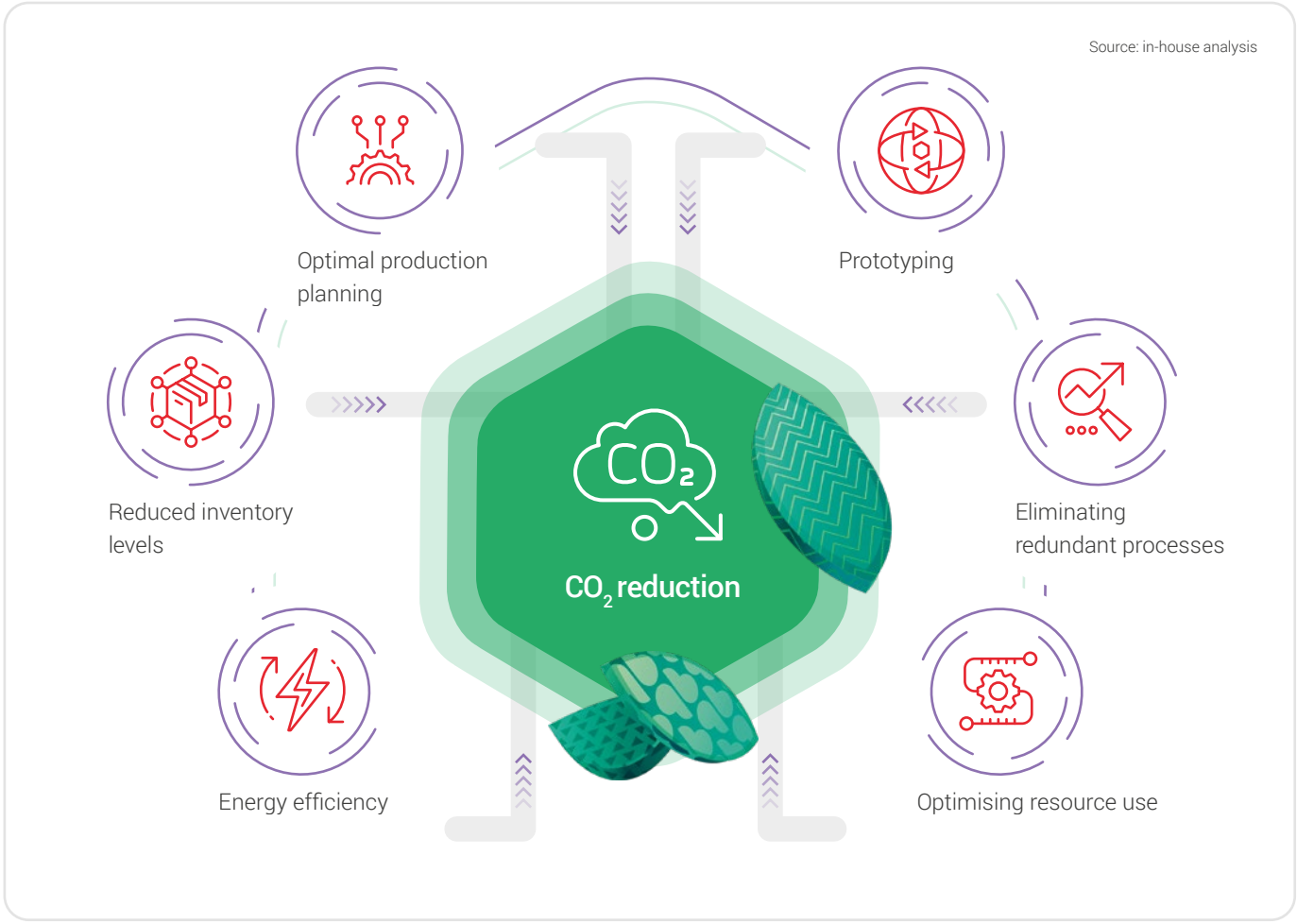
- **Operation and transactions in the distributed energy market** – Traditional power grids are centralised, with significant inefficiencies on the distribution side arising from energy losses and unused surpluses. In the new energy generation model consisting of distributed renewable energy sources, such as solar PV and small wind turbines supported by microgrids, energy flows and peer-to-peer transactions need to be controlled. In this transmission-trading model, the energy payment system bypasses banks and distribution network operators. EV charging payments can be made in the same way.

How does blockchain work?



Source: in-house analysis based on Computerworld

Decarbonisation is driven by optimisation and automation functions



According to estimates, smart industrial solutions have the potential to save 4.2bn MWh of energy and 81bn litres of water by enabling more efficient production processes.

Industrial process optimisation starts with sensors in a single machine. With artificial intelligence, the entire production control and management system is analysed. Artificial intelligence is capable of identifying the elements or areas of production worth investigating and optimising. This may involve reducing energy consumption where excess energy usage has been detected. Optimisations may also be implemented where a machine is less efficient performing a particular task or where suboptimal process parameters lead to excessive quality of production.

This helps to promptly detect shortcomings and make adjustments to the process flow, reducing the amount of resources used in the production process. It is worth mentioning that in line with the concept of Industry 5.0 artificial intelligence is to support humans rather than replace them in the decision-making process – the final decision is usually made by the process operator.

Fewer redundant processes, less raw material and energy usage and lower inventories directly contribute to reducing plant emissions. "By 2025, structured data and the algorithms that process it will help improve productivity, product quality and reduce waste by up to 50 percent," says Anna-Katrina Shedletsky, founder of Instrumental, a company engaged in solving problems in manufacturing.

Optimal production planning

Many industrial processes are non-linear. For example, an increase in temperature in a production process does not translate linearly into a proportional increase in product yield. Therefore, using tools based on linear modeling may not produce the optimal results. For this reason, non-linear modeling tools are increasingly being used to map reality with much greater accuracy.

Energy efficiency

The biggest challenges in industrial production are energy intensity of processes and, more importantly, flattening the demand curve. Energy efficiency tends to be the main aim of optimisation measures. Smart energy management platforms can be used to control consumption, forecast demand and adjust generation combined with storage in real time. By monitoring and adjusting current loads depending on energy demand, energy management systems (or EMS) help reduce energy bills while contributing to lower greenhouse gas emissions.

Global resource planning and optimisation

The ability to plan and optimise resources at the company level is of paramount importance in large, multi-site businesses. Global resource planning facilitates more effective deployment and lower purchasing costs, generating savings for the company. The trend is to move away from planning and optimisation tools employed at the single plant level towards global planning and optimisation tools encompassing multiple plants.

Optimal grid management

Energy generation advancement will be increasingly data-driven – it will rely on a network of sensors in the grid infrastructure to send data, with algorithms converting that data into energy demand forecasting models. The system will enable efficient management of energy flows and storage: smart grids supported by demand response models help to monitor changes in energy demand in real time and autonomously respond to the changes by adjusting energy distribution.

Decarbonisation is achieved by predicting and preventing accidents, leaks and contamination

One of the greatest applications of artificial intelligence in industry is modeling and predicting future events. The process involves analysing large sets of historical data as input to make useful predictions (forecasts). Prediction can be used in many ways, including for predicting resource and energy consumption, customer demand and behaviour, and defects and failures in production facilities.

Defect and leak detection – Image analysis supported by intelligent algorithms enables highly accurate, automatic detection of defects and anomalies. Accurate image data analysing tools quickly identify leaks and spills of hazardous substances or harmful gases. Another example is machine learning-based systems for analysing images beyond the spectrum of visible light. Infrared cameras measure temperatures of objects and substances, identifying problem areas, for example heat losses due to leakage. Multispectral cameras allow remote detection of environmental pollution. As chemical compounds, and organic compounds in particular, have characteristic electromagnetic emission and absorption spectra, this method of imaging is capable of detecting trace pollutants, for example traces of oil in water. It may also serve to monitor air emissions of greenhouse gases.

Manufacturing failure prediction (predictive maintenance) – The most widespread example of using AI for prediction is predictive maintenance. With AI, industrial machines can be closely monitored and failures can be predicted by analysing vibration levels, temperature fluctuations, power supply and other parameters. Predictive maintenance systems detect and recognise anomalies in machine operation early to prompt a quick response preventing damage to equipment. When a system detects a deviation in the equipment operational profile, an alert is created that requires intervention. The advantages of predictive maintenance include lower cost of failure, shorter downtimes, improved machine safety and performance, no secondary damage, and reduced repair time. Predictive maintenance may reduce machine downtime by up to 30–50% and increase machine life by 20–40%.

Plant energy demand forecasting – Electricity is among the most costly and carbon-intensive resources used in manufacturing plants, which is why estimating energy demand at various times of the day is vital. Analysed and supported by artificial intelligence, data collected in data warehouses makes it possible to predict actual production and adjust the volumes of purchased or generated electricity accordingly. Supply is adjusted to demand in real time, with reserve capacity reduced to mitigate the carbon footprint.

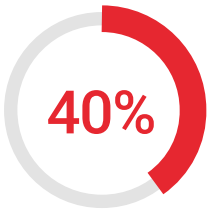
Predictive capabilities of digital tools

Source: in-house analysis

- Reduce the risk of equipment failure
- Eliminate or reduce machine downtime and repair and inspection costs
- Provide remote, constant insight into machine operation
- Enable operators to quickly respond to any malfunction
- Enhance machine safety and performance
- Eliminate secondary damage

Examples of how new technologies are harnessed to protect the environment and reduce greenhouse gas emissions

Percentages refer to current global emissions by industry

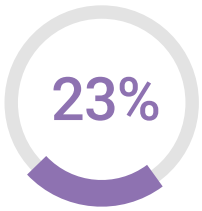


Energy generation

Forecasting electricity demand is a challenging task as many variables need to be taken into account in the process (weather factors, fluctuating customer demand, fuel price volatility, etc.).

This drives adoption of artificial intelligence for predicting energy consumption. Advanced algorithms accurately forecast energy demand, which helps to better adjust the operation of generating units.

Digital tools support the functioning of virtual power plants (VPP), which are decentralised units whose operation for the power grid is coordinated by a common control system. They encompass distributed renewable energy sources (wind and solar PV) as well as energy storage systems and electric vehicle chargers. A virtual power plant is a closed, controllable system that meets and optimally balances load and generation demand.



Industry

With digital tools, industrial plants can control energy efficiency. AI-assisted processes help to visualise energy and utility consumption data and optimise energy-intensive production processes. Advanced algorithms identify non-obvious areas of a company's operations capable of generating substantial energy savings.

Intelligent sensors monitor equipment in real time, and AI-based models optimise their operation and predict potential failures. This reduces unplanned downtime and lowers inspection costs, helping to cut raw material and energy consumption and improving the availability and productivity of factories and power plants.

Numerous research centres are working on technology for capturing CO_2 from the ambient air and storing it in underground reservoirs. MIT researchers have trained an earthquake neural network to evaluate low-frequency waves, which allows you to map underground structures and CO_2 storage sites.

Engineers are using deep learning to prototype chemical compounds as potential new fuels and to discover new metal alloys.

23%

Transport

In autonomous electric vehicles, it is the on-board computer, and not the driver, that drives the car. Rides are shared and the most optimal route is selected. A further reduction in GHG emissions is achieved through the use of chargers powered by renewable energy.

10%

Buildings

Sensors installed in smart buildings collect data that feed into models controlling the thermal comfort of a building, helping to improve its energy efficiency.

4%

Other industries

Deep learning, a type of artificial intelligence, is applied to effectively forecast weather conditions based on non-linear models capable of predicting extreme weather events such as thunderstorms, hail, flash floods and heat waves.

Artificial intelligence supports precision agriculture through the use of ground sensors, drones and satellite imagery to increase crop yields. Fertiliser is applied only to plants that need it, which helps reduce the amount and environmental impact of the resources used.

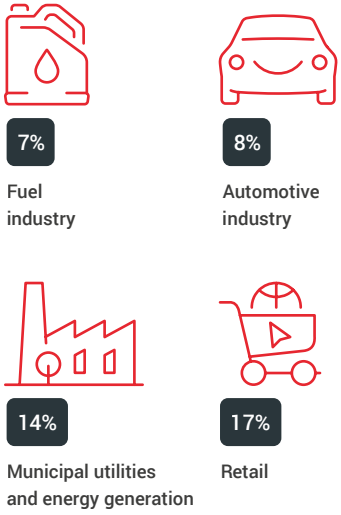
Image recognition techniques backed by artificial intelligence help sort waste properly. Smart trash cans use dedicated cameras to recognise the type of waste and place it in the appropriate compartment. The image processing technology enables smart recycling when the user is not sure where a problematic type of waste (a mirror or a deodorant container) belongs.

Three key technologies driving decarbonisation

Artificial intelligence

Artificial intelligence (AI) stands among the top technologies offering the greatest potential to support decarbonisation. It is the main driver of the digital transformation occurring across the economy and the key contributor to the achievement of Agenda 2030, Green Deal and Paris Agreement goals. It permeates most Industry 5.0 technologies and addresses global climate issues – with its applications ranging from the monitoring of climate trends and predicting weather events, to dedicated solutions designed to mitigate or eliminate greenhouse gas emissions.

AI-enabled emission reduction potential by industry



Source: in-house analysis based on Capgemini, Climate AI

5G

The new mobile communications standard called 5G NR (New Radio) was developed as a successor to 4G technology and addresses challenges that could not be solved in previous-generation networks. Compared with its predecessors, 5G is expected to bring about a revolution in data transmission. The technology promises higher data rates, lower latency (down to one millisecond) and reliable communications. It will enable the connection of up to one million devices per square kilometre. Given its potential, the technology will enable further development of Internet of Things and, thus, new solutions for smart transport, smart city and Industry 5.0.

In conjunction with artificial intelligence algorithms and machine learning, 5G underpins the Industrial Internet of Things (IIoT). These technologies support real-time data acquisition and use, investigation of interdependencies between variables under analysis and process optimisation. With its unique architecture and improved radio spectrum utilisation, 5G helps to improve energy efficiency and reduce the carbon footprint.

5G networks can make a real difference in reducing carbon emissions by operators in several ways. The networks will be more efficient in terms of the amount of data transmitted per unit of energy. With 5G, the energy consumption per bit is on average 90% less than on 4G. When millimetre wave transmission (mmWave) is used in the future, the figure could rise to 98%.

While 5G networks could save up to 0.5 billion tonnes of CO_2 globally by 2030, about 50% of that is attributable to effects not directly related to 5G. It is important to note that gains from implementing the 5G technology by far exceed the outlays, and its key beneficiaries will be the industrial and energy generation sectors.

Source: in-house analysis

Cloud computing

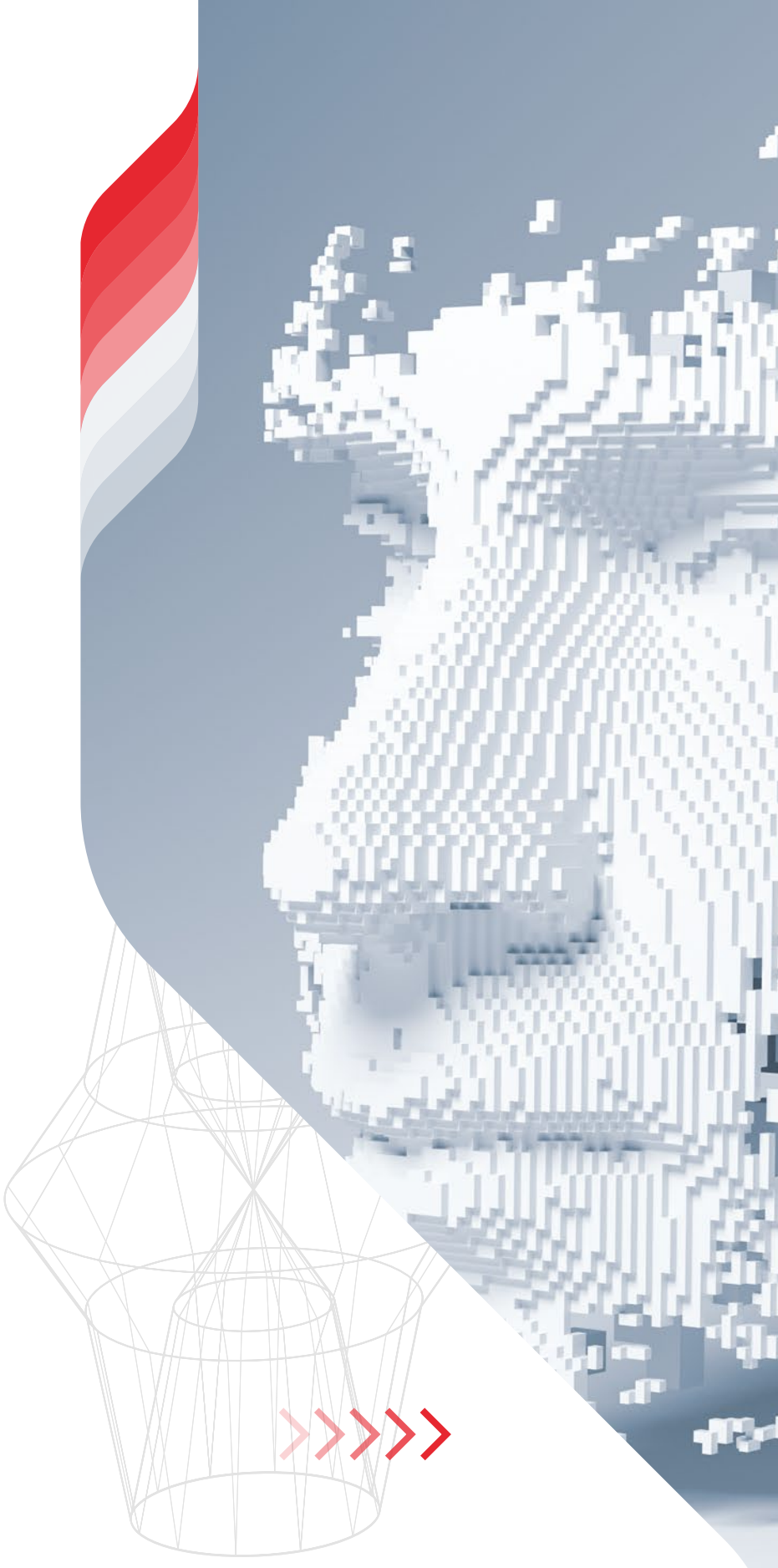
Public and private clouds are a computing power sharing solution. As the server power is used by multiple users, it is constantly enhanced and adjusted to specific needs, which contributes to reducing total demand for electricity.

Migrating data from on-premises locations to public cloud can reduce global carbon emissions by 59 million tonnes annually. This would be achieved through:

- automation and autonomous adjustment of computing power to current demand
- computing power sharing and real-time allocation
- more efficient cooling and heat recovery from server cooling systems
- powering data centres with clean energy sourced from large wind farms or high-efficiency solar farms

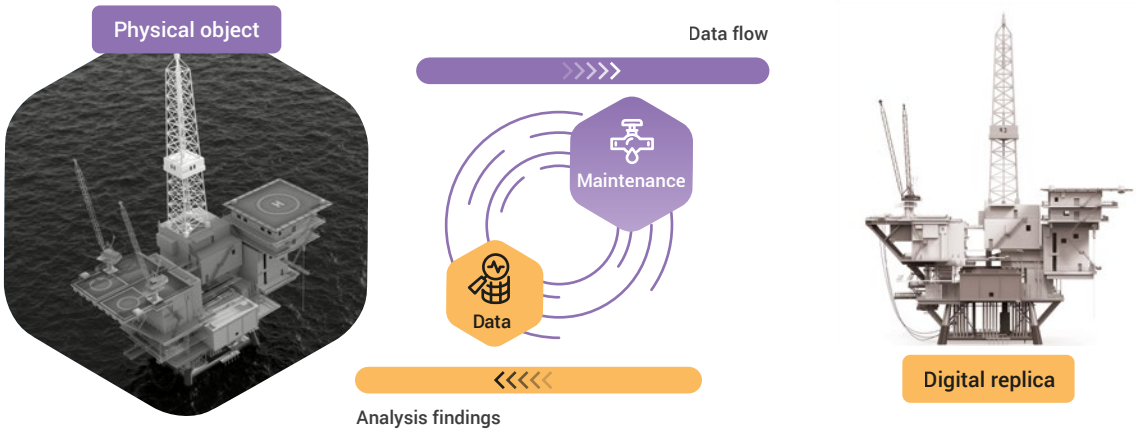
In addition to the environmental and social benefits, migrations to the cloud also offer economic benefits: they result in savings of up to 25–30% of total cost of ownership. This is due to greater workload flexibility, better server utilisation rates, and more energy-efficient infrastructure. Access to cloud services can help organisations achieve a meaningful reduction in carbon footprint. Service providers already offer reports detailing the carbon footprint generated by a service used by an organisation.

Source: in-house analysis



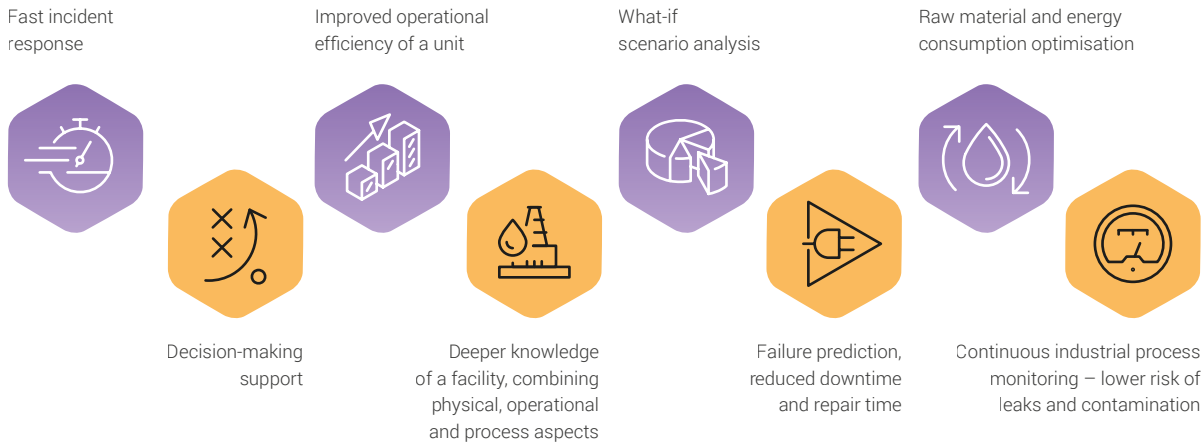
Digital twins: bridging the virtual and physical – an example of optimisation and prediction applications

A digital twin technology comprises a physical object, its digital representation and a thread connecting the two through a stream of data exchanged and processed to update the state of the replica in real time.



Source: in-house analysis

Digital twins help reduce greenhouse gas emissions and support decision-making by equipment operators



Source: in-house analysis

Digital twins is one of the most compelling technology concepts. It consists of a dynamic connection between an object in the real world with its replica in the virtual world. Individual devices, process units and entire factories can have their digital twins. The physical object and its digital replica exchange and analyse data to support decision-making processes.

NASA was the first to introduce digital twins. The space agency created replicas of spacecraft to test hardware and software installed inside. As technology progressed over time, physical replicas began to be transferred into virtual reality.

The digital twin concept has three dimensions

- **Physical** – creating a digital counterpart of a physical object with all its components: devices, equipment, pipeline infrastructure, and mapping them according to their location in the real world. This is the most obvious dimension of the digital twin technology.
- **Operational** – processing current data on equipment operation, process parameters, temperature, flows and other data gathered from sensors.
- **Behavioural** – defining the procedures and processes that take place when a particular event occurs. This can be a representation of security procedures implemented by the company and its responses to specific events that complement the operational picture of how the equipment is performing.

Digital twins serve concrete business goals: more precise process control, simulations, predicting incidents, etc. The potential to optimise and reduce greenhouse gas emissions and raw materials consumption may vary depending on the business goal.

A digital twin offers many practical advantages – powered by data, it can support operators in their decision-making by providing them with more complete operational and management information. It analyses the effects of various scenarios and selects the best ones, optimising production and enhancing operational efficiency, which helps to save raw materials, energy and resources and, ultimately, curb emissions. Real-time monitoring provides an insight into processes as they happen, helps to anticipate events, facilitates effective remote management and enables early failure detection.

03

Implementation case studies

PKN ORLEN Digital Transformation Programme

In February 2020, PKN ORLEN set up the Digital Transformation Programme as a joint initiative of the IT and Strategy & Innovation and Investor Relations teams. The Digital Transformation Programme aims to transform all business areas to take full advantage of new technologies such as advanced analytics and artificial intelligence, process automation, Internet of Things, 5G, and AR/VR.

Our ambition is to take a well thought-out, broad-based approach to digital transformation as opposed to isolated technology implementations. This will be achieved through digitalisation roadmaps prepared to fully address business challenges of each segment of the organisation and arrange them into a practical implementation plan. The first priority is to develop digitalisation roadmaps for production and energy generation.

When selecting projects, we consider their carbon footprint reduction potential, and not only their profitability or process efficiency profiles. We believe digitalisation can be a major decarbonisation enabler.

The Digital Transformation Programme is not only about business transformation projects, but also about changing processes and building competencies of the future among our employees. We embrace new agile working methods enabling us to quickly deliver customer value.

We are building a community committed to digital transformation. With our community in mind, we host meetings with digital transformation experts (AI Meetup), internal knowledge-sharing meetings (Digital Community) and training series, this year devoted to data science and agile project management.

The case studies presented in this section demonstrate how new technologies implemented by PKN ORLEN, such as advanced analytics and automation, can help address the challenges faced by business areas and contribute to optimising processes, reducing greenhouse gas emissions and creating added value for the Group and its stakeholders.

Energy Management System at the Płock Plant

The Energy Management System (EMS) is a tool supporting the energy balance management across the entire energy system at the Płock site. Dedicated for refining and petrochemical operations, the system monitors and optimises energy consumption in real time. Carbon emissions are reduced as energy efficiency improves.

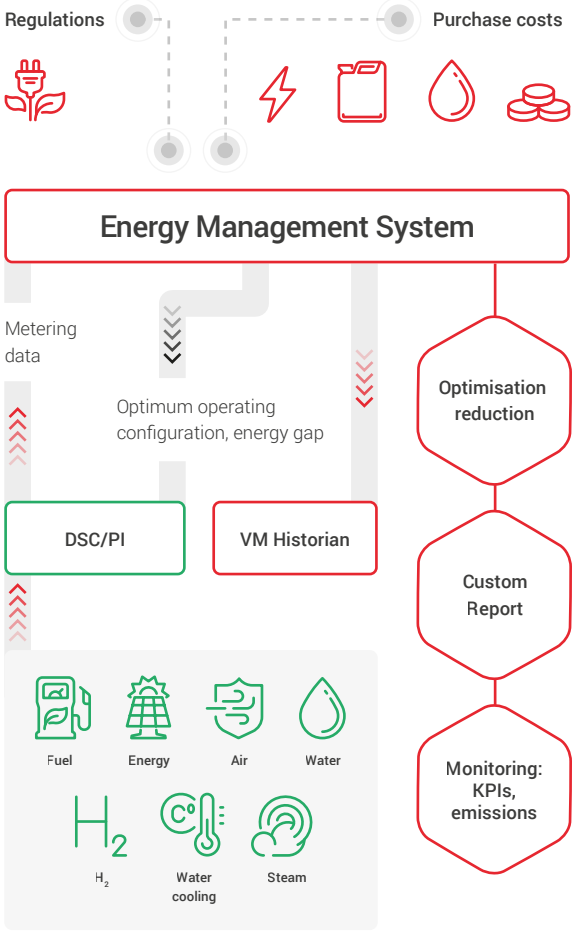
The EMS is tasked with managing energy flows in the Płock Plant in an economically efficient manner. A similar system is operated at the Czech refinery in Litvínov, which is owned by the ORLEN Group.

Energy costs account for the majority of variable costs at the Płock Plant. Therefore, cost optimisation is vital, offering considerable savings potential. The EMS has been in place at the Płock site since 2016, helping to optimise the operation of the entire energy system at the Plant, both the refining operations, petrochemical operations, in-house CHP plant and CCGT unit. The EMS analyses demand for and generation of each energy carrier online. Based on the analysis of metering data, the EMS identifies potential economic benefits from synergies between individual energy production facilities. The EMS system is responsible for:

- data collection and analysis
- management
- control
- optimisation

The EMS helps to optimise energy costs in real time, taking into account synergies existing between the various production units and the existing constraints. The software contains models of the energy processes taking place across all units at the Płock Plant and unit interconnections. It supports real-time optimisation and management of energy generation and consumption costs across the Plant.

The computational model determines the baseline state of the energy system at the Płock Plant through online analysis of multiple metering points. EMS aids identification of optimal operating points where a great deal of decision-making variables and multiple pieces of energy equipment and apparatuses exist (process furnaces, steam turbines, reduction and cooling stations, steam heaters, water deaerators, PSA units, etc.). In order to identify the optimum for a given period of time, the application of 'optimisation variables' recommended for daily production scheduling is also analysed.

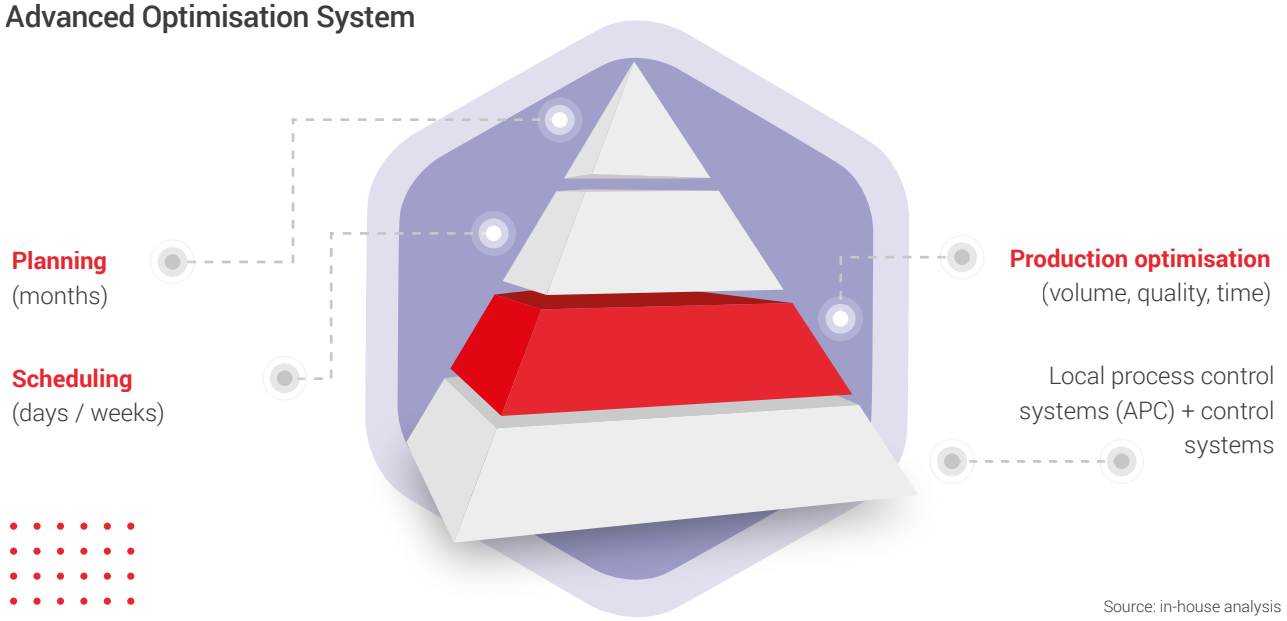


Source: in-house analysis

Another key feature of the software is the what-if analysis functionality used to evaluate ideas and initiatives related to process unit energy intensity, both at the unit and the Płock Plant level, taking into account relevant interconnections and energy cogeneration.

Implementation of recommendations from the EMS system contributes to optimising energy consumption across the Płock Plant. The system helps to deliver best quality product in a cost-effective way with account taken of the existing process and environmental requirements. Carbon emissions reduction is achieved through efficient use of energy streams.

Application optimising refinery production at ORLEN Unipetrol



We are testing an application designed to optimise refinery production at the ORLEN Unipetrol refinery in the Czech Republic. The solution supports coordinating and optimising the operation of a number of production units involved in the process of manufacturing and blending of diesel oil. It is used as a link between the refinery planning and scheduling and the advanced process control (APC) systems in each of the production units.

The possibility of simultaneous optimisation of a number of technological processes provided by advanced process control (APC) solutions is of particular importance to the refining and petrochemical industry, where processes in different units are closely interconnected. Coordinating the operation of multiple units while meeting the product quantity, quality and production time requirements is a challenge, but one that offers significant potential for savings.

The production optimisation solution is based on APC systems for individual production units. The master APC module uses an existing simple planning model (consisting of one period) to build a high-level model. The high-level model for the plant contains information about potential production yields, and is then fed with dynamic data. The master APC module controls inventory levels, operational capacities of the units as well as product quality, thus contributing to long-term optimisation of production plans in real time.

The solution is being deployed at the diesel oil production line of the ORLEN Group's refinery in the Czech Republic. The project is planned to be completed in the second half of 2022.

The main benefits of the solution include:

- Reduction of excessive quality through a better alignment of the product quantity and quality with the planning objectives
- Coordinated operation of the units supplying components for diesel oil production and elimination of inefficient processes
- Optimised energy consumption achieved through reduced consumption of fuel gas and electricity, which translates directly into lower CO_2 emissions

Private industrial 5G network testing

PKN ORLEN is testing 5G wireless communication at the Płock Plant and the adjacent service station. The project includes deployment of a private industrial 5G network, the network testing and measurements, critical connectivity testing, and 5G service quality testing and measurements.

The tests cover mass transmission of IIoT sensor data, as well as connectivity parameters for critical applications for real-time video and data transmission. Resistance to interference generated by the refinery units, the impact of industrial infrastructure on transmission delays, and the level of attenuation due to water vapor are analysed.

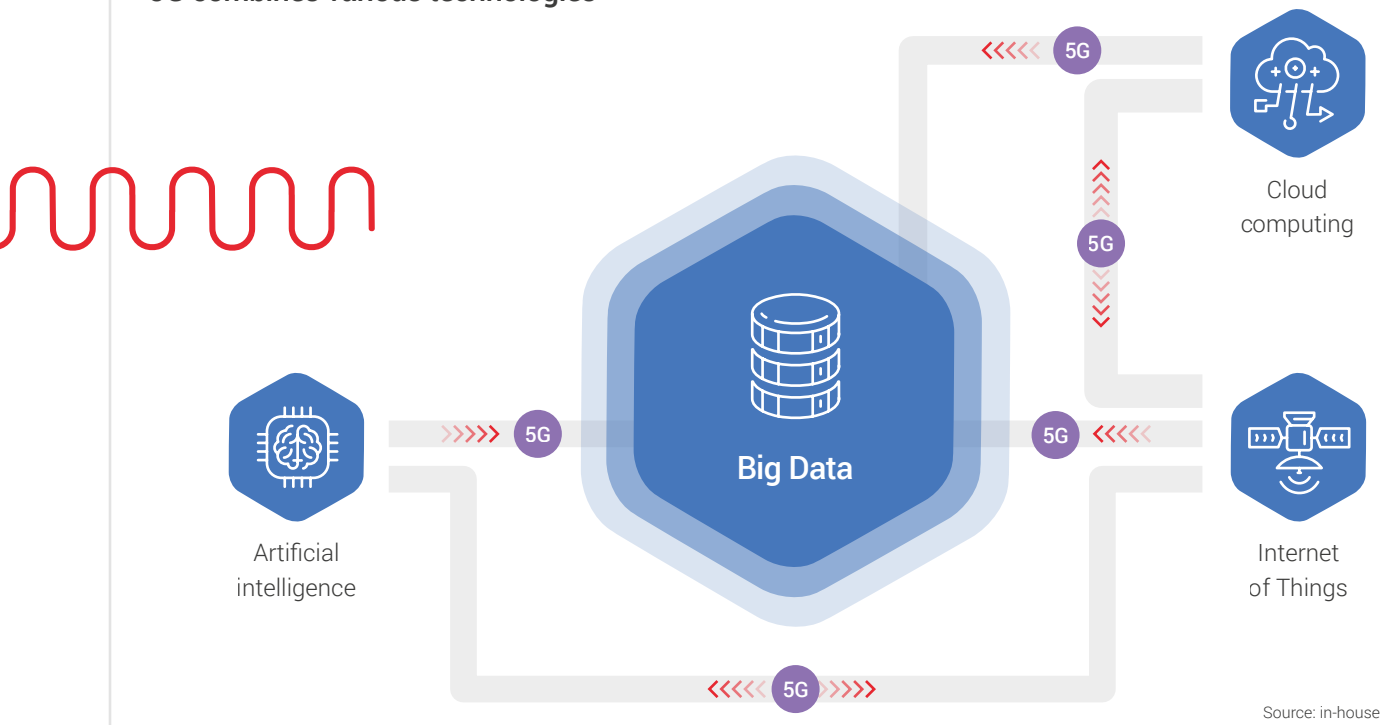
The test results will serve as a basis for evaluating different models of ICT infrastructure in the deployed private 5G broadband network ecosystems offered by leading suppliers, thus facilitating selection of the optimal technological solution in the future, to be applied across all of the ORLEN Group business segments.

Implementation of 5G networks in industry will offer access to new mobile services and reliable connectivity. AI systems using data obtained from multiple wireless sensors communicating in real time will reduce industrial process costs, improve productivity and enhance safety.

5G will also increase the density of mobile and wireless sensors and measurement devices (IoT) in those areas where sensor installation is currently constrained by the presence of cabling. An analysis of additional information streams in hybrid clouds integrated with a data warehouse will support designing, modeling and optimising new processes and products. The resulting gains will be lower consumption of raw materials, minimised production losses, and, ultimately, reduced carbon footprint and costs.

Creating conditions for testing 5G services and technologies in a real environment of industrial units for refinery and petrochemical production. Responsible unit: Data Communication Networks Department, PKN ORLEN.

5G combines various technologies



Source: in-house analysis

04

Corporate executives' approach to the challenges of digital transformation

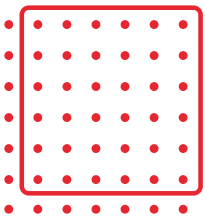
Introduction and key findings of the survey

Context

The survey was conducted by Accenture in 2020 and 2021 among more than 4,000 executives in Poland and worldwide. It complements the observations described in this report and confirms that corporate executives are reaching for digital tools to achieve their sustainability goals.

Respondents' countries and industries

Country	Number of respondents	Share %
Australia	350	9%
Canada	150	4%
China	320	8%
Japan	370	9%
Saudi Arabia	150	4%
Singapore	110	3%
United States	1300	32%
Europe	1304	32%
Total	**4054**	**100%**



Industry	Number of respondents	Share %
Aerospace and defence	147	4%
Airlines, tourism, transportation	179	4%
Automotive	170	4%
Banking (retail or investment)	293	7%
Capital markets	154	4%
Chemicals	166	4%
Communications, media and entertainment	315	8%
Consumer goods	186	5%
Energy (e.g. oil, gas, coal, renewables and other energy)	179	4%
Health care	267	7%
High technology	163	4%
Industrial goods and equipment	328	8%
Insurance	291	7%
Natural resources	160	4%
Pharmaceuticals, biotech and life sciences	308	8%
Public service (e.g. hospitals, administration, services to citizens, education, taxes, postal services, pensions)	143	4%
Retail	176	4%
Software and platforms	264	7%
Utilities	165	4%
Total	**4054**	**100%**

Key conclusions

#1 **The top two strategic priorities defined** by company executives for the next three years are:

Sustainable business development

Accelerating digital transformation

When implementing sustainability strategies, companies **are turning to digital technologies.** The technologies most often used for this purpose are:

Internet of Things

Prediction and analysis tools

5G

Process automation

2/3

of the companies taking part in the survey declare to have already developed a sustainability strategy for their organisation as a whole

30%

of executives declare to have such plans in place for particular business areas

#2 The surveyed executives believe that while digital tools will support sustainability initiatives, **they do not offer a complete solution.** Investments are required as well, for example in renewables.

#3 The **largest investments** in the digitalization of enterprises will be made in the area of **technology platforms, data analytics and agile working methods**

Internet of Things

Prediction and analysis tools

5G

#4 **The most serious challenge** caused by the pandemic is **disrupted supply chains.**

#5 Businesses are addressing this challenge by implementing the following solutions:

Internet of Things

Prediction and analysis tools

Process automation

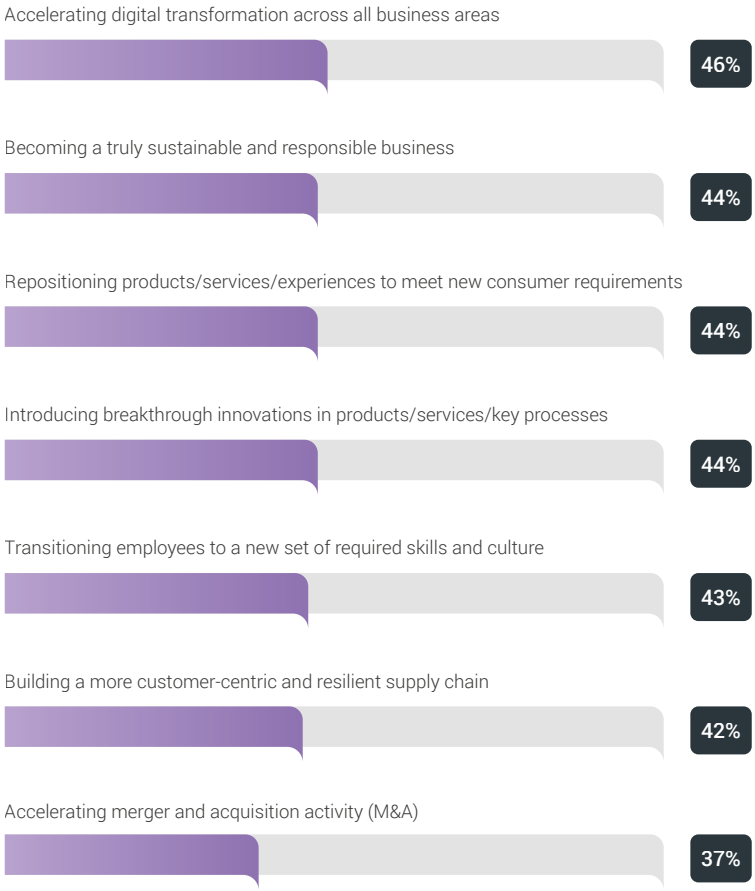
#6 Executives believe that **innovations involving small improvements** will support faster recovery from crisis after the pandemic is over.

Source: in-house analysis

Digital transformation and sustainability top the list of strategic priorities.

Question: Which strategic priorities will be building your company's competitive edge over the next three years?

Globally



Source: in-house analysis

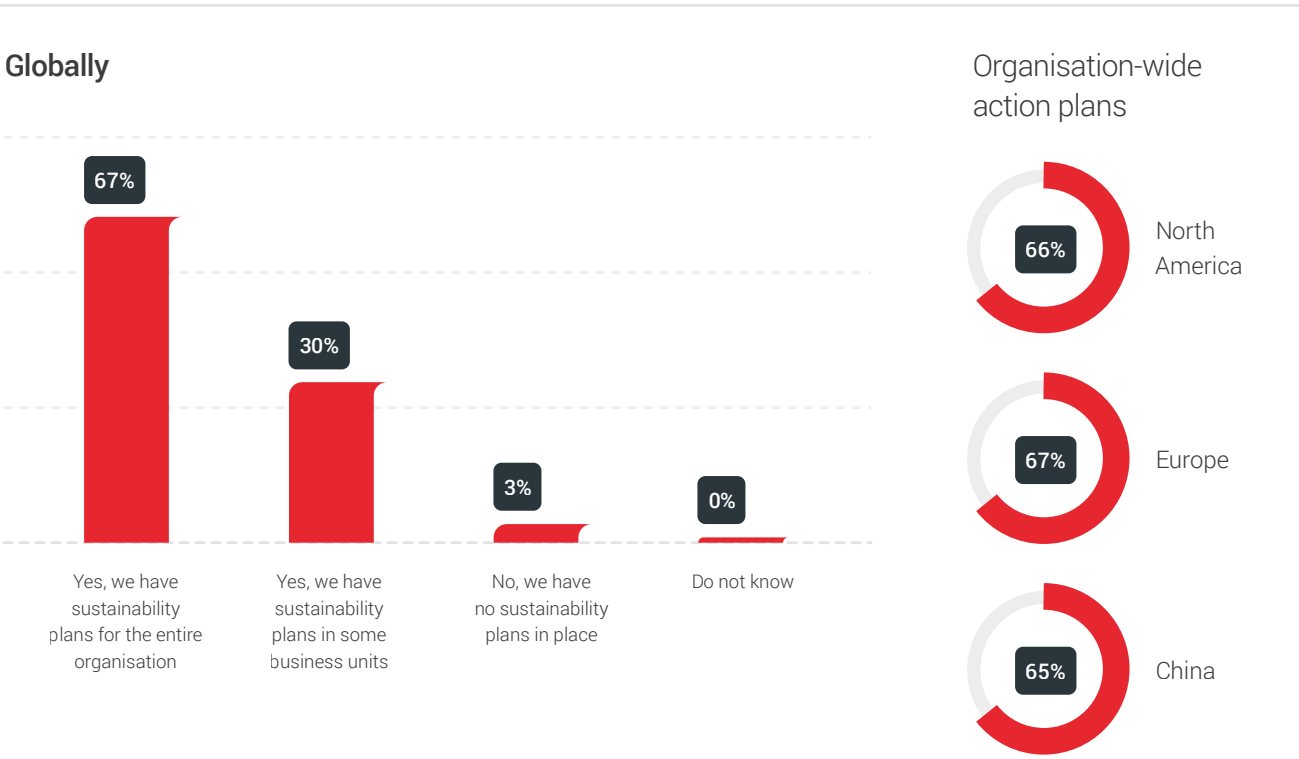
The executives participating in Accenture's global survey identified a list of strategic directions they rely on to build and reinforce their companies' competitive advantages. Most of them pointed to accelerating digital transformation as key (46%). The second position on the list, indicated by 44% of the respondents, was 'becoming a truly sustainable business'. Re-positioning products and services and innovating were ranked the same.

In Poland, digital transformation and sustainability are also more and more often cited as main the strategic goals, but they are yet to become commonly adopted directions.

4.1 Findings of a survey conducted among executive managers from Poland and abroad

Globally, two-thirds of large companies have already defined sustainability strategies encompassing the needs of the entire organization

Question: Does your organisation have sustainability plans in place?



Source: in-house analysis

Two-thirds of the surveyed companies say they have developed sustainability strategies for their entire organisation. At the same time, executives from 30% of the companies declare to have such plans in place for particular business areas.

The development and implementation of sustainability agendas is a global trend.

Polish companies are increasingly incorporating sustainability initiatives in their plans.

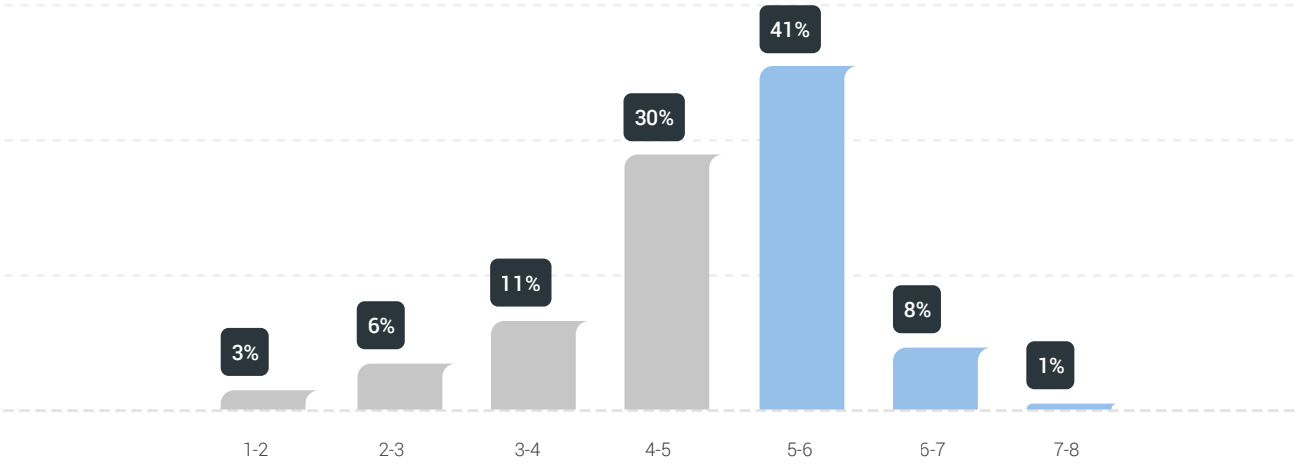
4.1 Findings of a survey conducted among executive managers from Poland and abroad

However, sustainability strategies are in early stages of implementation.

Question: What initiatives is your organisation taking to drive sustainability?

Globally

Level	1	2	3	4	5	6	7	8	9	10
Q21 – Stage	Not started	Early stages			Pilot to scale			Scaled		
Q21 – Level of priority	-	Minimal	Moderate	High	Minimal	Moderate	High	Minimal	Moderate	High



Source: in-house analysis

Base = all respondents

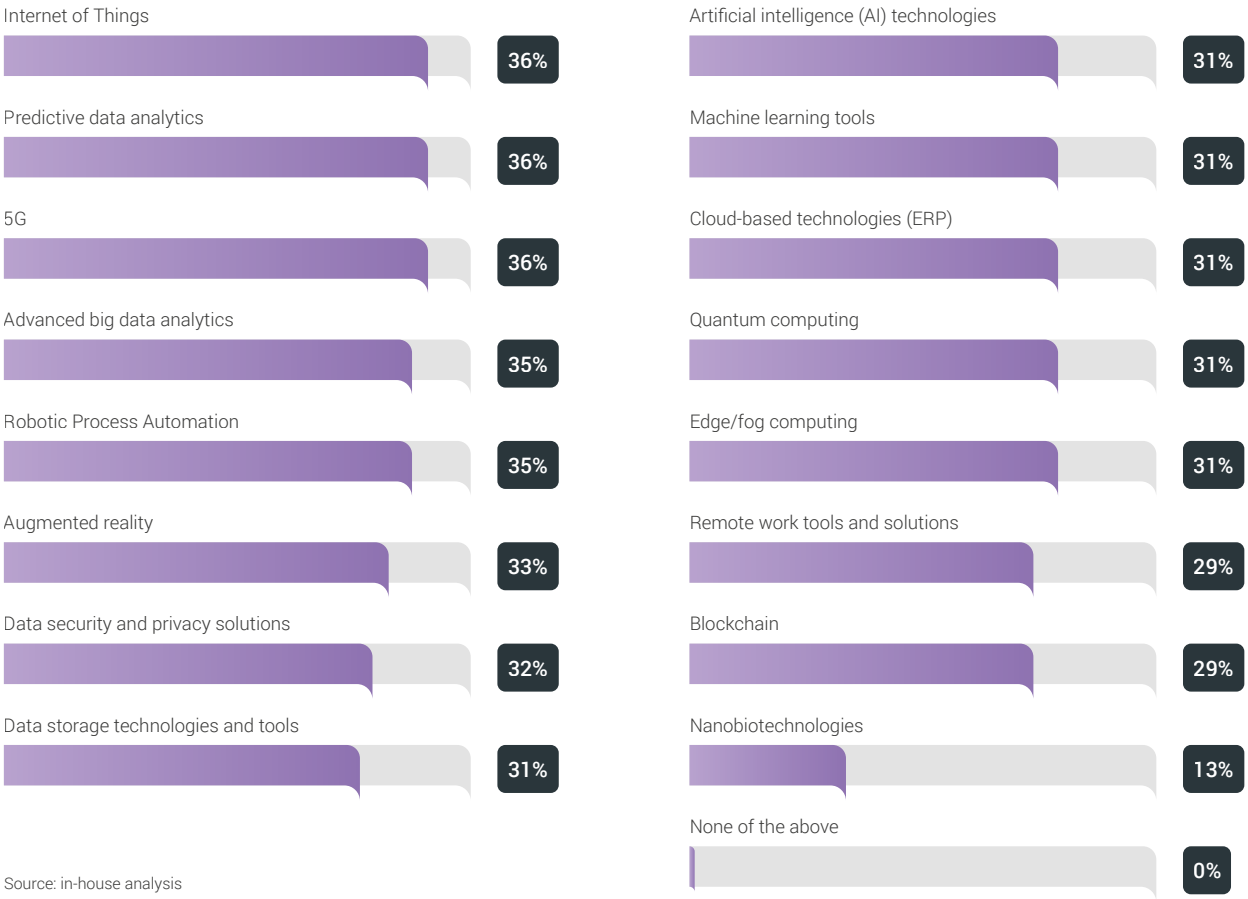
Half of large companies are in early or very early stages of incorporating sustainable practices into their business. Only 1% of companies declare to have already completed this process.

Polish companies are at a similar stage. The sustainability measures most frequently identified by the respondents concern energy: switching to renewable energy and investing in own renewable energy sources, as well as initiatives to achieve efficient resource management.

When implementing sustainability strategies, companies employ a variety of digital technologies. The most common are Internet of Things, prediction and data analytics tools, as well as 5G.

Question: Which technologies does your company plan to implement to drive sustainability?

Globally



Source: in-house analysis

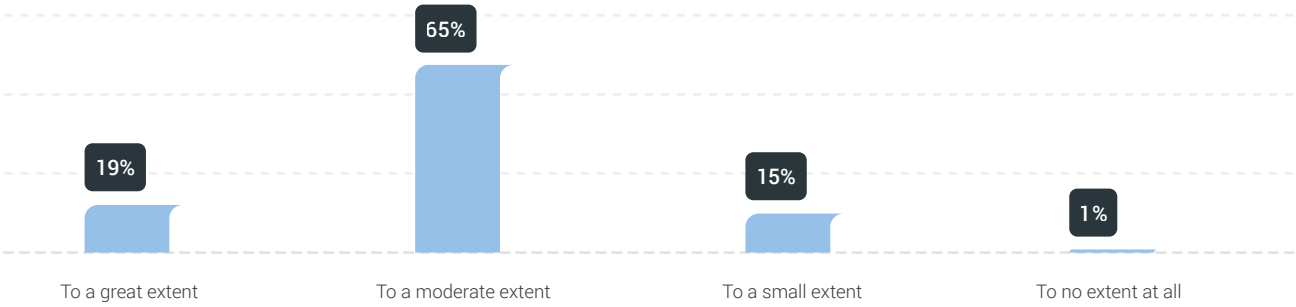
The importance of specific digital technologies as tools in building an organisation's sustainable business varies by region and industry. Executives from European companies identify IoT and data processing technologies as the most important ones. Next in line are augmented reality (AR) and virtual reality (VR), artificial intelligence and blockchain.

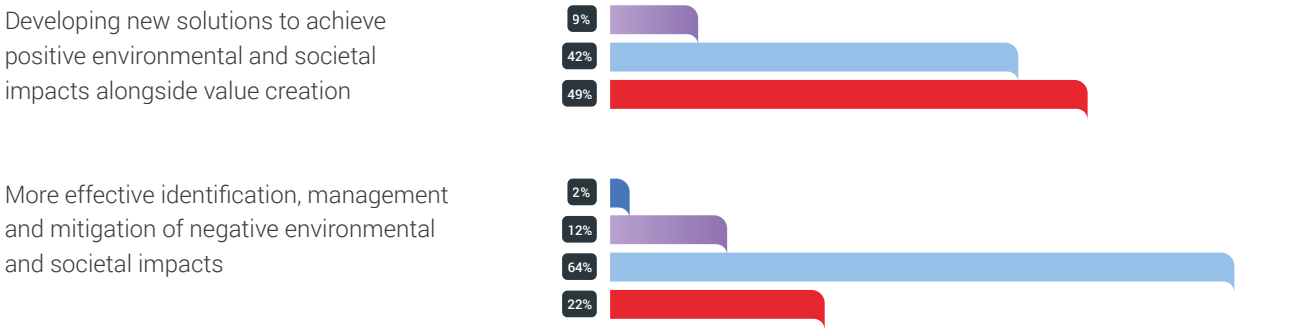
In Poland, the priorities in terms of technology implementation are similar. The focus is on developing data processing and data storage technologies, often without cloud.

Digital technologies make it possible to combine positive environmental and societal impacts with business value growth, but this is only one of multiple sustainability drivers

Question: To what extent do you think digital technologies will help your company achieve its sustainability initiatives?

Globally





Source: in-house analysis

To no extent at all | To a small extent | To a moderate extent | To a great extent

19% of the respondents believe that digital technologies will be of great help in implementing sustainability measures.

At the same time, according to 49% of executives digital technologies can provide new tools supporting the development of sustainable business. However, only 22% of them are of the opinion that such solutions can greatly contribute to solving the problem of an organisation's negative impact on the environment.

Polish executives taking part in the survey acknowledge that digital tools will support sustainability initiatives, but believe they do not offer a complete solution. Investments are required as well, for example in renewables.

The largest investments in the digitalization of enterprises will be made in the area of technology platforms, data analytics and agile working methods

Question: Which elements of your company's operating model require the most investment to prepare your organisation for future growth?

Globally

Source: in-house analysis

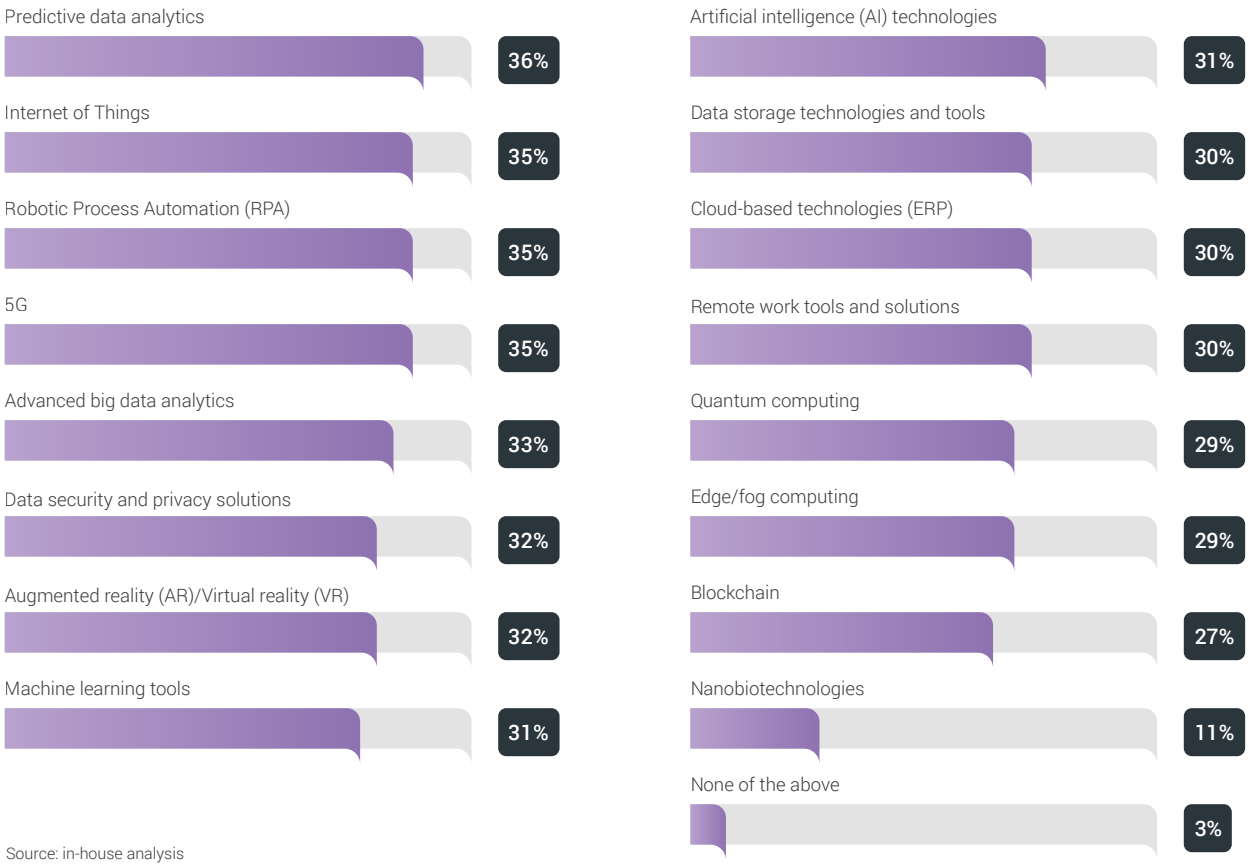
Technology platforms, data analytics and workforce agility are the three main areas where investment is needed according to global company executives. However, differences between the responses do not exceed 10 percentage points. This indicates that every area of investment is important to executives when it comes to supporting company value growth in the future.

In Poland, the respondents pointed to building alliances and partnerships as a priority. Investment in digital platforms or data analytics solutions is considered important, but to a lesser extent.

The most serious challenge caused by the pandemic is disrupted supply chains. Companies are addressing this challenge by implementing prediction, Internet of Things and process automation solutions.

Question: Which technologies does your company plan to implement as part of its supply chain initiatives?

Globally



Source: in-house analysis

Foreign companies anticipate a number of challenges, in particular related to the COVID-19 pandemic, which may disrupt supply chains. The source of the greatest concern is the limited number of alternative suppliers.

To prevent supply chain disruptions, companies are investing in digital solutions such as prediction tools, Internet of Things, automation and robotics.

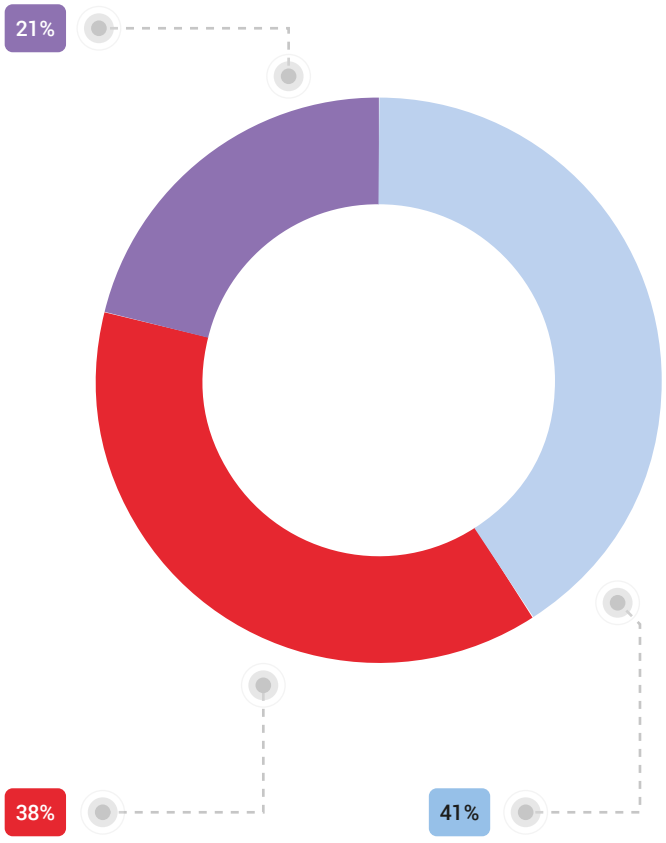
Polish executives are prioritising similar tools. They speak of plans to implement artificial intelligence, big data, automation and robotics projects.

Innovations involving small improvements will support faster recovery from crisis after the pandemic is over

Question: An organisation can invest in different types of innovation. Which one is your company going to invest in?

Globally

Disruptive innovations are the ones that make it possible to develop completely new products and services to meet new needs (e.g. high-speed transport systems, such as Hyperloop)



Breakthrough innovations involve development of new versions of a product or service using a new technology (e.g., the first iPhone)

Incremental innovations consist in small improvements to an existing product or service (e.g. smartphone or car model upgrades)

Source: in-house analysis

In the rebound phase following the pandemic companies globally want to step up investment in innovation (8.1% of revenue in 12 months; an increase of two percentage points year on year).

During this phase, companies focus mainly on incremental innovations, resulting in small improvements to existing products or services. To a similar extent the companies also want to invest in breakthrough innovations, enabling the creation of new product variants or services with the use of new technology.

Disruptive innovations are of lesser importance during this phase. Only 21% of companies want to focus on them.

The responses of Polish executives are in line with the ones provided by executives globally. The coming year is the time to focus on incremental innovations supporting stable business value growth.

Conclusion

The world needs radical action to stop climate change and excessive exploitation of the planet's resources. However, for companies, sustainability means not only care for the environment and the communities they operate in. It has a real impact on stock market ratings and investment decisions. Environmental, social and corporate governance considerations have a direct effect on company valuations, long-term value creation, stability and financial performance.

Commitment to sustainability needs to be supported by effective digital tools that will enable, or possibly even accelerate, achievement of the assumed climate, social and corporate governance goals.

Existing business models are running out of steam. Market changes and emerging technologies are giving rise to new ones, which are based on, among other things, sharing economy and closed loop economy. The new business models are more flexible and antifragile as they adapt faster to market changes.

The interrelations between manufacturers, distributors and consumers are changing, the case in point being the energy market. In the energy sector, we are seeing a shift in the roles of consumers, distributors and producers. Electricity generation is moving from centralised to distributed generations systems. Distribution system operators will cease to act as neutral energy market facilitators and will become leaders in many areas, including energy storage and smart grids, and, first and foremost, integrators between prosumers, renewable energy sources and energy consumers. Also, the role of energy consumers is changing into micro-producers and consumers at the same time. They will sell surplus energy to a neighbour or store it in the battery of an electric car. Such new business models will keep emerging from green transformation.

According to Accenture's research, companies pursuing a Twin Transformation, i.e. combining sustainability with digital transformation, are 2.5 times more likely to remain profitable after the pandemic.

Using digital tools will help cut global emissions by 15% by 2030. This goal will be pursued in three ways, i.e. by:

- improving knowledge of the carbon footprint impact of the measures taken and real-time process monitoring
- process automation and optimisation eliminating resource and energy waste
- predicting and quickly responding to incidents, which will contribute further to resource and energy savings

Taking its indirect effects into account, digitalisation could help curb emissions by a total of up to 35% by influencing consumer decisions, creating new business models and transforming processes and systems. Therefore, it is crucial that businesses consider deployment of technologies such as Internet of Things, artificial intelligence and 5G to reduce their carbon footprint when preparing their sustainability plans.

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