ETHICS AND ARTIFICIAL INTELLIGENCE IN CONSTRUCTION

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Tribun EU
2025

Number of pieces: 100

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ISBN 978-80-263-1857-6

INTRODUCTION

New construction technologies include artificial intelligence (AI) and machine learning, robotics and automation, and 3D printing for site surveys, safety training, and building structures. Other innovations are augmented and virtual reality (AR/VR), drones for monitoring, and data analytics tools like Power BI. Technologies like Building Information Modeling (BIM) are also evolving beyond design to become a comprehensive management system.

AI systems can be easily deployed in a large variety of sectors of the economy and many parts of society, including across borders, and can easily circulate throughout the Union. Certain Member States have already explored the adoption of national rules to ensure that AI is trustworthy and safe and is developed and used in accordance with fundamental rights obligations. Diverging national rules may lead to the fragmentation of the internal market and may decrease legal certainty for operators that develop, import or use AI systems. A consistent and high level of protection throughout the Union should therefore be ensured in order to achieve trustworthy AI, while divergences hampering the free circulation, innovation, deployment and the uptake of AI systems and related products and services within the internal market should be prevented by laying down uniform obligations for operators and guaranteeing the uniform protection of overriding reasons of public interest and of rights of persons throughout the internal market on the basis of Article 114 of the Treaty on the Functioning of the European Union (TFEU).

Given the major impact that AI can have on society and the need to build trust, it is vital for AI and its regulatory framework to be developed in accordance with Union values as enshrined in Article 2 of the Treaty on European Union (TEU), the fundamental rights and freedoms enshrined in the Treaties and, pursuant to Article 6 TEU, the Charter. As a prerequisite, AI should be a human-centric technology. It should serve as a tool for people, with the ultimate aim of increasing human well-being.[1]

Artificial intelligence (AI) seems to be everywhere these days—from predictive analytics to jobsite safety tools. Considering the hype, companies in the

[1] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence. Available at: https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng

construction industry are looking to cut through the noise and figure out how to use AI in ways that are practical and responsible. With so many tools on the market, it's no wonder that skepticism is becoming common. It's a challenge for construction leaders to make sense of it all as they look for ways to ensure that AI is used ethically and effectively in the construction industry.

The process of engineering helps in the development of an efficient mechanism that quickens and eases the work using limited resources or technology. Society demands principles of ethics which is equal to the moral standards of human beings. An engineer at a top engineering college with ethics can help society in a better way. Therefore, engineering ethics is the study of decisions, policies, and values. That are morally desirable in engineering research and practice.[2] Ethical behavior is often measured by the degree of trustworthiness and integrity with which companies conduct business. Professionals such as lawyers, engineers and surveyors have ethical codes to uphold as befits their profession, as do organizations. In the construction industry, ethics has developed both at a professional and organizational level.

The increasing emphasis on sustainability and environment in construction further requires companies to apply ethical standards to their activities. The role of managers/project managers is to promote these goals. Ethics is a key facet of a company's corporate social responsibility (CSR) which it must endeavor to fulfill.

Artificial intelligence ethics refers to the principles that guide the behavior of AI in terms of human values. Artificial intelligence ethics helps ensure that artificial intelligence is developed and used in ways that benefit society. It encompasses a wide range of considerations, including fairness, transparency, accountability, privacy, security, and potential societal impacts.

Information and communication technologies (ICT) are at the epicenter of the 4th industrial revolution, the prerequisite for using their effects is an educated

[2] ARYA. A., 2020. *Engineering Ethics - Awareness and Behavior.* [online] published June 2020, [cited May, 2023]. Available at: https://www.aryacollege.in/engineering-ethics-awareness-and-behavior/

workforce, including in the construction industry. They will achieve effective management of construction companies and will be able to initiate and promote changes.

The publication ***"Ethics and Artificial Intelligence in Construction"*** combines the topics of artificial intelligence, ethics and construction; therefore it is primarily focused on students of construction faculties, secondary school of civil engineering, but also for all construction experts from management, the business community and practice who are interested in the given issue.

The Slovak University of Technology (SUT) in Bratislava supports the use of progressive methods and tools of science and technology in both the pedagogical and scientific research process.
These tools include artificial intelligence, with special emphasis on generative artificial intelligence, capable of helping to create new content in the form of texts, computer programs, images and videos.[3]

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[3] SUT Measure No.: 1/2024 – O: Use of artificial intelligence at the Slovak University of Technology in Bratislava Date: November 27, 2024.

1 ARTIFICIAL INTELLIGENCE

AI is a fast-evolving family of technologies that contributes to a wide array of economic, environmental and societal benefits across the entire spectrum of industries and social activities. By improving prediction, optimising operations and resource allocation, and personalising digital solutions available for individuals and organisations, the use of AI can provide key competitive advantages to undertakings and support socially and environmentally beneficial outcomes, for example in healthcare, agriculture, food safety, education and training, media, sports, culture, infrastructure management, energy, transport and logistics, public services, security, justice, resource and energy efficiency, environmental monitoring, the conservation and restoration of biodiversity and ecosystems and climate change mitigation and adaptation.[4]

Artificial intelligence (AI)

Defining AI is not easy; in fact, there is no generally accepted definition of the concept. Numerous different ones are used, and this can easily lead to confusion. The sheer variety of definitions in circulation is not due to carelessness, but inherent in the phenomenon of AI itself. In its broadest definition, AI is equated with algorithms. Algorithms predate AI and have been widely used outside this field.

In its strictest definition, AI stands for the imitation by computers of the intelligence inherent in humans.[5]

Artificial intelligence is technology that functions appropriately and with foresight in its environment.[6]

Artificial intelligence

Systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.

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[4] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence. (4) Available at: https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng

[5] RUSSELl, S., & NORVIG, P. 2023. *Artificial Intelligence: Definition and Background.* [online] published January 31, 2023, [cited April 5, 2025]. Available at: https://link.springer.com/chapter/10.1007/978-3-031-21448-6_2

[6] NILSSON, J. N. 2013. *The Quest for Artificial Intelligence.* Cambridge University Press. August, 2013, online ISBN: 978-0511-8193-46. DOI: https://doi.org/10.1017/CBO9780511819346

High-Level Expert Group on Artificial Intelligence (AI HLEG) of the European Commission (EC), 2019.[7]

Artificial intelligence is a set of technologies that enables computers to simulate aspects of human intelligence and perform complex tasks. These include capabilities such as learning, pattern recognition, decision-making, and language processing. Traditional AI models have been used in finance for decades, primarily for predictive analytics and fraud detection. Since 2022, generative AI applications and advanced language models have been increasingly applied. AI enhances efficiency and accuracy in processes.[8]

AI system' means a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments.[9]
General-purpose AI models could pose systemic risks which include, but are not limited to, any actual or reasonably foreseeable negative effects in relation to major accidents, disruptions of critical sectors and serious consequences to public health and safety; any actual or reasonably foreseeable negative effects on democratic processes, public and economic security; the dissemination of illegal, false, or discriminatory content.

Artificial intelligence has become an integral part of everyday life for many people. It is therefore important to ensure that its use is safe, responsible and predictable. This means a higher level of protection and legal certainty, and clear rules for entrepreneurs without unnecessary administrative burdens. The aim of the draft law on artificial intelligence is to strike a fair balance between protecting the public interest and supporting innovation.[10]

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[7] High-Level Expert Group on Artificial Intelligence (AI HLEG) of the European Commission (EC), 2019. Available at: https://link.springer.com/chapter/10.1007/978-3-031-21448-6_2#Fn4
[8] National Bank of Slovakia. *What is Artificial Intelligence (AI)?* Available at: https://nbs.sk/en/financial-market-supervision1/fintech/financial-technology/what-is-artificial-intelligence-ai/
[9] EU Artificial Intelligence Act. [online] published February 2, 2025, [cited May 20, 2025]. Available at: https://artificialintelligenceact.eu/article/3/
[10] *Responsible Digitalization: MIRDI Presents Draft Laws on Artificial Intelligence and Data Management.* [online] published August 8, 2025, [cited September 8, 2025]. Available at: https://mirri.gov.sk/aktuality/digitalna-agenda/zodpovedna-digitalizacia-mirri-predstavilo-navrhy-zakonov-o-umelej-inteligencii-a-sprave-udajov/

1.1 KEY CHARACTERISTICS AND FUNCTIONS OF AI

Artificial Intelligence has emerged as one of the top revolutionary technologies of the present. From health to business, AI is revolutionizing industries by reducing the time required to process, increasing efficiency, and solving complex issues. What is it that makes AI such a powerful tool? The key is in the unique characteristics and capabilities that allow AI to imitate human intelligence and possibly exceed human capabilities.

The attributes of AI can be described as its abilities. These characteristics enable AI to be much more than just a computer and permit AI to learn, comprehend, and adapt to its surroundings.

The most important characteristics of artificial intelligence which makes it stand out:

► ***Learning Capability***

One of the main characteristics of AI is its capacity to be able to draw lessons from the data. Contrary to conventional AI systems, AI doesn't need explicit instructions for all tasks. Machine learning algorithms are used to process information, identify patterns, and make assumptions or make decisions. The more information AI gets exposed to, the better it gets at what it does.

AI systems can learn by mimicking humans' brains. In processing massive quantities of data AI can detect patterns, draw conclusions and modify its behavior according to experience. Deep learning and machine models play an important role in this.

► ***Problem-Solving***

AI is a master at solving difficult issues, including those humans are unable to solve. AI employs algorithms and data to analyze the problems and come up with efficient solutions. Often, it is faster than any human would.

AI breaks down complex issues into easily manageable pieces. In doing this it examines different outcomes and determines which one is the most efficient by using optimization methods.

► ***Reasoning***

Thinking is a different key characteristic that AI has. AI can make rational decisions in reliance on the data it holds, utilizing rules and logic to conclude.

Logical Reasoning in AI

AI makes use of deductive reasoning to determine outcomes and connections between the various elements of reality. It employs logical principles on data, and it can blend evidence to make informed choices.

► ***Perception***

AI's ability to sense the environment around it is a different characteristic that makes AI stand out. AI uses sensors and data to comprehend the environment around it, much like the way humans utilize their senses.

How AI Understands the World

By using technologies such as computer vision as well as speech recognition, AI can interpret images as well as sounds and gestures. This gives an impression.

► ***Adaptability***

It is the most important characteristic of AI applications. AI systems are constantly evolving and adaptable to the latest information or changes in their surroundings without needing to reprogram.

The Dynamic Nature of AI Systems

AI can adapt by learning by absorbing new information. If a system comes across changes in its environment, it can modify its behaviour accordingly to make it more robust and adaptable.

► ***Automation***

Automation is among the main features that can be utilized by AI. Automated completion of tasks with no human involvement, thereby increasing speed and decreasing mistakes.

How AI Automates Tasks

AI-driven automation automates routine tasks, freeing human employees to do more difficult work. From chatbots in customer support to automated production lines, AI helps make processes more efficient.

► ***Data Handling***

AI's capacity to process vast quantities of data is an amazing characteristic. AI is able to store, process data, and analyze it at a speed that humans cannot.

AI's Ability to Manage and Analyze Large Data Sets

Machine learning algorithms and AI can sift through massive amounts of data, spot patterns, and draw meaningful conclusions.

► ***Natural Language Processing (NLP)***

Natural Language Processing (NLP) lets AI comprehend and communicate with humans in a way that makes it much easier to communicate with machines.

AI Understands of Human Language

NLP can enable AI to process both text and speech. It can also recognize nuances in the language and provide relevant responses. This technology makes chatbots and voice assistants.

► ***Self-Correction***

Self-correction is an attribute of AI that improves its precision as time passes. AI systems take their lessons from mistakes and modify their strategies to enhance efficiency.

AI's Ability to Correct Itself

With feedback loops AI machines analyze mistakes and then refine their procedures so that they can deliver better outcomes soon.

► ***Efficiency***

One of the attractive features of AI applications is that they can improve effectiveness. AI is able to complete tasks faster and more precisely than human beings, thereby saving time and energy.

AI's Role in Improving Efficiency

It doesn't matter if it's the processing of financial transactions, or even performing scenarios, AI reduces the time needed to accomplish jobs, usually with greater accuracy.

► ***Decision - Making***

The ability of AI to make choices is crucial to many sectors. AI makes use of data analysis as well as pattern recognition in order to come up with accurate and informed decisions.

AI's Decision-Making Process

AI systems analyze huge quantities of information, evaluate the potential outcomes and make choices that are usually more precise and objective than human judgement.

AI isn't just the future of technology It's a fundamental element of our life. Artificial intelligence's characteristics, from learning and reasoning to recognition and automation are why AI is an indispensable tool in increasing efficiency and solving the problems of our day-to-day lives. As AI develops it is only expected that the capabilities of AI will grow by redefining industries and increasing human capabilities. In conclusion, artificial intelligence, the advancement and integration of artificial intelligence will continue to shape our world in profound ways.[11]

1.2 ARTIFICIAL INTELLIGENCE APPLICATION

AI is here to stay. The different types of Artificial Intelligence are not just a distant part of future business operations, but very much amalgamated into the present state of business. According to global business insights, the market for AI grew from USD 50 billion in 2023 to an exponential USD 184 billion in 2024. By 2030, it is expected to be USD 826 billion. It has now become impossible to ignore. In fact, knowing how to navigate these types of Artificial Intelligence best will put business ahead of the competition.

1.2.1 Types of Artificial Intelligence

Our understanding of Artificial Intelligence has evolved over the years, and data scientists are still at work to explore its scope. The study and implementation of the different types of Artificial Intelligence can be complex to understand. However, to understand its value, let’s look at its scope.

The types of Artificial Intelligence tools in businesses offer transformative potential in the decision-making process, with the goal of improving customer-centricity and long-term growth.

[11] Available at: https://www.virtubox.io/blog/characteristics-of-artificial-intelligence

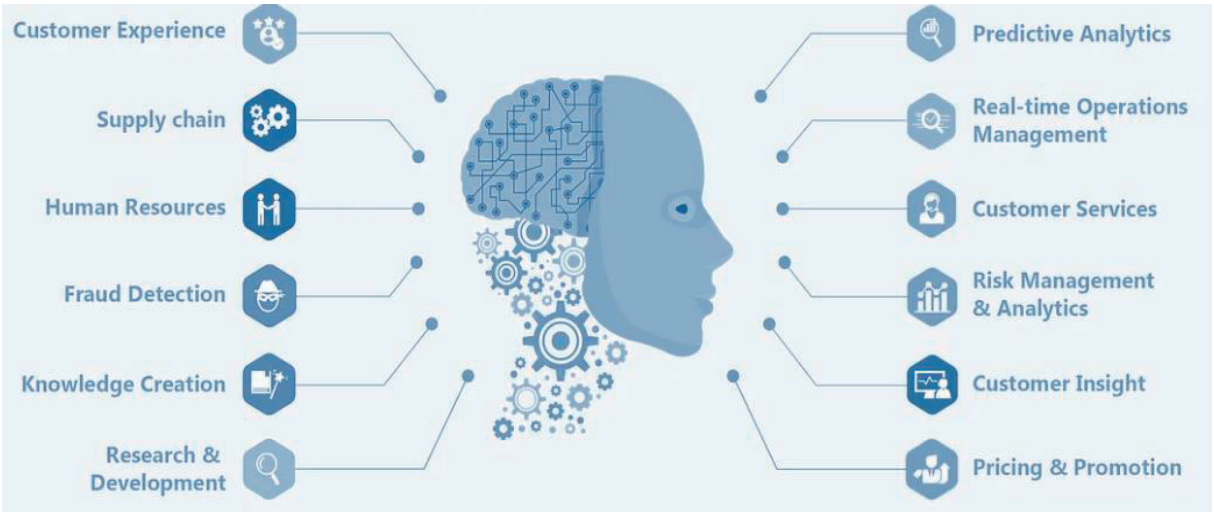

Figure 1: Top AI Use Cases[12]

Automation: The 7 types of artificial intelligence all help in one way or another to manage repetitive tasks. With Robotic Process Automation (RPA), AI frees up time spent here for big picture activities. Your team can focus on strategizing product design, marketing, sales and overall growth. For example, with the best AI chatbots, customer service agents can focus only on the bigger issues while leaving the easy ones to automated responses.

Data-Driven Decisions: AI helps gather, organize, analyze and interpret large amounts of data about the market, competitors and customers. Using predictive analytics models, you can understand the data and make informed decisions. For example, a retail e-commerce site uses different types of Artificial Intelligence to predict customer demands based on past trends and adjust supply accordingly.

Operational Efficiency: AI can optimize workflow by understanding available resources and allocating them in the most efficient way. For example, AI can keep tabs on a machine's working capabilities, warning the operator about maintenance before complete failure. This saves time.

Personalization: The different types of Artificial Intelligence help analyze customer preferences and behavior. This way, businesses can deliver personalized services based on what customers want. Streaming platforms use

[12] Jaro Education. [online] published September 26, 2024, [cited October 10, 2025].Available at: https://www.jaroeducation.com/blog/did-you-know-about-the-seven-types-of-artificial-intelligence/

recommendation algorithms to suggest content based on user history. This increases satisfaction.

Increased Security: AI can identify cybersecurity threats in real-time, keeping business integrity intact. For example, financial companies use types of Artificial Intelligence to identify fraud and scams.

1.2.1.1 Seven Types of AI

The seven types of Intelligence in AI can be categorized in a broad spectrum. From functionality and technology to degree of capability, this spectrum goes from basic types of Artificial Intelligence to highly advanced. Let's dive deep into these 7 types of Artificial Intelligence and how they are used by various industries.

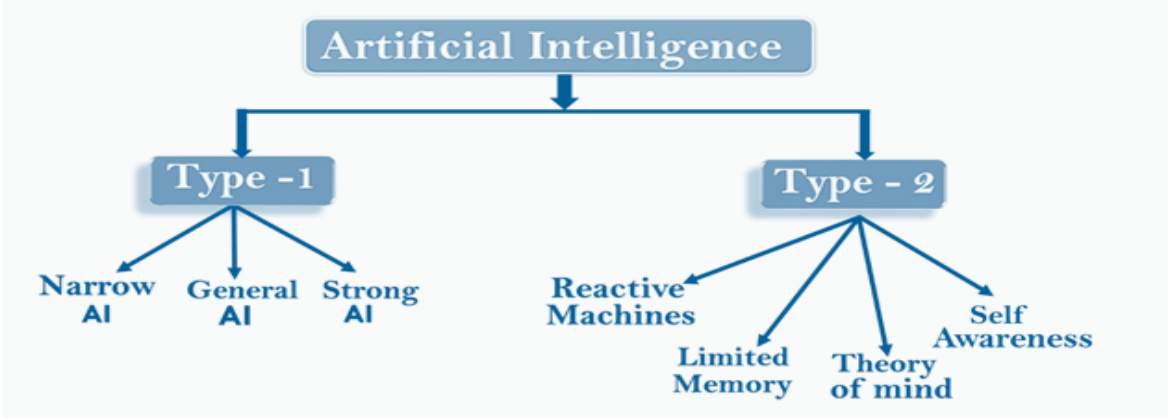

Figure 2: Types of AI[13]

Category 1: Functional Types of Artificial Intelligence

The seven types of artificial intelligence can be distinguished based on their uses and how they fit into organizational operations. Here's how:

1. Reactive Machines

Reactive AI is a type of Artificial Intelligence that focuses on immediate responses. Here, past experiences or the idea of "memory" do not come into

[13] Jaro Education. [online] published September 26, 2024, [cited October 10, 2025].Available at: https://www.jaroeducation.com/blog/did-you-know-about-the-seven-types-of-artificial-intelligence/

play. These systems can only perform limited and specific tasks but lack the ability to understand complex context or predict the future.

For example, Spotify uses reactive AI models to understand what the user is currently listening to (music, podcasts, books) and provide recommendations based on that. If the current listening style starts off with Bollywood, then this type of Artificial Intelligence will recommend more Bollywood playlists. But if the user switches over to another genre, like alt-pop, the immediate recommendations will also change to alt-pop playlists, with no memory of previous listening patterns. While Spotify is improving its reactive AI model, this is a great example.

2. Limited Memory

One of the seven types of intelligence is Limited Memory. This type of Artificial Intelligence can look at past data to make informed decisions and create a short-term memory that does not get retained indefinitely. This means that these Machine Learning models analyze patterns to make decisions, but they also require continuous training and data to learn and improve.

For example, generative AI tools like ChatGPT and conversational AI tools like Alexa and Siri are all different types of Artificial Intelligence in the Limited Memory category. The former relies on limited memory and data to predict the solution to a question or problem. The latter combines Natural Language Processing (NLP) and Limited Memory AI to understand questions and provide answers, links or media in response.

3. Theory of Mind

This type of Artificial Intelligence provides space for the potential of AI tools to be more advanced, designed to understand human emotions, thoughts and interactions. The Theory of Mind is one of the 7 types of intelligence that works towards AI responses based on user emotions and intentions.

For example, platforms that are customer-centric are exploring the Theory of Mind AI tool to improve interactions. For example, if a health app can detect signs of anxiety in a person's voice while asking for help, it can immediately offer ways to regulate breathing and emotions and calm the person. It can also know when to call an emergency ambulance or the medics. This type of Artificial Intelligence is a work in progress and is largely in the experimental and

developmental phases. The end goal is to make AI more intuitive, empathetic and interactive.

4. Self-Aware AI

This is a hypothetical type of Artificial Intelligence that data scientists look at as the ultimate end goal for AI. Here, AI would have human-like attributes such as consciousness, emotions and perception. There are, however, complex ethical and technical challenges involved in this type, making it currently only a future possibility. It is currently a futuristic AI model in the 7 types of intelligence conversation.

While there are no self-aware AI use cases or models yet, steps have been taken to humanize AI models, especially generative and conversational ones like Alexa or Siri. Media also shows hypothetical scenarios where AI becomes sentient like in the movie Her. With the right ethical, legal and technical frameworks in place, the development of self-aware AI is possible in the future. For now, we only have AI models that offer interactions and companionship.

Category 2: Capabilities of the Types of Artificial Intelligence

AI can also be categorized based on the extent of its capabilities. Here are the three main types based on its capabilities:

5. Narrow AI

This type of Artificial Intelligence is also known as "weak AI" because it is designed only to do the task in front of it without possessing any general intelligence. It can excel in areas but lacks the ability to look beyond the task assigned to it. It works based on predefined functions.

For example, voice assistants like Siri are considered narrow AI systems. They follow a set of instructions with predefined commands. They switch on to one command ("Hey Siri!") and answer basic questions like playing music or a video, setting reminders, etc., but do not do much outside these functions. Another example would be the types of Artificial Intelligence tools in the healthcare space. MRI machines use AI tools to do specific tasks such as detecting abnormalities early, assisting doctors by highlighting areas of concern and so on.

6. General AI

This type of Artificial Intelligence is also called Strong AI and is what data scientists and tech supergiants are working towards. Hypothetically, this is one of the 7 types of intelligence that would possess human-level understanding and

reasoning, with complex problem-solving abilities. General AI would also take situational context into account and adapt its course of action. While there are no specific cases for this type of Artificial Intelligence, general AI would do the role of an office worker, manage multiple tasks and process diverse roles.

7. Super AI

A type of Artificial Intelligence that would surpass human capabilities is not out of the question now. Future predictions all seem to suggest that a super AI would potentially change every industry with its ability to outperform humans in every field. However, for this to occur, strict governmental laws, ethical considerations and human autonomy need to be established. That's because any breakthroughs in this type of technology can lead to exponential consequences.

Other Types of Artificial Intelligence Based on Technology

Apart from the seven types of intelligence, there are AI classifications also based on technology. This includes:

1. Machine Learning

AI and ML are often used together because Machine Learning enables AI to process and interpret patterns in data. It equips AI to become more accurate with continuous data interpretation and less human intervention. For example, ML and this type of Artificial Intelligence can be vital in predictions in the stock market based on past data.

2. Deep Learning

Going one step further from Machine learning, this type of Artificial Intelligence uses neural networks to process huge chunks of data for more complex pattern recognition. This could include financial risk assessments and stock predictions at a grander level.

3. Natural Language Processing

NLP technology enables AI to understand and generate language, so any generative AI examples all work seamlessly with this technology. Chatbots, ChatGPT, Gemini, etc., are perfect use cases.

4. Computer Vision

This type of Artificial Intelligence uses visual cues, processes them and provides accurate information and predictions. For example, facial recognition technology could use computer vision and AI to read complex data and keep security intact.

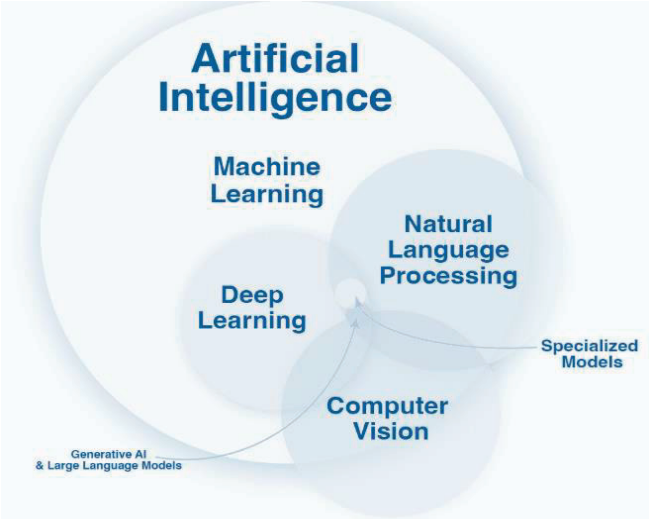

Figure 3: Types of AI Based on Technology[14]

Learning the 7 types of Artificial Intelligence is the need of the hour for anyone in the computer, tech or data industry. Understanding how to improve its accuracy, predictions and decision-making abilities can give the much-needed career boost.

Table 1: Types of AI

Distinction	Type of Artificial Intelligence	Table DefinitionHeader	Example
Functionality	Reactive AI	Focuses on immediate responses without considering past memory and data	Self Aware
	Limited Memory	Focuses on responses considering short term memory and data for decisions	Generative AI tools like ChatGPT, Gemini
	Theory of Mind	Hypothetical type where AI becomes human-like in processing information	Hypothetical type where AI becomes human-like in processing information
	Self Aware	*Hypothetical type of Artificial Intelligence that is sentient	
Technologies	Machine Learning	AI uses Machine Learning to understand complex data and reduce human dependency	Stock market predictions with past data
	Deep Learning	Using neural networks to enable deep information processing	Used for large-scale financial risk assessment
	NLP	Helping AI understand language	Any generative or communicative AI
	Computer Vision	Using visual information for data interpretation	Security tools like facial recognition

[14] Jaro Education. [online] published September 26, 2024, [cited October 10, 2025]. Available at: https://www.jaroeducation.com/blog/did-you-know-about-the-seven-types-of-artificial-intelligence/

1.3 RISKS OF ARTIFICIAL INTELLIGENCE

Artificial intelligence is already revolutionizing how we live, work, and play, and it's set to radically transform global progress on sustainability. It is no surprise therefore that business leaders predict that its impact on human society will be as profound as the discovery of fire.

But like fire, the transformative power of AI comes with risks too. So, the central question for investors right now is how to harness the potential of AI, without getting burned.

The way institutional investors in particular respond to this challenge could shape all our futures.

Institutional investors are large-scale players that manage huge pools of capital including pension and insurance schemes. Unlike other participants in global markets, they tend to take a long-term view – investing in a way that aims to produce sustainable returns 25 years or more from now. This makes sustainability a key consideration for institutional investors, as evidenced by the fact that over half of the world's institutional assets are now managed by signatories to the UN Principles for Responsible Investment.[15]

All of this makes institutional investors critical to shaping how AI gets embedded across industries in the years ahead. Currently, they are looking at AI to drive sustainability in two keyways:

1) Investing in the AI Sustainability Revolution: They see how investing directly or indirectly in companies that provide or deploy AI can help catalyze the transition to a low-carbon, sustainable economy. This could help them both to manage the long-term risks linked to climate change and nature loss and to grasp new opportunities to invest in the sustainability winners of tomorrow.[2]

2) Empowering Investment Decisions With AI: Investors are looking at AI as a tool to enhance the speed, quality, depth, and scope of their investment decision-making processes.

[15] ATKIN, D., 2024. *Meeting Investors Where They're At: PRI Launches New Strategy. Principles for Responsible Investment*. [online] published November 4, 2024, [cited October 10, 2025]. Available at: https://www.unpri.org/pri-blog/meeting-investors-where-theyre-at-pri-launches-new-strategy/12636.article.

1.3.1 Investing in the AI Sustainability Revolution

AI has the potential to revolutionize fields as diverse as energy, agriculture, healthcare, and ocean conservation, helping us **monitor, optimize, and predict** (MOP) progress toward global sustainability goals, as shown in Figure 1. I like to think of investors as using AI to "MOP up" sustainability challenges.

By channeling capital into AI-driven innovations, investors not only accelerate progress toward key global targets, such as the Paris Agreement, the SDGs, and the 30×30 goal of the Global Biodiversity Framework but also unlock potential opportunities for better risk-adjusted returns. In this dual role, they support a more sustainable, low-carbon economy while enhancing their own resilience in a rapidly changing market.

Figure 4: Using AI in Sustainability[16]

1.3.2 Empowering Investment Decisions With AI

The second approach to sustainability institutional investors are taking with AI is to enhance the speed, quality, depth, and scope of their investment decision-making processes.

Institutional investors diversify their portfolios across thousands of global companies and securities, creating an ecosystem of millions of data points. This comes with persistent challenges over the quality and coverage of that data and information, and how to turn it into valuable knowledge, wisdom, and action. Enter AI, with the potential to fundamentally reshape all parts of the Knowledge Pyramid behind each investment decision (See Figure 5).

[16] SAA, L., 2025. *The Essentials of AI and ESG: Opportunities, Risks, and Governance Insights for Institutional Investors.* [online] published August 14, 2025, [cited September 10, 2025]. Available at: https://www.clarity.ai

For data collection, AI and machine learning are invaluable for capturing information from diverse sources and formats (such as text, tables, and graphs) and improving data reliability. This quality control is not a marginal issue. Our research found that across three data providers that offered clients the same reported emission data points, the data was different 13% of the time and showed a discrepancy of over 20%.

AI can also help close data gaps when corporate self-reported data is not available, making more accurate estimations beyond industry averages by using comparable and alternative sets of information like news or geospatial data. For example, AI tools can now overlay corporate human rights disclosures with information pulled from global news and independent sources to see if they match up.

To transform data into actionable insights, AI assistant solutions now allow institutional investors to converse intelligently with their portfolios on sustainability topics. They can inquire about data sources, methodologies, performance, and recommendations for improving scores. Additionally, AI is being used to provide forward-looking insights. For example, we used AI to analyze the decarbonization plans of the world's 400 largest emitters, finding that only 40% have credible transition plans.

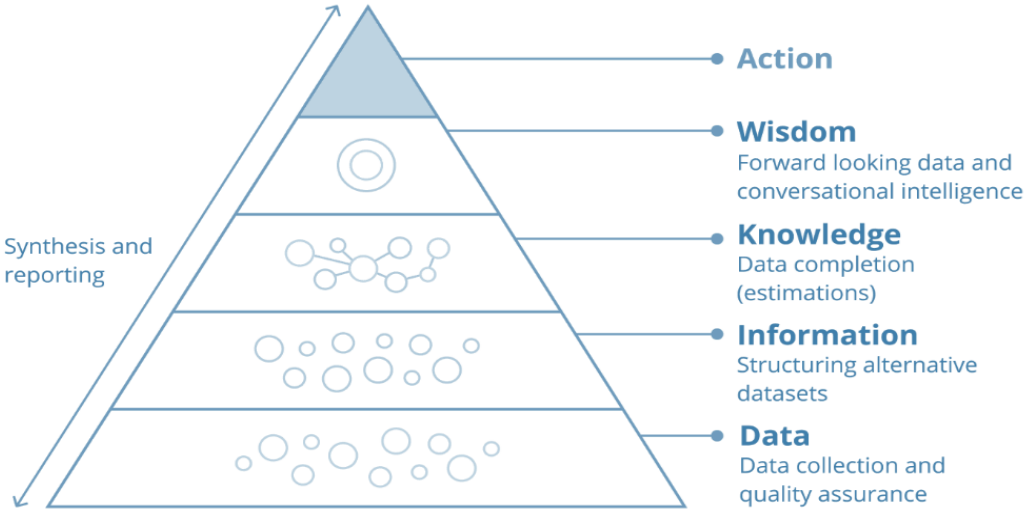

Figure 5: The Knowledge Pyramid[17]

[17] SAA, L., 2025. *The Essentials of AI and ESG: Opportunities, Risks, and Governance Insights for Institutional Investors.* [online] published August 14, 2025, [cited September 10, 2025]. Available at: https://www.clarity.ai

AI is already helping investors to report back to their many stakeholders in different formats, styles and languages. Perhaps most importantly for investors today, AI can offer ways to optimize compliance reporting, reducing the reporting burden, and allowing responsible investors to focus on making investment decisions.

1.3.3 Managing Governance Risks of AI

There are a lot of factors to capture in the governance of AI but a simplistic way to capture them is using the following main points:

- **Accountability and oversight:** Assigning clear responsibility for the ownership and management of the AI that they are investing in or using. It should never get to "it is the AIs' fault!"
- **Disinformation and hallucinations:** Ensuring that the AI model has the appropriate guardrails in place to avoid results that are misleading or outright fabrications.
- **Data privacy and security:** Ensuring that the AI or the user interacting with it is not using data that it does not have authorized access to.
- **Fairness and non-discrimination:** Ensuring that the AI model or algorithm is not trained on biased data which can lead to the unfair treatment or the exclusion of certain individuals or groups.
- **Transparency and explainability:** Ensuring that the workings of the AI model are disclosed and explained to an extent that makes it trustworthy and understandable.

Even in AI's early stages, poor governance has emerged, as seen with Clearview AI. The US-based facial recognition company faced fines from regulators in the UK, Netherlands, and elsewhere for scraping billions of social media images without user consent.

To address these risks, investors need to apply governance principles and guidelines for managing AI. The key principles guiding the industry are the OECD AI Principles. Updated in May 2024 to capture the emerging risks introduced by generative AI tools like ChatGPT and Google's Bard, they are the main reference point for anyone wanting to tackle AI responsibly.

In addition, there are a growing number of players offering risk management guidelines such as The Partnership on AI, AI4People, Future of Life Institute, The Green Digital Finance Alliance (GDFA) and The Responsible AI Institute (RAI).

Investor specific guidelines include WEF's Responsible AI Playbook for Investors, the CFA Institute's Ethics and Artificial Intelligence in Investment Management and RAI's Guiding Framework for Responsible AI Integration into ESG Paradigms tackles specifically sustainable investing.
These principles and guidance aim to prevent AI from amplifying issues like bias and misinformation or enabling harm such as mass surveillance and human rights abuses. They emphasize accountability, requiring transparency on who deploys AI and who is responsible for its outcomes.

1.3.4 Managing Environmental Risks of AI

AI has the potential to accelerate progress toward global climate and nature goals. However, AI also poses environmental challenges that must be managed.
Most prominent is its use of electricity and water.

Data centers, essential for AI infrastructure, account for 2-4% of electricity consumption in major economies like the US, China, and the EU—a figure expected to grow with rising demand for AI. Similarly, AI systems require significant water, with estimates predicting it may require up to 6.6 billion m^3 of water withdrawal globally by 2027, over half the UK's annual water use. Due to their investments in AI, tech players like Microsoft and Google have seen their GHGs grow about 30 to 50%, despite their net zero commitments.
Investors play a key role in managing these risks. AI's electricity consumption should increasingly rely on renewable energy, which is why tech companies are investing heavily in carbon-free energy. Examples include Microsoft's partnership with Brookfield Renewable and recent investments by Amazon and Google in small nuclear reactors for clean energy.
Water use should also be minimized through closed-loop systems and sustainable practices, ensuring it's not diverted from essential human needs and that wastewater is safely managed and reused, for example, in local heating systems.

To reduce environmental impacts, AI model designs should also be resource-efficient and aligned with specific use cases—generative AI models aren't always necessary when simpler, less resource-intensive models suffice. Notably, AI helps mitigate its own environmental footprint. Google's DeepMind AI, for example, optimizes the energy use in its data centers and has achieved a 40% reduction in energy use for cooling.[18]

Lastly, responsible environmental management of AI requires sustainable sourcing of materials for data centers and hardware. Rare earth metals, like lithium and cobalt, are vital for AI but carry environmental and human risks if mined irresponsibly. Additionally, AI hardware often uses toxic chemicals and heavy metals such as lead, cadmium, and mercury. Without proper disposal, these can leach into soil and water.

1.3.5 Managing Social Risks of AI

AI's potential social benefits, ranging from new healthcare treatments to improved access to education, are significant, though often less discussed than environmental impacts.

A study published in Nature Journal in 2020 found that AI could positively contribute to 134 of the 169 (79%) UN Sustainable Development Goals

However, it also warned that the social risks that come with AI might hinder progress on 59 of the 169 (35%) SDGs if it is not managed wisely. However, it also warned that the social risks that come with AI might hinder progress on 59 of the 169 (35%) SDGs if it is not managed wisely.

One of the most prominent social concerns discussed in relation to AI, is its impact on the labor market.

While AI will boost productivity and create new roles, McKinsey predicts that by 2030, activities that account for up to 30% of hours currently worked across the US economy could be automated due to the accelerating use of generative AI. Just like for climate change, this shift will require a "just transition", with governments and companies investing in training to help workers adapt.

[18] DeepMind. DeepMind AI Reduces Google Data Centre Cooling Bill by 40%. July 20, 2016. Accessed November 4, 2024. https://deepmind.google/discover/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-by-40/?t.

While it is not the whole story, there is something to the much-quoted point that "AI is not going to take your job, but someone who knows how to use AI will".

1.3.6 An AI Cheat Sheet for Investors

Institutional investors are already closely monitoring the ESG risks of AI. A recent Capital Group survey of over 1,000 institutional investors shows that these risks are viewed as material across various regions and topics. Data protection and privacy emerge as the top concerns, while other governance, environmental, and social issues are considered material by at least half of the respondents in one or more regions globally.[19]

To help investors address these challenges, Figure 6 outlines key risks and mitigation actions. These can be applied when employing AI or used as criteria when evaluating investments in companies that develop or deploy AI.

[19] GROUND, J., 2024. *The Rise of AI and ESG. Capital Group.* [online] published November 8, 2024, [cited October 10, 2025]. Available at: https://www.capitalgroup.com/institutions/fr/en/insights/articles/the-rise-of-ai-and-esg.html.

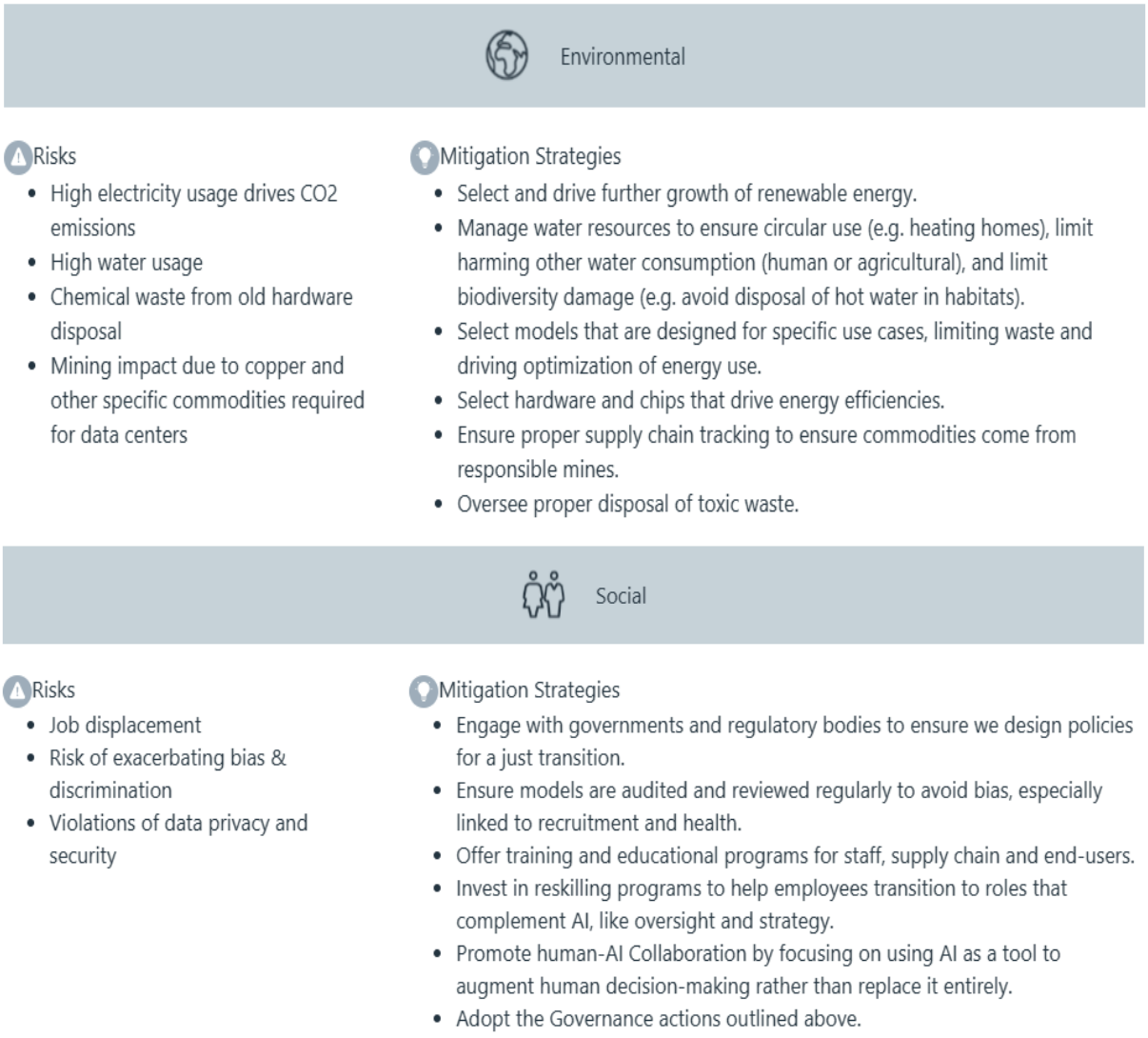

Figure 6: Key ESG Risks of AI for Sustainable Investors and Management Strategies[20]

1.4 KEY TRENDS SHAPING THE FUTURE OF AI

As we enter a new tech era, several trends will shape the future of AI technology.

► AI and Workforce Augmentation

The concept of a "superagency" in the workplace is becoming a reality. Rather than simply replacing human jobs, AI is increasingly seen as a partner that augments human capabilities. By automating mundane tasks, AI frees up time for employees to engage in more meaningful work.

[20] SAA, L., 2025. *The Essentials of AI and ESG: Opportunities, Risks, and Governance Insights for Institutional Investors.* [online] published August 14, 2025, [cited September 10, 2025]. Available at: https://www.clarity.ai

This AI trend also drives team trainings at companies around the globe, as businesses invest in educational programs to help their teams get the most out of AI systems.

► Ethical AI & AI Governance

With great power comes great responsibility—and nowhere is this truer than in AI. As artificial intelligence development expands, ethical considerations are more important than ever.

Addressing algorithmic bias, data privacy, and accuracy is crucial for building trust in AI systems. As a result, governments and regulatory agencies are stepping in with policies to ensure responsible AI development and usage.

► AI and the Metaverse

The rise of the metaverse is also creating new opportunities for AI. Virtual assistants and immersive AI-driven experiences transform interactions. This intersection of AI and virtual reality is redefining business ventures and contributing to a forward-thinking future.

► Sustainable AI & Green Computing

As AI systems become more powerful, their energy demands also rise. To combat this issue, there's a growing trend toward sustainable AI and green computing. Researchers are developing energy-efficient algorithms and eco-friendly hardware that reduce the carbon footprint of AI tools. This focus on sustainability ensures that the rapid progress in artificial intelligence doesn't harm our environment.

► AI in Education & Skill Development

Education is also getting a major upgrade thanks to AI. Personalized learning platforms, AI tutors, and automated content generation, from lesson plans to quizzes, are changing learning practices. Students can now access tailored educational resources that adapt to their unique learning style. This trend shows one of the best aspects of AI progress: training future generations with vital skills needed in the working world.

1.4.1 Challenges in AI Development and Adoption

As exciting as AI advancements are, there are still a variety of challenges that businesses need to navigate carefully:

► Data Privacy & Security Concerns

One of the major concerns in AI development is ethical data use. Data privacy and security have become critical concerns, with AI systems relying heavily on large amounts of information. Issues such as unauthorized surveillance, data breaches, and misuse of personal information are major discussion topics about AI progress.

► Job Disruptions & Workforce Changes

While AI is helpful for improving productivity and shaping innovation, it raises valid concerns about job displacement. As machines take over repetitive tasks, some fear that the human workforce may be left behind.

However, history shows that technological changes often create new jobs even as old ones disappear. The key is to ensure that workers are equipped with the skills needed for emerging roles in the future of AI.

► Regulatory & Legal Challenges

Rapid advancements require in-depth legal frameworks. Governments worldwide are struggling with how to regulate AI while still leaving room for innovation. Transparency and accountability within AI systems require a close attention to detail. As policies evolve to keep pace with the fast-moving tech landscape, companies involved with artificial intelligence development must stay compliant to avoid legal penalties.

►Technical Limitations

Even as AI technologies push boundaries, they can't do everything. Technical challenges such as AI hallucinations (where systems generate plausible but incorrect responses), algorithmic biases, and dependence on massive computational power remain major issues. These limitations remind us that while the progress in artificial intelligence is impressive, there is still lots of work to be done.

1.4.2 Challenges and Future of AI

The future of AI is both exciting and a bit daunting. We're at the turning point of realizing Artificial General Intelligence (AGI) systems that could potentially match or exceed human intelligence in every way. This isn't just about making smarter chatbots but fundamentally changing interactions.

► The Rise of Artificial General Intelligence (AGI)

AGI represents the next big leap in AI, where machines are not just good at specific tasks but can understand, learn, and apply knowledge across a range of areas. The implications are huge—imagine systems that can think critically and work alongside humans seamlessly. While AGI is still evolving, every aspect of AI progress brings us closer to this reality.

► AI-Human Collaboration

One of the most promising aspects of AI technology's future is the potential for improved human-machine collaboration. Decision-making in industries from finance to healthcare could be transformed by AI systems. This boosts efficiency and innovation, as human intelligence complements AI's analytical skills.

► Solving Global Challenges

AI's potential extends beyond business and entertainment—it can contribute to solving some of the world's biggest challenges. From combating climate change and improving energy efficiency to aiding in disease eradication and disaster management, AI is becoming a critical tool in solving global challenges.

► Weighing the Risks

Of course, no discussion of AI's future would be complete without acknowledging its potential risks. Ethical concerns and even existential threats are all part of the conversation. Balancing AI's benefits with these risks is something that researchers are working to address through responsible AI usage and regulation.

► Moving Forward

While breakthroughs in 2025 have brought exciting advancements, from generative AI and healthcare innovations to business automation and cybersecurity improvements, challenges remain. Data privacy, job disruptions, and regulatory issues remind us that the path ahead is complex.

Embracing these changes while staying aware of the risks will be key to getting the most out of AI and ensuring that it benefits everyone.[21]

[21] MILES IT, 2025. *Progress in Artificial Intelligence: Key Breakthroughs, Trends, and Challenges in 2025.* [online] published March 26, 2025, [cited September 10, 2025]. Available at: https://www.milesit.com/progress-in-artificial-intelligence/

2 ETHICS OF ARTIFICIAL INTELLIGENCE

Ethics consists of the standards of behavior to which we hold ourselves in our personal and professional lives. It establishes the levels of honesty, empathy, and trustworthiness and other virtues by which we hope to identify our personal behavior and our public reputation. In our personal lives, our ethics sets norms for the ways in which we interact with family and friends. In our professional lives, ethics guides our interactions with customers, clients, colleagues, employees, and shareholders affected by our business practices. Should we care about ethics in our lives? In our practices in business and professions? That is the central question; our goal is to understand why the answer is "yes".[22]

Our time is marked by dynamic changes taking place in the political, economic, and social life of society. These changes affect every individual. It is the dynamics that help us to be better aware of the change in relationships, values and value orientations of people affected by the times. Today, we no longer doubt that ethics and its use in management practice is an essential part of management. Ethics contributes to the observance of moral principles, but also to the professionalism of a senior employee. Ethical behavior is not just about being honest and behaving honestly. It also affects others so that they can trust us to be able to motivate them and create a collaborative environment.

Ethics, the discipline concerned with what is morally good and bad and morally right and wrong. The term is also applied to any system or theory of moral values or principles. Ethics deals with questions at all levels. Its subject consists of the fundamental issues of practical decision making, and its major concerns include the nature of ultimate value and the standards by which human actions can be judged right or wrong.[23]

Ethics is concerned with what is good for individuals and society and is also described as moral philosophy. At its simplest, ethics is a system of moral principles. They affect how people make decisions and lead their lives.

[22] BYARS, S. 2018. *Business Ethics.* Houston: Rice University. ISBN 978-1-947172-56-2, 377 pp.
[23] SINGER, P., 2025. *Ethics Philosophy.* [online] published Oct. 1, 2025, [cited Oct. 10, 2025]. Available at: https://www.britannica.com/topic/ethics-philosophy

The term is derived from the Greek word ethos which can mean custom, habit, character or disposition.[24]

2.1 MANAGERIAL ETHICS

Managerial ethics is a set of standards and principles that guide the actions and decisions of managers and based on this, determine whether the behavior of the manager in question is considered ethical or unethical. This means that ethical behavior is the behavior of a manager that is in accordance with the law and at the same time corresponds to the company's moral code.
Managers should be an example of ethical behavior for other employees of the organization. Hence the double role of the manager in the organization: to ensure its efficient functioning, but at the same time to ensure that this efficiency is achieved by means that are in accordance with the ethical code of the company.[25]

Managerial ethics are the standards that affect the conduct of employees within an organization. These are the sets of principles and rules chosen by upper management that explain what is right and wrong within an organization. Employees tend to follow the examples set by their leaders, so it is important for companies to ensure their managers project the image the organization supports. Good managerial ethics lead to a culture of positivity within the workplace, which, in turn, causes employees to feel supported and valued. Poor managerial ethics lead to employee distrust and negativity and can affect a company's bottom line.

Central problem in managerial ethics lies in the relation between superior and its subordinates, between managerial staff and other employees in the organization. The level, state and quality of managerial ethics influence quality of the development of interpersonal relationships in the workplace.

Managerial ethics is normally characterized as critically normative reflection of managing the organization from managerial staff side. From the point of a manager it, fulfills 2 functions: presents basic normative orientation in relation to

[24] BBC *Ethics: a General Introduction.* Available at: https://www.bbc.co.uk/ethics/introduction/intro_1.shtml
[25] Euroekonóm*, 2019. Organizational Behavior and Ethics.* [online] published February 21, 2019, [cited September 21, 2022]. Available at: https://www.euroekonom.sk/organizacne-spravanie-a-etika/

subordinates and presents a how to guide for self-reflection, self-control, self-regulation of own behavior. The matters of managerial ethics are questions of justice, boundaries and responsible disposal of power of management towards co-workers in formally organized socially economical system, whose work and hierarchy is structured. The initial step is the allocation of roles and power in specific hierarchal organization.

Top management is confronted with ethical problems independently from where the organization stands on the market, what her structure or size is. Some demands for responsible decision making are clear and easy, some aren't. We need to consider that decisions a manager needs to make are important from the business functions aspects as well as an ethical aspect.

2.1.1 Types of Managerial Ethics

Moral ethics and legal ethics are the key types of managerial ethics. Moral ethics management is when decisions are made not because there is a legal requirement to do so, but because management feels it is the right thing to do, such as being honest, treating others with respect, etc. Legal ethics is when a decision is made because it is the law, such as not taking bribes and not falsifying documents.

The types of managerial ethics are also called models. Usually, there are three types of management ethics in the organization. They are:

► *Immoral*

Immoral means acting unethically. Immoral ethics is when a manager unethically acts in the organization. Managers do not assume the welfare of employees or society while executing business activities.

And their sole goal is to maximize profits even if it is by means of breaking the legal laws or indiscriminately exploiting employees. In a simple sense, here a manager recognizes what is the wrong thing and does the wrong thing.

► *Moral*

The moral is the condition where a manager acts ethically and abides by the legal standards and laws. Managers do their best to recognize the wrongdoing and try to minimize it.

Here, the manager's goal is to work ethically and maximize revenue within moral principles and standards. While making the decisions every organizational member is invited, everyone's suggestions are valued, and the welfare of the employees, organization, public, and environment is equally valued.

The goal of moral managerial ethics is to achieve the organization's desired goals and achieve the welfare of employees and society.

► *Amoral*

In this ethics, managers are irrelevant to what is wrong and what is right in the work environment. They lack a sense of ethical awareness and perception.

It lies between immoral and moral management ethics. Usually, managers respond to ethical or unethical behaviors only when they are required to do so.

2.1.2 Importance of Managerial Ethics

Ethical standards affect managerial actions and practices. Managers need to conduct each activity of an organization from an ethical and moral perspective. Following are some importance of managerial ethics that your organization may get by maintaining it.

► ***Healthy Working Environment*** – Management ethics ensure equality and fairness in the workplace. Every organizational member is treated fairly and given equal opportunities to express and act as they see fit. Fairness and respect for every organization member promote a healthy working environment.

► ***Better Relationship Between Managers and Employees*** – A better relationship is maintained between managers and employees when employees are given value for what they are. And it is ensured by management ethics.

► ***Fair Competition*** – If every firm operates under business ethics – issues like unfair pricing, adulteration, black marketing, etc. are reduced which results in fair competition in the market.

► ***Better Customer Relation*** – Customers are the main source of achieving organizational goals. It focuses on valuing customers' needs, interests, and preferences and acting upon the customer's expectations.

► ***Customer Satisfaction*** – As business ethics focuses on working upon customers' expectations it increases the success rate of achieving customer satisfaction. Better relationships with customers and exceeding their expectations result in greater customer satisfaction.

► ***Good Public Image*** – Management ethics does not only focus on ethically working within the organization instead it equally emphasizes working ethically outside the organization.

► ***Long-Run Success*** – It also gives importance to achieving long-run success for an organization by satisfying employees, and customers, and acting upon building a good public presence.

► ***Less Government Interference*** – A business that works unethically and ignores the legal laws is always in the eye of the government.

► ***Happy Stakeholders*** – Management ethics does not only focus on building good relationships with employees, customers, and society but with all the stakeholders who directly or indirectly have an influence on the organizational performance.

► ***Promotes Social Responsibility*** – Managers work in society to fulfill the economic objectives of the organization. Business ethics guide them to work for society's welfare, arrange awareness programs, support education, participate in environmental protection programs, etc. All these promote the social responsibility of the organization.[26]

2.2 ENGINEERING ETHICS

Engineering ethics is the field of system of moral principles that apply to the practice of engineering. The field examines and sets the obligations by engineers to society, to their clients, and to the profession. As a scholarly discipline, it is closely related to subjects such as the philosophy of science, the philosophy of engineering, and the ethics of technology.[27]

Engineering ethics are principles and guidelines engineers follow to ensure their decision-making is aligned with their obligations to the public, their clients, and the industry. The National Society of Professional Engineers' (NSPE) code of ethics (it can be found in the annex of this publication) outlines the standards of ethical behavior engineers should follow in their professional lives. These include:

► Protecting public safety

► Only performing tasks they're qualified to do

[26] MELE, D., 2011. *Management Ethics. Placing Ethics at the Core of Good Management.* London: Palgrave Macmillan. ISBN 978-1-349-31947-3, 182 pp.

[27] PETERSON, M., 2020. *Ethics for Engineers*. Oxford University Press. ISBN 9780190609191, 256 pp.

► Being honest in public communications

► Remaining faithful and trustworthy to employers

► Acting with integrity

These principles are designed to help you, as an engineer, make ethical decisions in your work and promote responsible use of industry technologies.[28]

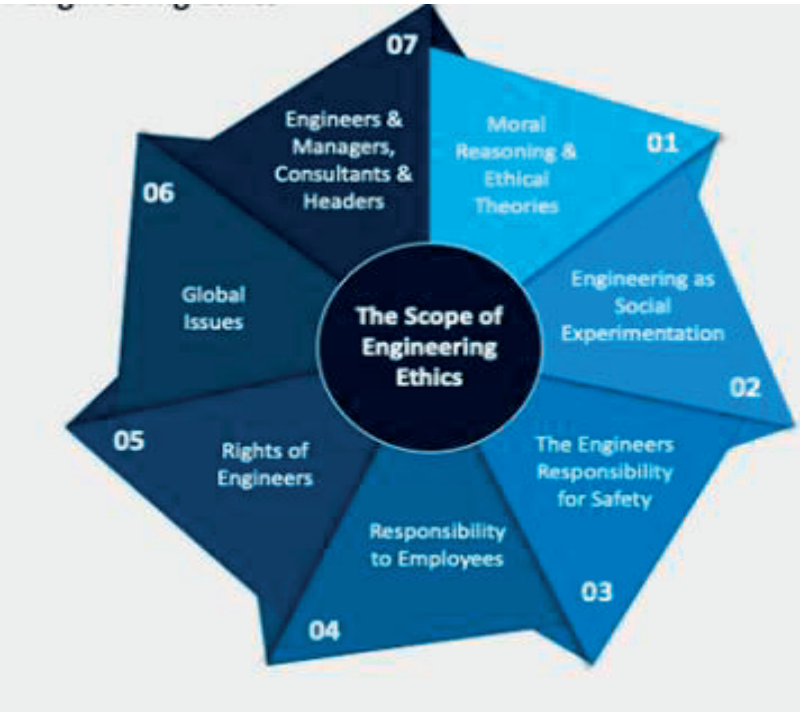

Figure 7: The Scope of Engineering Ethics[29]

2.2.1 Importance of Engineering Ethics

Here are seven reasons why ethics matter in engineering.

1. Promote Safety

The NSPE's code of ethics requires you to prioritize public safety in your work.

For instance, you're expected to notify employers and clients when their judgment is overruled because of dangerous circumstances or when documents don't conform with applicable standards. Doing so can prevent harm to individuals and communities and ensure your work meets the highest safety and reliability standards.

Prioritizing safety not only protects employees and customers but also improves productivity and reduces costs associated with accidents and injuries.

[28] HAN, E., 2023. *Why ist Ethics Important in Engineering?* Harvard Business School, online. Available at: https://online.hbs.edu/blog/post/ethics-in-engineering

[29] Available at: https://www.sketchbubble.com/en/presentation-engineering-ethics.html

2. Enhances Quality

Engineering ethics are also critical to improving your quality of work. According to NSPE's code of ethics, you should only perform tasks that closely align with your education and experience.

This is important when working toward an engineering leadership position. For instance, as an organizational leader, you'll often manage individuals who are experts in areas you know little about. You'll need to shift from a specialist to a generalist management style by focusing on relationships, adding value by enabling work, considering the bigger picture, and relying on executive presence. The goal is to enable specialists on your team to do their highest-quality work.

3. Improve Public Opinion

Ethics also helps improve public opinion about engineering professions.

For example, the NSPE's code of ethics requires you to be honest in your public communications through objective, truthful statements free of private interest, deception, or misrepresentation. Honesty in public relations is crucial to building trust. It's even more critical for you as an engineer because your decisions directly affect the public's safety and well-being.

In an era where communication skills are increasingly valued, it's crucial to act ethically in your interactions with the public. Doing so can help improve perceptions about the engineering industry and demonstrate your commitment to ethical, responsible behavior.

4. Safeguards the Company's Interests

Adhering to engineering ethics can also help protect your company's interests.

The NSPE's code of ethics discourages you from disclosing sensitive or confidential company information without explicit consent, obtaining employment or advancement with improper methods, and unethically harming other engineers' professional reputations.

By adhering to these principles, you can help protect your firm's interests—as well as your team's—and ensure you contribute to its success.

5. Fosters Sustainability

Engineering ethics promote sustainability by requiring you to consider your work's long-term impact on the environment and society. Additionally, sustainability is vital to modern business because it can improve your organization's reputation, increase growth opportunities, and boost financial performance.

If you struggle to understand sustainability's context in your role as an engineer, consider the triple bottom line, a concept that asserts businesses should go beyond financial performance and measure their social and environmental impacts. If you consider profit, people, and the planet in your daily work, you're more likely to follow the industry's ethical standards around sustainability.

6. Protects Other Engineers

Engineering ethics aren't just meant to protect employers, clients, and the public. They also help protect individual engineers by discouraging all industry professionals from engaging in unethical or illegal behavior for their benefit.

The NSPE's code of ethics specifically states that "engineers shall not attempt to obtain employment or advancement by untruthfully criticizing other engineers." It also specifies that "engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers."

These guidelines are especially important when considering your team's performance and productivity. Fostering an environment that promotes employee engagement can prevent negative dynamics from corrupting your workplace.

7. Securities Company Assets

Engineering ethics help ensure your team members and organizational leaders act in ways that protect your company's intellectual property and confidential information.

The designs, inventions, and writings created by your team are often recognized as the property of either your client or the individual responsible for those assets. You must acknowledge such ownership agreements prior to beginning work. In doing so, you can prevent theft and misuse of your company's assets and protect its investments.[30]

2.3 BUSINESS ETHICS

Business ethics is a branch of ethics that examines ethical rules and principles in a business context; the various moral and ethical issues that may arise in business and all the duties and obligations that apply to the people involved in

[30] MOAVENI, S., 2019. *Engineering Fundamentals: An Introduction to Engineering.* Cl-Engineering; 6th edition, 2019, ISBN 978-1337705011, 868 pp.

the business. Those who study business ethics examine various types of business activity and ask, "is this behavior ethically correct or not?"[31]

Business ethics can be characterized very simply as a scientific discipline that examines the possibilities of applying moral principles and principles in business activities. Therefore, ethics in business means more than adapting to prevailing norms and laws. It can be said that it represents such an approach to business, the main goal and purpose of which is to provide services to the public without the economic entity mainly following its own interest, i. e. maximize your profit under all circumstances.

Because, if there were to be profit creation, or in the process of its investment, there should be damage or abuse of resources and people in the humane, social, or ecological field, the creation of profit would be unethical and thus ultimately anti-social. In other words, profit becomes unethical when its purpose is unethical; it is obtained by unethical means, and when its creation creates externalities that harm other business entities. This means that the business entity needs to be managed in such a way that it serves not only investors, but also employees, customers, the public and, finally, the entire external environment in which it operates.[32]

2.3.1 Principles Driving Business Ethics

Business ethics involves the moral principles guiding companies and individuals in the business world. These principles go beyond legal obligations, establishing a code of conduct that promotes trust and integrity at every level of a business. By understanding and implementing effective business ethics, companies can enhance their reputation, foster customer loyalty, and achieve long-term success.

- Business ethics are foundational principles that guide the behavior and decision-making of companies and individuals, promoting trust and fairness in business operations.

[31] MEINHOLD, R., 2022. *Business Ethics and Sustainability* (1 ed.). New York: Routledge. pp. 75–76. ISBN 978-1-003-12765-9.
[32] JANKOVICHOVÁ, E., 2009. *Business Ethics.* Brno: Tribun EU, Ltd., 76 pp., ISBN 978-80-7399-858-5, p. 11.

- Ethical business practices not only comply with legal standards but also enhance a company's reputation, fostering customer trust, brand growth, and long-term success.
- A comprehensive understanding of business ethics includes a focus on leadership, accountability, transparency, and environmental concerns, among other key principles.
- Companies with strong ethics programs can better avoid scandals and legal issues, benefiting from increased customer and investor confidence.
- Corporate social responsibility is a crucial aspect of business ethics, as it emphasizes balancing stakeholder needs with a commitment to societal welfare and sustainability.[33]

2.3.2 Building Trust and Fair Practices

Business ethics ensure that a certain basic level of trust exists between consumers and various forms of market participants with businesses. For example, a portfolio manager must give the same consideration to the portfolio of family members and small individual investors as they do to wealthier clients. These kinds of practices ensure the public receives fair treatment.

Business ethics goes beyond just a moral code of right and wrong; it attempts to reconcile what companies must do vs. maintaining a competitive advantage over other businesses. Firms display business ethics in several ways.

2.3.3 Key Principles of Business Ethics

There are generally 12 business ethics principles:

- **Leadership**: The conscious effort to adopt, integrate, and emulate the other 11 principles to guide decisions and behavior in all aspects of professional and personal life.
- **Accountability**: Holding yourself and others responsible for their actions. Commitment to following ethical practices and ensuring others follow ethics guidelines.

[33] TWIN, A., 2025. *Business Ethics: Key Principles and Their Importance in Today's Market.* [online] published August 17, 2025, [cited September 20, 2025]. Available at: https://www.investopedia.com/terms/b/business-ethics.asp

- **Integrity**: Incorporates other principles—honesty, trustworthiness, and reliability. Someone with integrity consistently does the right thing and strives to hold themselves to a higher standard.
- **Respect for others**: To foster ethical behavior and environments in the workplace, respecting others is a critical component. Everyone deserves dignity, privacy, equality, opportunity, compassion, and empathy.
- **Honesty**: Truth in all matters is key to fostering an ethical climate. Partial truths, omissions, and under or overstating don't help a business improve its performance. Bad news should be communicated and received in the same manner as good news so that solutions can be developed.
- **Respect for laws**: Ethical leadership should include enforcing all local, state, and federal laws. If there is a legal grey area, leaders should err on the side of legality rather than exploiting a gap.
- **Responsibility**: Promote ownership within an organization, allow employees to be responsible for their work, and be accountable to yours.
- **Transparency:** Stakeholders are people with an interest in a business, such as shareholders, employees, the community a firm operates in, and the family members of the employees. Without divulging trade secrets, companies should ensure information about their financials, prices changes, hiring and firing practices, wages and salaries, and promotions are available to those interested in the business's success.
- **Compassion:** Employees, the community surrounding a business, Business partners and customers should all be treated with concern for their well-being.
- **Fairness:** Everyone should have the same opportunities and be treated the same. If practice or behavior would make you feel uncomfortable or place personal or corporate benefit in front of equality, common courtesy, and respect, it is likely not fair.
- **Loyalty:** Leadership should demonstrate commitment to their employees and the company. Inspiring loyalty in employees and management ensures that they are committed to best practices.
- **Environmental concern:** In a world where resources are limited, ecosystems have been damaged by past practices, and the climate is changing, it is of utmost importance to be aware of and concerned about the environmental impacts a business has. All employees should be

encouraged to discover and report solutions for practices that can add to damage already done.[34]

2.3.4 Importance of Business Ethics for Modern Companies

There are several reasons for business ethics that are essential for success in modern business. Importantly, ethics programs set a code of conduct guiding personnel behavior, from executives to new employees.

When all employees make ethical decisions, the company establishes a reputation for ethical behavior. Its reputation grows, leading to benefits like:

- ► Brand recognition and growth
- ► Increased ability to negotiate
- ► Increased trust in products and services
- ► Customer retention and growth
- ► Attracting talent
- ► Attracting investors

The growing use of technology of all forms in business operations inherently comes with a need to ensure the technology and information being gathered is used ethically. Additionally, it should ensure that the technology is secured to the utmost of its ability, especially as many businesses store customer information and collect data that those with nefarious intentions can use.

A workplace should be inclusive, diverse, and fair for all employees regardless of race, religion, beliefs, age, or identity. A fair work environment is where everyone can grow, be promoted, and become successful in their own way.

Fostering an environment of ethical behavior and decision-making takes time and effort and starts at the top. Most companies need to create a code of conduct/ethics, guiding principles, reporting procedures, and training programs to enforce and encourage ethical behavior.

Once conduct is defined and programs are implemented, continuous communication with employees becomes vital. Leaders should constantly

[34] TWIN, A., 2025. *Business Ethics: Key Principles and Their Importance in Today's Market.* [online] published August 17, 2025, [cited September 20, 2025]. Available at: https://www.investopedia.com/terms/b/business-ethics.asp

encourage employees to report concerning behavior. Additionally, there should be assurances that whistle-blowers will not face adversarial actions.

2.3.5 Subject of Business Ethics

The emergence and development of business ethics is a violation of the fact that economics and morality represent two different worlds. The moral principle in the economic sphere requires a person to renounce actions that contradict generally accepted rules, i. e. that he does not use unethical practices in acquiring and fulfilling his goals, which means that exclusion of himself from a privileged position is of particular importance in ethical thinking, because what may be good for one person may not be good for others.

This subject addresses the ethical challenges confronting managers and marketers in contemporary business organisations. Ethically questionable practices can include sweatshop labour, the destruction of the natural environment, sex in advertising, and political lobbying and influence. But business and marketing can also demonstrate ethical leadership, for example through green products, cause-related marketing and sustainable supply chains.

The subject will explore why firms respond in these ways from the context of debates on corporate social responsibility (CSR) and sustainability, including strategic, ethical and critical/political perspectives. The subject then addresses what ethical issues are important to specific stakeholder groups, including employees, consumers, governments and NGO activists.[35]

2.3.6 Functions of Business Ethics

The main functions of business ethics can be defined as follows:

- revealing working ethical standards and principles,
- by confronting functioning principles with desired human values, i. e. with ideas about a dignified, just, good life,
- formulating new ethical standards and principles,
- developing a strategy for applying these standards and principles in the sphere

[35] Handbook of Melbourne University, 2025. *Business and Marketing Ethics.* [online] published [cited September 20, 2025]. Available at: https://handbook.unimelb.edu.au/2025/subjects/mktg30012

business.

In fulfilling several important functions, the main task of business ethics consists in identifying an ethical problem and its causes in the context of business, in choosing an appropriate standard and developing methods and procedures through which these standards are to be put into practice in order to solve the problem. When applying it, conflicts can be prevented at the initial stage by helping to find a generally acceptable solution. Compliance with business ethics is voluntary and presupposes respect for the basic moral principles of society. It is based on a mutual understanding between business entities and those people that entrepreneurs influence.

2.4 ETHICS IN CONSTRUCTION INDUSTRY

Ethics is a key facet of a company's corporate social responsibility (CSR) which it must endeavour to fulfill. The increasing emphasis on sustainability and environment in construction further requires companies to apply ethical standards to their activities.

In the construction industry, ethics has developed both at a professional and organisational level. Professionals such as lawyers, engineers and surveyors have ethical codes to uphold as befits their profession, as do organisations. Ethical behaviour is often measured by the degree of trustworthiness and integrity with which companies conduct business.

Personal ethics tend to be a product of beliefs, values, personality, and environment, while an organisation’s ethics must be instilled by its culture and leadership. Ethical failure in an organisation can often be the result of poor promotion of ethical practices by managers, as an individual’s ethics become subsumed among the wider non-observance of professional ethics.

Construction Industry Ethics will help you:

► Understand what is included in “ethical behavior”

► Be aware of the importance of ethics in business

► Recognize ethics in the context of the law

►Understand the direct link between ethics and a company’s success

► Know how to make ethical decisions[36]

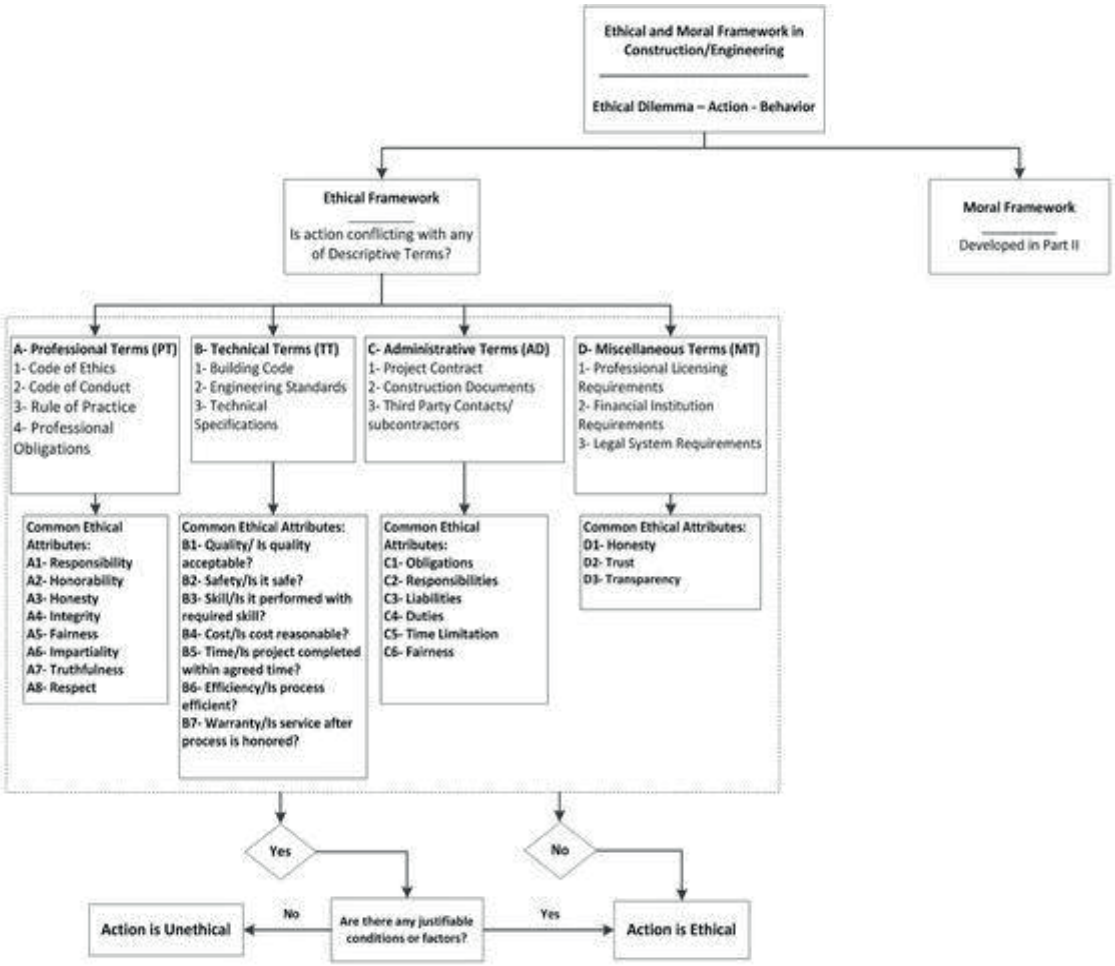

Figure 8: Complete structure of ethical and moral framework as related to construction/engineering[37]

The construction industry is usually characterized as a fragmented system of multiple-organizational entities in which members from different technical backgrounds and moral values join to develop a particular business or project. The greatest challenge in the construction process for the achievement of a successful practice is the development of an outstanding reputation, which is built on identifying and applying an ethical framework. This framework should reflect a common ethical ground for myriad people involved in this process to survive and compete ethically in today's turbulent construction market.

[36] Calgary Construction Association, 2025. *Construction Industry Ethics.* [online] published September, 2025, [cited October 11, 2025]. Available at: https://cgyca.com/courses/construction-industry-ethics/

[37] ALKHATIB, J. O., 2017. *Complete Structure of Ethical and Moral Framework as Related to Construction/Engineering.* [online] published March 20, 2017, [cited April 10, 2024]. Available at: https://link.springer.com/article/10.1007/s11948-017-9895-1#Fig1

This structure (Fig. 8) establishes a framework for ethical judgment of behavior and actions conducted in the construction process. The framework was primarily developed based on the essential attributes of business management identified in the literature review and subsequently incorporates additional attributes identified to prevent breaches in the construction industry and common ethical values related to professional engineering. The proposed judgment framework is based primarily on the ethical dimension of professional responsibility.

The Ethical Judgment Framework consists of descriptive approaches involving technical, professional, administrative, and miscellaneous terms. The framework provides the basis for judging actions as either ethical or unethical. Furthermore, the framework can be implemented as a form of preventive ethics, which would help avoid ethical dilemmas and moral allegations. The framework can be considered a decision-making model to guide actions and improve the ethical reasoning process that would help individuals think through possible implications and consequences of ethical dilemmas in the construction industry.[38]

2.4.1 Ethical Principles in Construction

There are several ethical principles that are important for construction professionals to uphold.

► Integrity: Honest and transparent practices in all dealings.

► Accountability: Taking responsibility for actions and decisions.

► Fairness: Equitable treatment of all stakeholders.

► Respect: Maintaining dignity and respect for employees, clients and community.

► Compliance: Adhering to laws, regulations and industry standards.

► Sustainability: Commitment to environmental stewardship and sustainable practices.

► Quality Assurance: Upholding high standards in construction processes and outputs.

► Safety: Construction professionals should take all necessary steps to protect the safety of workers and the public

[38] ALKHATIB, J. O., 2017. *Complete Structure of Ethical and Moral Framework as Related to Construction/Engineering.* [online] published March 20, 2017, [cited April 10, 2024]. Available at: https://link.springer.com/article/10.1007/s11948-017-9895-1#Fig1

Any company, including construction firms, can promote ethical principles at the workplace. Here are five tips to follow:

1. Lead by example: The company's leaders should set a good example by upholding ethical standards in their own behavior.
2. Create a code of ethics: The company should develop a code of ethics that outlines the ethical principles that are expected of employees.
3. Provide training on ethics: The company should provide training to employees on ethics and how to apply ethical principles in their work.
4. Encourage a culture of ethics: The company should create a culture of ethics where employees feel comfortable speaking up about unethical behavior.

Reward ethical behavior: Recognize and reward employees who demonstrate ethical practices.[39]

2.4.2 Ethical Guidelines in Construction

Construction projects involve multiple stakeholders, including clients, investors, contractors, and employees. With these various interests at play, ethical guidelines provide a framework for ensuring that everyone involved follows the same set of principles and values. Here are some key reasons why ethical guidelines are necessary:

■ **Positive Reputation:** Construction companies with a reputation for ethical practices tend to attract more clients and investors. This leads to increased business opportunities and growth.

■ **Consistent Decision-Making:** Ethical guidelines help employees make consistent decisions, even in challenging situations. It promotes fairness and mitigates the risk of favoritism and unethical behavior.

■ **Employee Morale and Retention:** A strong ethical culture within a construction company leads to higher employee morale and job satisfaction. It fosters a sense of belonging and loyalty among employees, resulting in better retention rates.

[39] *Importance of Ethics in the Construction Industry.* [online] published August, 2024, [cited September, 2024]. Available at: https://www.cicconstruction.com/blog/the-importance-of-ethics-in-the-construction-industry/

■ **Legal Compliance:** By adhering to ethical guidelines, construction companies can ensure legal compliance. This reduces the risk of lawsuits, penalties, and damages the company's reputation.

Ethics in construction goes hand in hand with Corporate Social Responsibility (CSR), and while this isn't currently a legal requirement for construction companies, it is good business practice and a great way to demonstrate good ethics. Consider that, just because something can be built, does that mean it should be? CSR has a large role to play in this, and construction companies can only be truly ethical if they critically consider the ethics of some of the early decisions required for a construction project.[40]

2.4.3 Construction Manager´s Code of Ethics

A construction-company code of conduct is an indication that the company is prioritising good practice and values in the workplace. As it isn't a legal requirement, companies that take these steps should be going above and beyond what is required of them to promote ethical business practices.

A code of ethics is a guide of principles designed to help professionals conduct business honestly and with integrity. A code of ethics document may outline the mission and values of the business or organization, how professionals are supposed to approach problems, the ethical principles based on the organization's core values and the standards to which the professional is held. Both businesses and trade organizations typically have some sort of ethics that their employees or members are supposed to follow. Breaking the code of ethics can result in termination or dismissal from the organization. A code of ethics is important because it clearly lays out the rules for behavior and provides a preemptive warning.

A value-based code of ethics deals with a company's core value system. It may discuss standards of responsible conduct as they relate to the larger public good and the environment. Value-based ethical codes may require a greater degree of self-regulation than compliance-based codes.

[40] MINETT, A., 2021. *Promoting Good Ethical Practice in Construction.* [online] published June, 2021, [cited April 10, 2023]. Available at: https://www.chas.co.uk/blog/promoting-good-ethics-in-construction/

For all businesses, laws regulate issues such as hiring and safety standards. Compliance-based codes of ethics usually not only set out guidelines for conduct but also lay out penalties for violations.
In some industries, including banking, specific laws govern business conduct. These industries tend to formulate compliance-based codes of ethics to ensure that legalities are being followed. Employees usually undergo formal training to learn the rules of conduct.

This type of code of ethics is based on clear-cut rules and well-defined consequences rather than individual monitoring of personal behavior. Therefore, despite strict adherence to the law, some compliance-based codes of conduct do not promote a climate of moral responsibility within the company.

Codes of ethics in construction firms are essential for creating a culture of integrity and promoting ethical behavior among employees. By setting clear expectations and guidelines, construction firms can foster a positive work environment, build trust with stakeholders, and prevent legal consequences. Embracing an ethical framework not only enhances the reputation of construction firms but also contributes to the overall success and sustainability of industry.

2.4.3 Ethical Program

Any form of institutionalization of ethics in a company that speaks and especially clarifies the values and standards to which its company subscribes is necessary. However, it is necessary to ensure that all employees understand its content and identify with these values, which can be considered as the first step on the way to integrating ethics into the life of the company.

Ethical programs contain both explicit and implicit components. An ethical program is created by the values, policies and activities that support the correct conduct of the organization.

Explicit components are represented by ethical codes, company policy manuals, ethical committees, commissions, social, cultural and ethical audits, materials for employee training, organization programs, ethical seminars, managers'

statements and their ethical decisions, internal control systems and ethical staff activities.

Implicit components of an ethics program include such elements as: corporate culture, changes in corporate structure, incentive systems, performance evaluation, promotion policy, performance measurement systems, and management behavior.

Basic elements of an ethics program include, for example:

► Code of ethics

The code of ethics is an important tool, especially when applying ethics to the company's internal environment. It represents, as a rule, a written summary of moral requirements, which take the form of moral standards, principles or ideals, by which every employee of the company should be guided.

► Ethical leitmotif

This form of institutionalization sounds unusual to us, as such it has rather a supplementary character. As a rule, it involves the development of case studies that illustrate a real or fictitious situation from business practice, i.e. economic-ethical dilemma.

► Ombudsman/trustee/collective representative for ethics

The creation of such a function means that the management of the company perceives ethical reflection as a permanent process, and not as a one-time matter. An ethical confidant is a person who develops, coordinates, and implements procedures and methods for enforcing the basic ethical principles already in force in the company.

► Seminar on ethics, seminar part on ethics

These forms are considered complementary, while fulfilling the function that it is desirable to develop a systematic program of ethical education, which would be accessible not only to employees at all levels of the organization, but also to all those affected by the serious consequences of possible non-compliance with ethical principles. Through them, employees not only learn what is right and what is wrong at the level of model situations but train them to think about the effects of their behavior and actions on other people.

► Ethics workshop

The company workshop has the character of further ethical education, in which individual topics are elaborated in more detail. However, they only make sense if they take place in an atmosphere of openness, while these open discussions and

dialogues can reveal weak points in the solution of the problem, and on this basis, it is possible to prepare procedures for their elimination.

► Hotlines

Hotlines play a special role in the ethics program, although their creation is very difficult. Through the lines or mailboxes set up in this way, workers can contact the ethics committee or the ethics trustee anonymously to report facts that they believe are not correct, or to receive information on how to behave when their superior suggests unethical behavior, etc. The employee can report things that he is afraid to officially disclose, or that are subjectively unpleasant and stressful for him.

2.4.4 Benefits of Managing Ethics in Workplace

Many people are used to reading or hearing the moral benefits of attention to business ethics. However, there are other types of benefits, as well. The following list describes various types of benefits from managing ethics in the workplace.

1. Attention to business ethics has substantially improved society.

A matter of decades ago, children in our country worked 16-hour days. Workers' limbs were torn off, and disabled workers were condemned to poverty and often to starvation. Trusts controlled some markets to the extent that prices were fixed, and small businesses choked out. Price fixing crippled normal market forces. Employees were terminated based on personalities. Influence was applied through intimidation and harassment. Then society reacted and demanded that businesses place high value on fairness and equal rights. Anti-trust laws were instituted. Government agencies were established. Unions were organized. Laws and regulations were established.

2. Ethics programs help maintain a moral course in turbulent times.

Attention to business ethics is critical during times of fundamental change — times much like those faced now by businesses, both nonprofit or for-profit. During times of change, there is often no clear moral compass to guide leaders through complex conflicts about what is right or wrong. Continuing attention to

ethics in the workplace sensitizes leaders and staff to how they want to act — consistently.

3. Ethics programs cultivate strong teamwork and productivity.

Ethics programs align employee behaviors with those top priority ethical values preferred by leaders of the organization. Usually, an organization finds surprising disparity between its preferred values and the values reflected by behaviors in the workplace. Ongoing attention and dialogue regarding values in the workplace builds openness, integrity, and critical ingredients of strong teams in the workplace. Employees feel a strong alignment between their values and those of the organization. They react with strong motivation and performance.

4. Ethics programs support employee growth and meaning.

Attention to ethics in the workplace helps employees face reality, both good and bad — in the organization and themselves. Employees feel full confidence they can admit and deal with whatever comes their way. Bennett, in his article "Unethical Behavior, Stress Appear Linked" (Wall Street Journal, April 11, 1991, p. B1), explained that a consulting company tested a range of executives and managers. Their most striking finding: the more emotionally healthy executives, as measured on a battery of tests, the more likely they were to score high on ethics tests.

5. Ethics programs are an insurance policy — they help ensure that policies are legal.

There is an increasing number of lawsuits regarding personnel matters and to effects of an organization's services or products on stakeholders. As mentioned earlier in this document, ethical principles are often state-of-the-art legal matters. These principles are often applied to current, major ethical issues to become legislation. Attention to ethics ensures highly ethical policies and procedures in the workplace. It's far better to incur the cost of mechanisms to ensure ethical practices now than to incur costs of litigation later.

A major intent of well-designed personnel policies is to ensure ethical treatment of employees, e.g., in matters of hiring, evaluating, disciplining, firing, etc.

6. Ethics programs help avoid criminal acts "of omission" and can lower fines.

Ethics programs tend to detect ethical issues and violations early on so they can be reported or addressed. In some cases, when an organization is aware of an actual or potential violation and does not report it to the appropriate authorities, this can be considered a criminal act, e.g., in business dealings with certain government agencies, such as the Defense Department. The recent Federal Sentencing Guidelines specify major penalties for various types of major ethics violations. However, the guidelines potentially lower fines if an organization has clearly made an effort to operate ethically.

7. Ethics programs help manage values associated with quality management, strategic planning and diversity management — this benefit needs far more attention.

Ethics programs identify preferred values and ensure organizational behaviors are aligned with those values. This effort includes recording values, developing policies and procedures to align behaviors with preferred values, and then training all personnel about the policies and procedures. This overall effort is very useful for several other programs in the workplace that require behaviors to be aligned with values, including quality management, strategic planning, and diversity management.

Total Quality Management includes high priority on certain operating values, e.g., trust among stakeholders, performance, reliability, measurement, and feedback. Eastman and Polaroid use ethics tools in their quality programs to ensure integrity in their relationships with stakeholders. Ethics management techniques are highly useful for managing strategic values, e.g., expanding market share, reducing costs, etc. McDonnell Douglas integrates their ethics programs into their strategic planning process.

Ethics management programs are also useful in managing diversity. Diversity is much more than the color of people's skin — it's acknowledging different values and perspectives. Diversity programs require recognizing and applying diverse values and perspectives — these activities are the basis of a sound ethics management program.

8. Ethics programs promote a strong public image.

Attention to ethics is also strong public relations — admittedly, managing ethics should not be done primarily for reasons of public relations. But frankly, the fact that an organization regularly gives attention to its ethics can portray a strong positive to the public. People see those organizations as valuing people more than profit, as striving to operate with the utmost of integrity and honor. Aligning behavior with values is critical to effective marketing and public relations programs. Consider how Johnson and Johnson handled the Tylenol crisis versus how Exxon handled the oil spill in Alaska. Bob Dunn, President, and CEO of San Francisco-based Business for Social Responsibility, puts it best: "Ethical values, consistently applied, are the cornerstones in building a commercially successful and socially responsible business."

9. Overall benefits of ethics programs:

Managing the ethical values in the workplace legitimizes managerial actions, strengthens the coherence and balance of the organization's culture, improves trust in relationships between individuals and groups, supports greater consistency in standards and qualities of products, and cultivates greater sensitivity to the impact of the enterprise's values and messages.

10. Last – and most — formal attention to ethics in the workplace is the right thing to do.[41]

2.5 ETHICS IN ARTIFICIAL INTELLIGENCE

Artificial Intelligence is becoming the Primary stage of Economic growth making operations run seamlessly and opening doors for new possibilities. While its efficiency and productivity are not undeniable, ensuring trustworthy use remains crucial. It leads to the proliferation of **ethical AI** in the workplace, a stand that focuses on the fair implementation of AI.

Ethical AI in the workplace refers to well-defined guidelines related to individual values, which involve adhering to non-discriminatory practices, non-

[41] CARTER, M., 2023. *Benefits of Managing Ethics.* [online] published January, 2023, [cited April, 2023]. Available at: https://management.org/blogs/business-ethics/2010/10/23/10-benefits-of-managing-ethics-in-the-workplace/#google_vignette

manipulation, respecting individual rights, privacy and fair AI practices at the workplace to improve AI job quality.

It prioritizes fundamental importance to ethical considerations in determining the legitimate use of AI in the workplace.

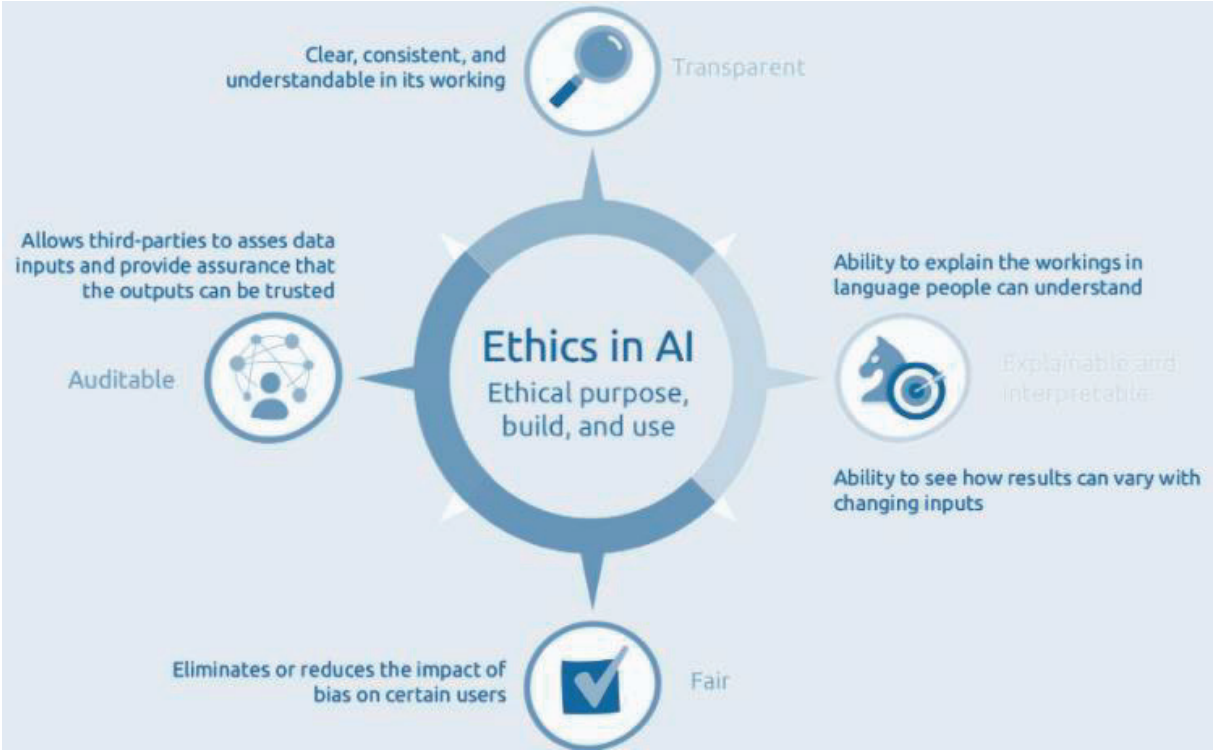

Figure 9: What do we Mean by Ethics in AI?[42]

2.5.1 Strategies for Fairness and Sustainability

There are Five Pillars of AI Ethics which include:

1. Accountability: Accountability in AI is crucial for completing and speeding up processes which ensure reliability, requiring continuous evaluation by CIOs to maintain efficient business operations.

2. Reliability: AI must be dependable, for seamless and error-free outputs.

3. Explain-ability: AI and ML models should be understood and well explained across departments and organizations otherwise the benefits of AI become irrelevant if the technology is not coherent.

4. Security: It is essential to understand the potential risks of AI. If AI does not guarantee privacy, businesses will struggle to keep customers.

[42] Hibernian Recruitment, 2024. *Ethical AI: Buildind Fair and Sustainable Workplaces.* [online] [cited October, 2025]. Available at: https://www.aicerts.ai/blog/ethical-ai-building-fair-and-sustainable-workplaces/

5. Privacy: As individuals and Businesses heavily rely on and work on the cloud it becomes essential to Protect customer data.

2.5.2 Implementing Fair AI Practices

- ***Inclusive and Equity:*** Ensuring equal opportunities and treatment for all employees.
- ***Fairness:*** Actively work to eliminate biases and promote fairness in operations.
- ***Transparency:*** Maintaining openness about processes and decisions to build trust.
- ***Societal Impact:*** Considering the broader societal consequences of workplace actions.
- ***Continuous Assessment:*** Regularly evaluating and improving workplace practices for ethical integrity.

Figure 10: AI Applications That Can Support the Social Side[43]

2.5.3 AI and Future of Work

Here are five ways in which AI is generally improving job quality:

[43] Deloitte Analysis, 2024. *Ethical AI: Buildind Fair and Sustainable Workplaces.* [online] [cited October, 2025]. Available at: https://www.aicerts.ai/blog/ethical-ai-building-fair-and-sustainable-workplaces/

1. Automation of Routine Tasks: It eliminates repetitive tasks and frees up time for thinking, creating, and innovating therefore increasing productivity and efficiency

2. Enhanced Decision Making: AI empowers you to make informed decisions with Data-driven insights

3. Personalized Learning and Development: AI tailors your development to your unique needs and goals and unlocks your full potential with custom learning paths.

4. Improved Work-Life Balance: It focuses on what matters most with AI taking care of the rest, achieving a healthier, happier work-life balance with technology's help.

5. Creation of New Job Opportunities: AI creates new roles demanding human skills that require human intelligence, creativity, and emotional intelligence areas where machines currently fall short. While we previously explored the ways AI can enhance productivity, decision-making, and learning, Let's delve deeper into the potential downside of AI in the workplace and how it can be solved.

2.5.3.1 Balancing Automation and Human Work

In a world where we heavily rely on AI intelligence, it is important to understand ethical AI in the workplace. One of the primary concerns is the fear of Job displacement, therefore while we automate our task the focus should be more on how automation is going to add value to the work and make it efficient rather than replacing humans. Organizations should Promote a human-centered approach to avoid over-reliance on AI which results in Job insecurity and reduced human efficiency.

Balancing Automation with **Human Work** in a **Sustainable AI Era**

1. From Displacement to Upskilling: Partnering with educational institutions and training providers is crucial. By undertaking targeted programs that equip workers with the skills needed for the AI-powered workplace, can empower them to thrive rather than fear displacement. Continuous learning and adaptation become essential mantras in this evolving landscape.

2. Collaborative Harmony: We need to encourage collaborative work environments that facilitate seamless interaction and communication, ensuring humans remain at the heart of decision-making and problem-solving.

3. Building Ethical Guidelines: To ensure AI serves humanity, we need clear ethical guidelines for its development and deployment. These guidelines should address critical concerns like job displacement, bias, privacy, and accountability.

4. Continuous Monitoring and Adjustment: When we closely monitor and adjust AI implementation based on these assessments, we ensure it aligns with ethical principles and continues to benefit the workforce.

Establishing ethical AI in the workplace is crucial given the industry's commitment to responsible AI development. In the age of automation, ethical AI is essential for guaranteeing job quality and fairness.

2.6 AI ETHICS AND RISKS

Artificial intelligence is currently the hottest technology on the market. It has the potential to dramatically reshape how we work (as developers and users of technology) and play (as consumers and creators).

As AI is becoming more widely used, the risks associated with AI are also being laid bare. But how do we go about understanding those risks? And perhaps more importantly, how do we safeguard implementation and future use for both businesses and consumers?

2.6.1 Understanding Risk

Putting yourself on the line a little and accepting risk is seen as the key to success. But does that hold true for AI implementation?

The potential prize for harnessing AI can be great – from optimisation of supply chains to improvements in automation and productivity. But no new technology is ever risk-free. While AI ethics used to be a niche topic of academia, it is rapidly emerging into the mainstream.

Many of the risks associated with AI can seem opaque, especially to those who are not working with the AI applications firsthand. Some of these concerns relate

to privacy and data use, the potential for accidental biases and the lack of transparency and human agency (See Fig. 11). But there are also risks at the business level, especially as the conversation around ethical use and AI regulation grows. Misuse of AI can harm a business' reputation or draw the ire of regulatory and legal bodies.

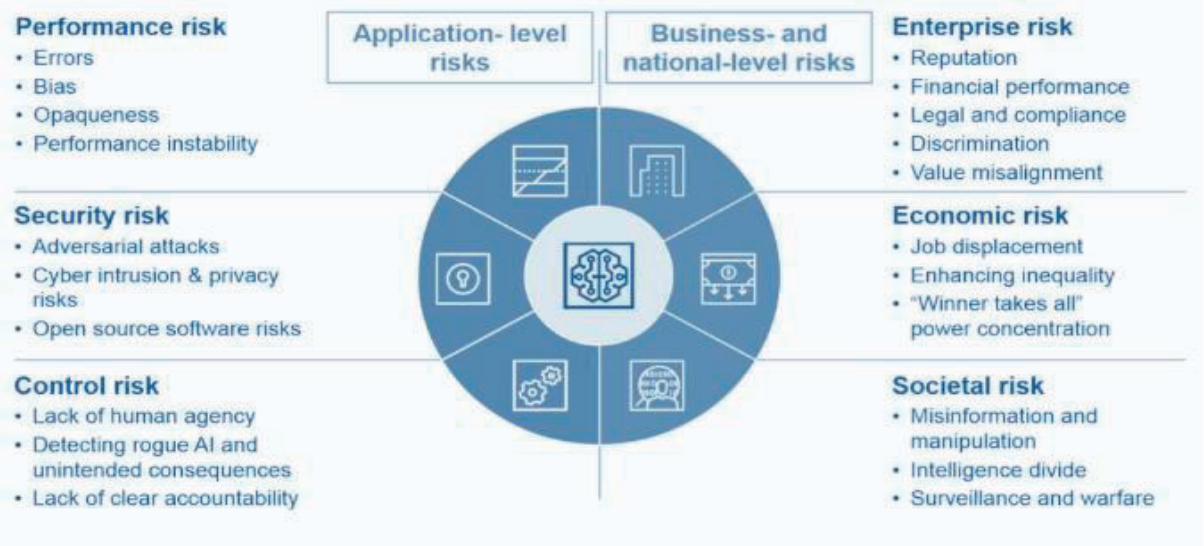

Figure 11: Risks of AI[44]

The consequences can range from wasted resources (e.g., scraping a project over mounting ethical concerns) to legal repercussions and fines. Given that these risks can apply at any level of business, the only solution is to create a comprehensive protocol around raising and addressing ethical issues.

2.6.2 Regulations and AI Ethics

AI regulations and ethical standards will have to advance significantly for AI ubiquity to become a reality. Driven by frameworks such as the EU AI Act, a key development will be the creation of rigorous risk management systems, classifying AI into risk tiers and imposing stricter requirements on high-risk AI.
AI models, especially generative and large-scale ones, might need to meet transparency, robustness and cybersecurity standards. These frameworks are

[44] Hibernian Recruitment, 2024. *Ethical AI: Buildind Fair and Sustainable Workplaces.* [online] [cited October, 2025]. Available at: https://www.hibernian-recruitment.com/en/what-do-business-leaders-need-to-know-about-ai-ethics-and-risk/

likely to expand globally, following the ***EU AI Act***, which sets standards for healthcare, finance and critical infrastructure sectors.

Ethical considerations will shape regulations, including bans on systems that pose unacceptable risks, such as social scoring and remote biometric identification in public spaces. AI systems will be required to include human oversight, protect fundamental rights, address issues such as bias and fairness and guarantee responsible deployment.

At the same time, depending on the circumstances regarding its specific application, use, and level of technological development, AI may generate risks and cause harm to public interests and fundamental rights that are protected by Union law. Such harm might be material or immaterial, including physical, psychological, societal or economic harm.
In order to ensure a consistent and high level of protection of public interests as regards health, safety and fundamental rights, common rules for high-risk AI systems should be established. Those rules should be consistent with the Charter, non-discriminatory and in line with the Union's international trade commitments. They should also take into account the European Declaration on Digital Rights and Principles for the Digital Decade and the Ethics guidelines for trustworthy AI of the High-Level Expert Group on Artificial Intelligence (AI HLEG).[45]

A Union legal framework laying down harmonised rules on AI is therefore needed to foster the development, use and uptake of AI in the internal market that at the same time meets a high level of protection of public interests, such as health and safety and the protection of fundamental rights, including democracy, the rule of law and environmental protection as recognised and protected by Union law. To achieve that objective, rules regulating the placing on the market, the putting into service and the use of certain AI systems should be laid down, thus ensuring the smooth functioning of the internal market and allowing those systems to benefit from the principle of free movement of goods and services.

[45] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence. (5), (7) Available at: https://eur-lex.europa.eu/eli/reg/2024/1689/oj

Those rules should be clear and robust in protecting fundamental rights, supportive of new innovative solutions, enabling a European ecosystem of public and private actors creating AI systems in line with Union values and unlocking the potential of the digital transformation across all regions of the Union. By laying down those rules as well as measures in support of innovation with a particular focus on small and medium enterprises (SMEs), including startups, this Regulation supports the objective of promoting the European human-centric approach to AI and being a global leader in the development of secure, trustworthy and ethical AI as stated by the European Council, and it ensures the protection of ethical principles, as specifically requested by the European Parliament.[46]

2.6.3 Recommendation on the Ethics of Artificial Intelligence

Getting AI governance right is one of the most consequential challenges of our time, calling for mutual learning based on the lessons and good practices emerging from the different jurisdictions around the world.

The aim of the **Global AI Ethics and Governance Observatory** is to provide a global resource for policymakers, regulators, academics, the private sector and civil society to find solutions to the most pressing challenges posed by Artificial Intelligence.

The Observatory showcases information about the readiness of countries to adopt AI ethically and responsibly.

It also hosts the AI Ethics and Governance Lab, which gathers contributions, impactful research, toolkits and good practices.

With its unique mandate, UNESCO has led the international effort to ensure that science and technology develop with strong ethical guardrails for decades.

Be it on genetic research, climate change, or scientific research, UNESCO has delivered global standards to maximize the benefits of the scientific discoveries, while minimizing the downside risks, ensuring they contribute to a more inclusive, sustainable, and peaceful world. It has also identified frontier

[46] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence. (8) Available at: https://eur-lex.europa.eu/eli/reg/2024/1689/oj

challenges in areas such as the ethics of neurotechnology, on climate engineering, and the internet of things.

The rapid rise in **artificial intelligence (AI)** has created **many opportunities globally**, from facilitating healthcare diagnoses to enabling human connections through social media and creating labour efficiencies through automated tasks.

However, these rapid changes also raise **profound ethical concerns**. These arise from the potential AI systems have to embed biases, contribute to climate degradation, threaten human rights and more. Such risks associated with AI have already begun to compound on top of existing inequalities, resulting in further harm to already marginalised groups.

UNESCO produced the first-ever global standard on AI ethics – the 'Recommendation on the Ethics of Artificial Intelligence' in November 2021. It is applicable to all 194 member states of UNESCO.

The protection of human rights and dignity is the cornerstone of the Recommendation, based on the advancement of fundamental principles such as transparency and fairness, always remembering the importance of human oversight of AI systems.

However, what makes the Recommendation exceptionally applicable are its extensive Policy Action Areas, which allow policymakers to translate the core values and principles into action with respect to data governance, environment and ecosystems, gender, education and research, and health and social wellbeing, among many other spheres.

Central to the Recommendation are four core values which lay the foundations for AI systems that work for the good of humanity, individuals, societies and the environment:

► **Human rights and human dignity**

Respect, protection and promotion of human rights and fundamental freedoms and human dignity

► **Living in peaceful just, and interconnected societies**

► **Ensuring diversity and inclusiveness**

► **Environment and ecosystem flourishing**

The Recommendation interprets AI broadly as systems with the ability to process data in a way which resembles intelligent behaviour.
This is crucial as the rapid pace of technological change would quickly render any fixed, narrow definition outdated, and make future-proof policies infeasible.

2.6.3.1 Human Rights Approach to AI

Ten core principles lay out a human-rights centred approach to the Ethics of AI.

1. **Proportionality and Do No Harm**

The use of AI systems must not go beyond what is necessary to achieve a legitimate aim. Risk assessment should be used to prevent harms which may result from such uses.

2. **Safety and Security**

Unwanted harms (safety risks) as well as vulnerabilities to attack (security risks) should be avoided and addressed by AI actors.

3. **Right to Privacy and Data Protection**

Privacy must be protected and promoted throughout the AI lifecycle. Adequate data protection frameworks should also be established.

4. **Multi-stakeholder and Adaptive Governance & Collaboration**

International law & national sovereignty must be respected in the use of data. Additionally, participation of diverse stakeholders is necessary for inclusive approaches to AI governance.

5. **Responsibility and Accountability**

AI systems should be auditable and traceable. There should be oversight, impact assessment, audit and due diligence mechanisms in place to avoid conflicts with human rights norms and threats to environmental wellbeing.

6. **Transparency and Explainability**

The ethical deployment of AI systems depends on their transparency & explainability (T&E). The level of T&E should be appropriate to the context, as there may be tensions between T&E and other principles such as privacy, safety and security.

7. **Human Oversight and Determination**

Member States should ensure that AI systems do not displace ultimate human responsibility and accountability.

8. **Sustainability**

Public understanding of AI and data should be promoted through open & accessible education, civic engagement, digital skills & AI ethics training, media & information literacy.

9. Awareness & Literacy

Public understanding of AI and data should be promoted through open & accessible education, civic engagement, digital skills & AI ethics training, media & information literacy.

10. Fairness and Non-Discrimation

AI actors should promote social justice, fairness, and non-discrimination while taking an inclusive approach to ensure AI's benefits are accessible to all.[47]

2.6.3.2 Actionable Policies

Key policy areas make clear arenas where Member States can make strides towards responsible developments in AI

While values and principles are crucial to establishing a basis for any ethical AI framework, recent movements in AI ethics have emphasised the need to move beyond high-level principles and toward practical strategies.

The Recommendation does just this by setting out eleven key areas for policy actions, as summarised in the figure 12 below.

Figure 12: Key Policy Area[48]

[47] UNESCO, 2021. *Recommendation on the Ethics of Artificial Intelligence.* Available at: https://www.unesco.org/en/artificial-intelligence/recommendation-ethics

2.6.3.3 Implementing the Recommendation

There is still a long way to go to provide Member States with actionable resources that ensure the effective implementation of the Recommendation. For this reason, UNESCO has developed two practical methodologies:

- **Readiness Assessment Methodology (RAM)**

By providing detailed and comprehensive insights into different dimensions of AI readiness, it helps highlight any institutional and regulatory gaps and enables UNESCO to tailor support for governments to fill those gaps, to ensure an ethical AI ecosystem in line with the Recommendation.

In this way, it complements the Ethical Impact Assessment tool, which provides a micro-level perspective on the ethical impacts of AI systems.

The Readiness Assessment Methodology includes a range of quantitative and qualitative questions designed to gather information about different dimensions related to a country's AI ecosystem, including the legal and regulatory, social and cultural, economic, scientific and educational, and technological and infrastructural dimensions.

Each dimension features a series of quantitative and qualitative assessment questions, setting the RAM apart from other existing readiness assessment tools.

- **Ethical Impact Assessment (EIA)**

The Ethical Impact Assessment considers the entire process of designing, developing and deploying an AI system allowing for assessment of the risks before and after the system is released to the public.

This is a vital component of ensuring the ethical design and use of AI. AI systems and tools have often been released to users without clear and transparent analysis of the potential risks and how they might be mitigated, even when such risks were foreseeable.

The dangers of this approach have been exacerbated by the arrival of powerful new generative AI tools branded "experimental" by their developers, such as large language models that have routinely generated inaccurate, misleading or discriminatory content.

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[48] UNESCO, 2023. *Recommendation on the Ethics of Artificial Intelligence: Key Facts.* Available at: https://unesdoc.unesco.org/ark:/48223/pf0000385082.page=12

The EIA is initially intended to help public sector officials involved in the procurement of AI systems, furnishing them with the set of questions to ask to ensure that the AI systems they are purchasing are aligned with the ethical standards set out in the Recommendation. However, it can also be used by developers or others in the private sector and elsewhere to facilitate the ethical design, development and deployment of an AI system.

2.7 ARTIFICIAL INTELLIGENCE ACT

The aim of the law is to protect fundamental rights, democracy, the rule of law and environmental sustainability from high-risk artificial intelligence, while supporting innovation and ensuring European leadership in this area. The regulation sets out obligations for artificial intelligence based on its potential risks and impacts.

The AI Act classifies AI according to its risk:

- Unacceptable risk is prohibited (e.g. social scoring systems and manipulative AI).
- Most of the text addresses high-risk AI systems, which are regulated.
- A smaller section handles limited risk AI systems, subject to lighter transparency obligations: developers and deployers must ensure that end-users are aware that they are interacting with AI (chatbots and deepfakes).
- Minimal risk is unregulated (including most AI applications currently available on the EU single market, such as AI enabled video games and spam filters – at least in 2021; this is changing with generative AI).

Most obligations fall on providers (developers) of high-risk AI systems.

- Those that intend to place on the market or put into service high-risk AI systems in the EU, regardless of whether they are based in the EU or a third country.
- And an also third country provider where the high-risk AI system's output is used in the EU.

Users are natural or legal people that deploy an AI system in professional capacity, not affected end-users.

- Users (deployers) of high-risk AI systems have some obligations, though less than providers (developers).

- This applies to users located in the EU, and third country users where the AI system's output is used in the EU.

General purpose AI (GPAI):

- All GPAI model providers must provide technical documentation, instructions for use, comply with the Copyright Directive, and publish a summary about the content used for training.
- Free and open licence GPAI model providers only need to comply with copyright and publish the training data summary, unless they present a systemic risk.
- All providers of GPAI models that present a systemic risk – open or closed – must also conduct model evaluations, adversarial testing, track and report serious incidents and ensure cybersecurity protections.[49]

2.7.1 Prohibited AI Systems

The following types of AI system are 'Prohibited' according to the AI Act.

AI systems:

- deploying **subliminal, manipulative, or deceptive techniques** to distort behaviour and impair informed decision-making, causing significant harm.
- **exploiting vulnerabilities** related to age, disability, or socio-economic circumstances to distort behaviour, causing significant harm.
- **biometric categorisation systems** inferring sensitive attributes (race, political opinions, trade union membership, religious or philosophical beliefs, sex life, or sexual orientation), except labelling or filtering of lawfully acquired biometric datasets or when law enforcement categorises biometric data.
- **social scoring**, i.e., evaluating or classifying individuals or groups based on social behaviour or personal traits, causing detrimental or unfavourable treatment of those people.
- **assessing the risk of an individual committing criminal offenses** solely based on profiling or personality traits, except when used

[49] EU Artificial Intelligence Act, 2024. *High-Level Summary of the AI Act.* [online] published February 27, 2024, [cited September 8, 2025]. Available at: https://artificialintelligenceact.eu/high-level-summary/

to augment human assessments based on objective, verifiable facts directly linked to criminal activity.

- **compiling facial recognition databases** by untargeted scraping of facial images from the internet or CCTV footage.
- **inferring emotions in workplaces or educational institutions**, except for medical or safety reasons.
- **remote biometric identification (RBI) in publicly accessible spaces for law enforcement**, except when:
    - searching for missing people, abduction victims, and people who have been human trafficked or sexually exploited.
    - preventing substantial and imminent threat to life, or foreseeable terrorist attack; or
    - identifying suspects in serious crimes (e.g., murder, rape, armed robbery, narcotic and illegal weapons trafficking, organised crime, and environmental ctime, etc.).

2.7.2 High Risk AI Systems

Some AI systems are considered 'High risk' under the AI Act. Providers of those systems will be subject to additional requirements.

Classification rules for high-risk AI systems (Art. 6)

High risk AI systems are those:

- used as a safety component or a product covered by EU laws in Annex I and required to undergo a third-party conformity assessment under those Annex I laws; or
- listed under Annex III use cases (below), except if:
    - the AI system performs a narrow procedural task.
    - improves the result of previously completed human activity.
    - detects decision-making patterns or deviations from prior decision-making patterns and is not meant to replace or influence the previously completed human assessment without proper human review; or
    - performs a preparatory task to an assessment relevant for the purpose of the use cases listed in Annex III.

- AI systems listed under Annex III are always considered high-risk if it profiles individuals, i.e. automated processing of personal data to assess various aspects of a person's life, such as work performance, economic situation, health, preferences, interests, reliability, behaviour, location or movement.
- Providers whose AI system falls under the use cases in Annex III but believes it is not high-risk must document such an assessment before placing it on the market or putting it into service.

Requirements for providers of high-risk AI systems (Art. 8–17)
High risk AI providers must:

- Establish a **risk management system** throughout the high-risk AI system's lifecycle.
- Conduct **data governance**, ensuring that training, validation and testing datasets are relevant, sufficiently representative and, to the best extent possible, free of errors and complete according to the intended purpose.
- Draw up **technical documentation** to demonstrate compliance and provide authorities with the information to assess that compliance.
- Design their high-risk AI system for **record-keeping** to enable it to automatically record events relevant for identifying national level risks and substantial modifications throughout the system's lifecycle.
- Provide **instructions for use** for downstream deployers to enable the latter's compliance.
- Design their high-risk AI system to allow deployers to implement **human oversight**.
- Design their high-risk AI system to achieve appropriate levels of **accuracy, robustness, and cybersecurity**.
- Establish a **quality management system** to ensure compliance.[50]

[50] EU Artificial Intelligence Act, 2024. *High-Level Summary of the AI Act.* [online] published February 27, 2024, [cited September 8, 2025]. Available at: https://artificialintelligenceact.eu/high-level-summary/

3 ETHICS OF AI IN CONSTRUCTION

With the ever-evolving landscape of the construction project management software industry, the incorporation of AI technologies is revolutionizing how construction projects are executed. AI in construction enhances operational efficiency, improves safety measures, and promotes sustainable practices, but it also presents ethical challenges that require careful consideration.

3.1 KEY CONCEPTS AND BENEFITS OF AI IN CONSTRUCTION

Artificial Intelligence is making significant strides across various domains, and the construction industry is no exception. Some of the key benefits include:

► ***Efficiency and Productivity:*** AI optimizes design processes, project planning, and resource management. Algorithms can analyze large datasets to predict potential delays, assess risks, and recommend more efficient scheduling. With AI, the construction process can potentially see a productivity increase of up to 20 %.

► ***Safety and Risk Management:*** AI technologies, such as computer vision and machine learning, continuously monitor construction sites to identify and mitigate safety hazards, significantly reducing workplace accidents by as much as 25%.

► ***Sustainable Practices:*** By optimizing material usage and reducing waste, AI contributes to the development of infrastructure that is both efficient and environmentally friendly.

► **Generative Design:** AI tools can formulate design solutions that meet various criteria including performance metrics and aesthetic requirements, enabling not only efficiency but also cost-effective project outcomes.[51]

3.2 ETHICAL CHALLENGES OF AI IN CONSTRUCTION

While the benefits are significant, the ethical challenges posed by the deployment of AI in construction cannot be overlooked. Key issues include:

► **Data Privacy and Governance:** The utilization of AI raises concerns about how data is collected, used, and protected. Effective data governance policies are critical to maintain trust among stakeholders.

[51] ZEPTH, 2024. *The Ethics of AI in Construction: Challenges and Opportinities.* [online] published November 19, 2024, [cited September 8, 2025]. Available at: https://www.zepth.com/ethics-of-ai-in-construction/

► ***Liability and Accountability:*** Should an AI system lead to defective designs or accidents, questions of liability arise. The person or entity deploying the AI tool is likely to bear these responsibilities, emphasizing the need for clear contractual agreements.

► ***Human Oversight and Skills Erosion:*** A heavy reliance on AI systems without adequate human oversight may result in unchecked errors and may also contribute to the erosion of critical skills among workers.

► ***Transparency and Fairness:*** It's vital to ensure transparency and fairness in AI-driven decisions. This includes establishing audit trails for algorithms and fostering accountability in the design process.

3.2.1 Legal Implications of AI in Construction

The integration of AI raises several legal concerns that industry professionals must navigate carefully. These include:

- *Contractual Provisions:* Contracts must be meticulously crafted to encompass roles, responsibilities, and collaborative principles associated with AI usage. Neglecting these aspects could lead to disputes and compliance failures.
- *Regulatory Compliance:* Adhering to safety and regulatory standards is crucial for AI systems in construction. Companies must work with regulatory bodies to remain compliant and informed about evolving standards.
- *Ownership and Intellectual Property:* The ownership of AI-generated designs presents further complexities, with potential implications for patents and copyrights that developers must navigate.

3.2.2 Emerging Innovations and Use Cases

As the construction sector increasingly adopts AI technologies, several exciting innovations are on the horizon:

- *Autonomous Systems:* Future projects may feature autonomous machinery and drones for construction tasks. Ethical considerations and frameworks will be essential to ensure their safe interaction with human workers.

- *AI-Powered Image Recognition:* Image recognition tools can be utilized to inspect worksites for defects or deviations from standards, helping maintain higher quality control benchmarks.
- *Predictive Maintenance:* AI's capability to monitor equipment conditions in real-time allows for predictive maintenance measures, thereby reducing downtime and extending asset lifespans.

3.3 BEST PRACTICES FOR ETHICAL AI DEVELOPMENT IN CONSTRUCTION

To ensure the responsible use of AI technologies, construction companies should adopt the following best practices:

► ***Ethical Frameworks:*** Establishing rigorous ethical standards ensures the responsibility and accountability of AI systems and their outcomes.

► ***Clear Contractual Terms:*** Contracts should be detailed regarding AI's usage, including stipulations about liability and ownership of AI-generated outputs.

► ***Human-AI Collaboration:*** AI technologies must be designed for effective collaboration with human workers, balancing automation with necessary oversight to avoid skill erosion.[52]

3.4 EUROPEAN CONSTRUCTION INDUSTRY

The construction market in Europe is experiencing notable growth, driven largely by strong government support and the rollout of major infrastructure projects. National and regional governments across Europe are actively investing in initiatives aimed at modernizing transportation networks, expanding renewable energy capacity, and promoting sustainable construction practices.

Significant investments are being funneled into rail network upgrades, airport expansions, highway improvements, and large-scale renewable energy developments, including wind and solar power infrastructure. These projects are not only enhancing connectivity but also aligning with Europe's climate objectives and green transition goals.

[52] ZEPTH, 2024. *The Ethics of AI in Construction: Challenges and Opportinities.* [online] published November 19, 2024, [cited September 8, 2025]. Available at: https://www.zepth.com/ethics-of-ai-in-construction/

Despite ongoing challenges such as rising material costs, labor shortages, and regional geopolitical uncertainties, government-backed funding and policy support continue to provide a stable foundation for growth. The sustained commitment to public infrastructure is reinforcing the construction sector's role in driving economic resilience and regional development.[53]

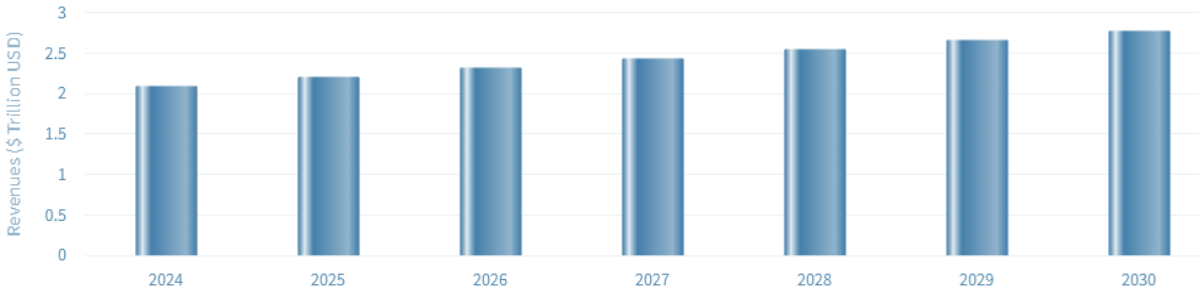

Figure 13: Market Snapshot, 2024-2030, Trillion USD[54]

3.5 SWOT ANALYSIS OF THE CONSTRUCTION SECTOR IN EU

The construction sector can be characterized also in the form of a SWOT analysis:

► ***Strengths***

• Increased focus on R&D among the large construction companies,

• growing specialization in many firms has created highly knowledgeable and competent companies within specific construction fields.

► ***Opportunities***

• Growth markets in new Member States, China, India and others;

• demographic changes leading to new markets developing;

• environmentally sustainable development, including waste management;

• off-site construction (pre-assembly);

• embedding ICT in construction products and processes to improve effi ciency and effectiveness;

• virtual prototyping for design, manufacture and operation ;

• new market segments in BOOT activities (Build-own-operate-transfer).

► ***Weaknesses***

[53] *Europe Construction Market.* [online] published August 7, 2025, [cited September 8, 2025]. Available at: https://www.nextmsc.com/report/europe-construction-market

[54] *Europe Construction Market.* [online] published August 7, 2025, [cited September 8, 2025]. Available at: https://www.nextmsc.com/report/europe-construction-market

• Low productivity;
• weak industry image among customers and potential new workers;
• problems with health and safety in terms of accidents and physical strain on employees;
• problems with undeclared work;
• little interest in further education and training among small construction companies;
• low level of R&D investment among SME construction companies;
• SMEs lack marketing, ICT and management skills.

► ***Threats***

• Many European markets with stagnating growth, if any growth at all;
• increasingly globalised engineering sector where Japanese and US construction companies will enter certain European constructi on sectors;
• recruitment and retention of ageing workforce in some low-skilled professions;
• inter-European price-based competition represents a threat to employment in some EU countries.[55]

3.6 PRODUCTIVITY GROWTH

In the EU, productivity of the construction sector has been considerably lower than in the manufacturing sector in general over the last 10 years. This is related to the fact that the sector is very home-market oriented and less exposed to international competition. This, in turn, should increase the demand for higher productivity and thereby increase competitiveness. As most sector products are solid and difficult to move over long distances, exports consist primarily of knowledge or entire production processes (labour, materials, etc). Apart from civil engineering, there is very little international competition within most construction activities. This does, however, not exclude competition in domestic markets.

A more competitive domestic market driven by higher productivity levels is thus essential for the sector. Various factors impact on the sector's productivity level, such as the development and use of technology, increases in R&D investment as

[55] JANKOVICHOVÁ, E. et al., 2016. *Construction Economics I.* Brno: Tribun EU, 2016, ISBN 978-80-263-1129-4, p. 14.

well as public initiatives regarding procurement incentives and sector improvement programmes.

3.7 DEMOGRAPHIC DEVELOPMENT

In future, demographic development will play a key role driving development in the construction sector as well as in most other economic sectors in the EU. The ageing of the population represents a challenge for the sector regarding recruitment of labour. In addition, the construction sector suffers from a relatively poor image in large parts of Europe since the work is hard and physically demanding, but not well paid. This is also documented by a poor occupational safety and health (OSH) record (European Agency for Safety and Health at Work, 2004), and research indicating a great deal of monotonous tasks and a perception of health or safety being at risk because of the work situation.

Recruitment of qualified labour will become critical for the construction sector, with a declining number of young people and higher job specialisation. Various strategies exist to recruit qualified labour, such as improving career development opportunities and job security and health and safety in the workplace.

The social partners at EU and national levels also consider initiatives to improve working conditions, to enhance the sector's image and attract potential workers to the sector. Health and safety is a central topic in this context, as the construction sector has a high rate of accidents and health problems compared to other sectors. According to the third European survey on working conditions, a total of 43 % of construction workers think their health and safety is at risk because of their work; this is the highest level of all sectors.

3.7.1 Demographic Changes and New Market Opportunities

The ageing of the population involves changing needs in the housing sector, which cannot be met solely by new construction activities, but also require the renewal of existing buildings. Structural requirements of the population must be considered (doors that open in a different direction, location of light switches, differences in heights, etc) as well as services targeted at senior citizens living in their homes (cleaning services, nursing, etc). These requirements concern the residents as well as their surroundings. In addition, the busy lives that people

lead today, and an increasing awareness of energy costs are driving forces to build more intelligently in the future. For example, buildings that can be pre-programmed or reprogrammed remotely, and are able to detect and turn off excess use of energy, are likely to be developed in the future. This development will require additional skills among workers in all phases of the construction process in relation to building management systems, networks, and electronics.

3.7.2 Transfer of Company Ownership to Younger Generation

Part of the challenge of the ageing population is the transfer of company ownership to the younger generation. This is a general problem for business and industry and challenges particularly the construction sector, consisting of large number of small, family-owned companies, as is the case especially in the completion/building sub-sector. Companies must tackle this issue as well as national governments since the fiscal legislation is in their domain. If ownership transfer is not handled properly, a few small, family-owned companies could close when the owner retires.

This could change the sector's company structure, leading to a higher rate of one-man companies or medium and large companies with ownership structures other than family/private ownership.

3.8 NEW MARKETS IN THE EUROPIEN UNION

EU enlargement opens new markets and new competition from the construction sector in the new Member States.

Considering the expected high growth rates and subsequent need for new infrastructure and urban development in the new Member States, a new market appears to be opening for the highly specialised and large civil engineering companies.

To some extent, the competition between construction companies or labour from the new Member States put a downward pressure on employment and wages for local labour. This could lead to a higher unemployment rate among the local workforce due to social dumping, involving the export of labour from a country with weak or poorly enforced labour standards. To what extent this will happen depends on the work of local actors in organising employers and employees

under the general national conditions (or enforcing the workers directive posted). The higher level of competition in national markets may lower the prices for construction work and benefit large companies, which could use low-cost companies from the new Member States as sub-contractors.

3.8.1 Movement of Labour

There is already a certain amount of labour from the new Member States working in the EU15 construction sector. The number of incoming workers varies from country to country with a tendency of influx being high between border countries. The number of workers is still limited because of the transitional schemes in various EU15 countries that regulate (and restrict) the possibilities for east European labour to enter EU15 labour markets.

The movement of labour should also be considered in the light of possible recruitment difficulties for the sector in the future, not least because of the ageing population in most parts of Europe. The consequences for the movement of labour depend on how the sector acts in the process. Social dumping can be diminished if the social partners (often the trade unions) ensure that workers are covered by national collective agreements and that foreign companies accept these agreements.
In countries where union penetration in the construction sector is weak, as is the case in many of the new member countries, this will be a difficult process. Apart from Slovakia, where a national agreement for the sector covers working conditions for about 70% of the workforce, most other new member countries only cover a low percentage of the workforce that is regulated by collective agreements.

3.8.2 Enlargement of Market

In terms of the EU construction sector in general, enlargement opens new markets as the accession countries will need major investment in infrastructure, energy, manufacturing, and processing. According to the European Construction Industry Federation (FIEC), the sector sees this as an important consequence of enlargement. This may also encourage an influx of labour and contractors from the old to the new Member States. It is emphasised that due to the nature of

construction enterprises in the old Member States, they are likely to bring in management facilitation and, to some extent, high-value materials, and highly specialised workers/sub-contractors while local main and sub-contractors will undertake most of the building and completion activities. In addition, most of the building materials will be sourced locally.

The European Construction Institute (ECI), which has some of the largest contractors based in Europe as members, emphasises, however, that the low productivity of the construction sector can have a negative impact on growth and subsequently on investments in building and construction in the new Member States.

3.9 NEW CONSTRUCTION TECHNOLOGIES

Technological development drives change in the construction sector as research and development leads to innovation and new technologies. However, the pace at which these developments are integrated and implemented in the sector, particularly among the smaller companies, is very slow. The main barriers to unfolding the potential of these technological developments are awareness, knowledge, competencies among construction companies and incentives.

3.9.1 European Technological Platform for Construction

As part of the general policy on research, the European Research Advisory Board recommends the establishment of European technological platforms. These platforms cover the following aspects: development of a shared long-term vision by representatives of public and private stakeholders; creation of a coherent, dynamic strategy to achieve this vision; a leading role for industry, as part of a partnership to include research and financial communities, public authorities, users, and representatives of civil society.

The platform for construction embraces the following themes:

1. *"smart construction"* which is based on applying innovative and cutting-edge technologies in construction projects, as well as research results in new construction products and processes, etc.
2. *"building the future"* which sets out the visions for a future European construction sector as a key element in achieving the Lisbon objectives – a

knowledge-based economy, sustainable development and environment, a high quality of life for all, employment, international competitiveness, safety.
3. *"strategies for innovation"* which represents the e-Core strategy for European construction research together with other strategies for related sectors and sub-sectors.
4. *"strategic alliances"* which addresses new mechanisms and groupings to create a European research area in the built environment, brought about by new procurement processes, ICT systems that link all partners in a project, alliances to create sustainable construction, etc.

3.9.2 Use of ICT in Construction

Information and communication technologies (ICT) influence the construction process in various ways, for instance by embedding ICT in 'smart' materials/construction products and by offering new ways of interaction and coordination in trade, construction process and monitoring of materials.

R&D and innovation in intelligent materials, constructions and buildings will be a major source for future competitive advantage for construction enterprises. Buildings that will automatically adjust to various external changes and allow occupants to customise them to individual preferences (change of wall colour, art, etc.) and materials, components and systems that communicate with each other to optimise their use, are likely to become an everyday need in the future as ICT becomes embedded in everything.

E-solutions will lead to a more open procurement process expected to result in increased competition. E-procurement can further assist the process of more elaborate procurements and thus a higher level of precision in the procurement process.

In the construction process, e-technologies enable openness and involvement of various actors, such as customers, the main contractors, sub-contractors and others. The openness of the processes includes online access to documents, specifications, etc, as well as online communication and interaction between the actors, such as designers, customers, and contractors in the design process, in

planning and management of the building process, etc. Several tools are available, but use of ICT is spread differently among the actors.
Virtual reality (VR) and simulation technologies used for visualisation support digital communication during the construction process, and of the expected results to customers and occupants. Visualisation of construction projects allows customers and users to get a look and feel for the construction before it is built. During the construction process, designs can be improved, and clashes and inconsistencies can be examined and eliminated. Furthermore, these technologies improve cooperation as non-technical staff and end-users can understand the project in a better way than simply looking at drawings and designs.

To monitor activities, materials, or equipment, or to optimise their use, mobile devices and tagging technology is used in various ways. For construction companies with various construction sites, it is a challenge to monitor the actual localisation of materials and equipment. Building workers are known to spend much time searching for building sites for equipment and materials. Technology also helps to monitor the actual workplace and employees within building maintenance.

3.9.3 Building Information Modelling

FIEC (EUROPEAN CONSTRUCTION INDUSTRY FEDERATION) saw a growing interest among EU members in this topic, which hitherto has been associated with national construction markets in the Nordic countries and the UK. The European construction sector looks to be braced for a revolution, but BIM is not without controversy, and it has its share of sceptics. Nevertheless, CEN took the first steps towards standardisation in 2013, establishing a Working Group on BIM. FIEC will participate in this group.[56]

3.9.4 Energy and Climate Change

Another emerging topic dominating discussions in the EU institutions in 2013, in the policy areas of sustainability, energy and resource efficiency and climate change, was that of Smart and Sustainable Cities and Communities.

[56] FIEC Available at: http://www.fiec.eu/, p. 45

The major policy development in this area in 2013 related to the climate and energy framework 2030. FIEC responded to the Commission's consultation amid concerns that the EU's 20-20-20 targets will be missed. (20% reduction in greenhouse gas emissions from 1990 levels, 20% increase in energy consumption from renewable sources and 20% improvement in the EU's energy efficiency.)[57]

3.9.5 E-Business

There is an ongoing process to develop and elaborate norms and standards at EU and international level within the construction material sector, driven by the international community and political institutions.
This process is an important drive to further open the European and international markets for construction materials. It also encourages the use of e-business in terms of B2B (business-to-business).

Doing business electronically helps to streamline processes and acquire new clients, as already experienced by large construction companies.

Goods, in particular tools, and services are increasingly being procured online, through e-auctions, electronic catalogues, and e-tendering. E-business brings new challenges and opportunities to the businesses operating in the construction sector. They need to be aware of various issues, such as legal ones, that arise from communicating electronically. However, benefits are extensive, and it helps to avoid common difficulties in tendering for, ordering, planning, and organising construction projects. In this respect, companies save costs when using e-business successfully.
There is a need to improve the information quality and structure, which must be done collaboratively to gain wider acceptance. Some initiatives are under way, but the process should be accelerated, so that large and small as well as geographically disadvantaged participants in the construction industry can quickly harness current ICT developments. This will enable companies to 'work apart together' in a more integrated manner and to deliver the type of benefits enjoyed by the financial, insurance, retail, and certain manufacturing sectors.

[57] FIEC Available at: http://www.fiec.eu/, p. 47

However, the construction sector may experience similar difficulties as these sectors, including restructuring, human and social turmoil, if it is not prepared to face such developments.

3.9.6 Industrialisation and Prefabrication of the Construction Process

Use of industrial robots and automation technology in off-site manufacturing as well as material manufacturing is likely to be a driver of change in the construction process. This will introduce more prefabricated materials and preassembled parts in construction. Increased use of off-site manufacturing furthers the industrialisation of the construction process.

By preassembling parts of buildings or constructions (or even whole constructions), the construction process becomes more standardised and less dependent on weather conditions. This could speed up construction, improve quality, reduce waste (and waste control) and make constructions cheaper (Ong, 2004). However, this development also demands extensive coordination between the actors collaborating from different pre-assembling sites.

3.9.7 Environmentally Sustainable Developments

The importance of environmental sustainability will increase in the future, based on demand from customers, climate changes and legislative measures. Solutions are thus often based on combinations of construction and building design and new materials. This includes, for example, the use of passive heating and implementation of new technologies/materials, such as photovoltaic solar cells to generate electricity for heating and energy requirements in buildings. Operators in the construction sector need to upgrade continuously their knowledge of new designs, building methods and materials. To stay ahead of competitors, construction companies are obliged to innovate their own products and processes to support sustainable development.

Sustainability awareness is rising among public and private users of buildings and constructions. The sustainability trend spans the whole life cycle of a building. In the construction process, various aspects should be taken into consideration:

- re-using existing built assets

● designing for minimum waste
● minimising energy use throughout the life cycle
● avoiding pollution
● adding to biodiversity
● conserving water resources
● respecting people and communities.

3.10 BUILDING MATERIALS MARKETS

An important drive for market developments is the internationalisation and globalisation of the sector's activities:

◇ The market for construction materials is becoming increasingly internationalised and globalised. The impact varies from large civil engineering projects to building completion and maintenance sectors, where materials are often bought in very small quantities. Within these sub-sectors, effects will only show through a concentration of warehouses for construction materials.

◇ The internationalisation and globalisation of knowledge-intensive activities is particularly important for the civil engineering sub-sector. In the short term, the very intensive hands-on activities in construction will still rather be based on local labour.

◇ Only in the medium term will internationalisation, primarily in the form of EU enlargement, open for international competition within the most labour-intensive parts of construction – building completion.

3.10.1 Internationalisation of Markets for Building Materials

This driver is partly described in relation to the EU initiatives for certification for all products to be sold or traded on the European market, the CE marking. Internationalisation or globalisation will lead to decreasing material prices, which benefits larger enterprises that can purchase in bulk. Small construction companies will have to cooperate to command in bulk together, or charge customers a higher material price.

Large construction companies are already changing their purchasing behaviour from decentralised site-specific purchasing to centralised-bulk purchasing of frequently needed building materials. This, however, is a lengthy process and requires substantial organisational changes and development to ultimately reduce material costs and gain in productivity.
Globalisation of the markets will help develop 'smart/intelligent' construction materials as costs can be shared across a broader market. This process might bring about the internationalisation of labour – engineers and, to a certain degree, highly specialised manual workers will be needed to drive these developments.

3.10.2 Knowledge-Intensive Services

The internationalisation of construction activities is primarily based on large companies which export management and planning concepts, and managerial and engineering labour. The manual labour, however, stays mainly local or regional and is therefore not exposed to internationalisation. Highly specialised construction functions and materials will pull manual work teams, for example, tunnel or bridge construction workers specialised in the use of equipment and specific processes. The expanding EU internal market, strengthened by the proposed service directive, will boost the internationalisation of construction services in general.

3.10.3 Development of Supply Chain

The sector should be able to innovate and deliver best value and satisfaction to its customers. This requires better coordination across the supply chain where suppliers as specialist contractors and component suppliers must play a more integrated role in the construction process.

Complex developments of the sector structure will continue. For larger companies, increasing customer demand – public and private, and public-private project-arrangements – will further consolidation of the sector. Companies require a broad range of qualifications, as well as a solid financial base to be able to interact with the customer to develop building solutions, including the construction and possibly also the management of the construction. To

complement the fullservice consolidated companies, small, specialised suppliers will evolve. Their function will be to offer highly specialised and qualified services, which the large companies do not regard as one of their key competencies.

3.10.4 Financing of Construction Projects

In the years to come, new financial arrangements will develop. These include risk sharing between the constructor/operator and the customer, and PPP/BOOT (Private-Public Partnerships/Build-Own-Operate-Transfer).
Private-public partnerships (PPP) are a realtively new way of financing big construction projects. Many European countries use PPP, though in some places they are still at an experimental stage. In these partnerships, the private contractor will construct and run a certain facility, while the public institution rents the service for a few years. Subsequently the construction will be sold to the public sector under certain conditions (BOOT).

To participate in these arrangements the construction entities should be large in volume and financial terms or will have to build consortia with financial operators and arrange the management of the facility for the period of return of investment.

The PPP/BOOT projects concern typically large infrastructural projects; the construction of hospitals, prisons, educational institutions, etc, have also been financed through such partnerships. As these arrangements relate to large projects, this opportunity is mainly open to big companies that are main contractors on these projects. Consequently, the contracting company needs a very strong capital base, or build a permanent partnership with financial institutions, investors, or operational companies.
As the operational dimension is now included in the contract, it can be expected that even large companies will specialise in certain industrial sectors.

3.11 LEGISLATION AND REGULATIONS

The public sector influences the development of the construction sector in various ways through:

● public regulation, the level of investment in construction, public investments in infrastructure, and construction as an instrument of structural regulation. The sector is very labour intensive and has a relatively high level of publicly finan ced or directed activities (either direct public investments or tax conditions on private construction investments). A country's economic outlook and political response of either increasing (to boost the economy) or decreasing (to avoid overheating of the economy) construction investments drive the overall development of the construction sector.

● direct regulation and legislation regarding construction. Important areas are environmental regulations with respect to the construction process (environment and labour safety) as well as the construction materials in use. Other regulations and legislative traditions often embedded in the national settings around the construction sector also drive change in the sector.

● the public sector which can enforce the development of new standards in the sector, by coordinating the demand in relation to public construction projects. Various examples are underway in European countries. The public sector acts as a strong demanding customer by combining requirements in relation to procurement with legislation and regulations.

3.11.1 Legislation for Trade, Health, and Safety

In the Member States and at EU level, initiatives are under way to harmonise standards and regulations.

An EU initiative that has importance for the construction sector is the CE marking of building materials. Its intention is to establish an internal market for building materials through technical harmonisation, thereby removing technical barriers to trade. The CE marking is supposed to replace all national standards, approval systems, conformity systems or other systems, which may constitute technical barriers to trade in a single European system. The requirements of the CE marking relate to various aspects, such as mechanical resistance and stability, safety in case of fire, hygiene, health and the environment, safety in use, protection against noise and energy economy and heat retention.

3.11.2 Safety at Work

Safety is a very specific problem in the construction sector, as the risk of accidents in construction is considerably higher than the EU average for all other economic sectors.

Initiatives at EU level (such as directives and European safety weeks) as well as national initiatives from authorities and unions will put pressure on changing construction processes and improve safety. The Bilbao Declaration – an agreement between six leading industry, engineering and architecture groups and the EU presidency – aims at reducing the number of accidents in the construction industry. The declaration suggests five key actions to boost construction safety standards in Europe:

1. integrate health and safety standards into procurement policies,
2. ensure health and safety is considered at the design and planning stages of construction projects,
3. use site inspections and other techniques to encourage more businesses to comply with the legislation,
4. develop guidelines to help businesses comply with this legislation and stimulate higher standards of safety and health,
5. social dialogue and agreements on training, accident reduction targets and other issues.

3.11.3 Public Procurement

Public procurement will play a role in the development of the construction sector in at least two ways:

- higher degree of transparency of the procurement process;
- higher qualitative standard of requirements and specifications in public procurement.

Public procurement procedures have developed across the EU. They constitute an important element of the European internal market to safeguard fair and transparent competition, and to have an efficient judicial review in the case of infringements. The latter is done by simplifying the existing legal framework and adapting electronic tools. Electronic tenders will secure a transparent process and

probably provide the basis for improved competition. According to the FIEC representative, national legislation remains an important barrier to international (even inter-EU) competition. Simplification and harmonisation of the legal framework will therefore be a possible drive for international competition in the construction sector.

At national level, a process of rendering public procurement more professional and standardised is under way on both the demand and supply sides. This will be a drive for implementing several of the regulations and legislative demands in the companies which operate in the public market.

3.11.4 Undeclared Work

Undeclared work is of growing concern in the EU. According to a report to the EC, undeclared work is assessed to be between 1.5 and 20% of the GDP in the EU15 Member States. The construction sector is the most affected sector for undeclared work.

Minimising the financial drivers (such as taxes and VAT) for undeclared work is expected to lead to legalisation regulating this kind of work, and hence boost some construction activities which are currently postponed for financial reasons:

- companies must demand proof of payment of tax and pension contributions from prospective contractors when they call for tenders. If these payments have not been made, it is justifiable to reject a bid;
- information about contracts must be delivered quarterly to the tax administration;
- electronic pass systems must be used for workers and contractors at building sites.

Of the three measures, only the latter has proven to be effective.

A successful reduction in undeclared work would increase demand for construction work within the legal framework. At the same time, reducing

undeclared work would ease the pressure for low cost and salaries in legal companies in the subsectors that are under pressure from undeclared work.

3.11.5 Framework Factors

FIEC emphasises that reorganising risk sharing, as well as liability and insurance issues related to construction projects would be an important factor for innovation and productivity growth in the sector in most countries. In some countries, under the current liability regime, there is no incentive for the different parties in a project to work as a team and offer advice and help in the event of a problem. Even peripheral involvement, such as providing advice, can bring about total liability for a failure in the outcome. This works against innovation since cooperation beyond the letter of the contract is actively discouraged. As a result, construction companies act mainly in their own interests to protect themselves instead of looking for the best solution.

3.11.6 EU Internal Market

The European Commission continues with its aim to strengthen the internal market for services to facilitate international competition within the EU, including the construction sector. Various instruments are used to reach that goal, like specifying the right of recipients to use services from other Member States, harmonisation of legislation, development of administrative cooperation, particularly in the case of posting workers, and development of measures (voluntary certification of activities, etc) to promote the quality of services.

3.12 NEW TYPES OF QUALIFICATIONS

New types of qualifications are required so that construction workers can handle new machinery, technologies, processes, and materials. Furthermore, strong company specialisation in certain parts of the construction process tends to define new specialised crafts or further specialisation within existing crafts. Following the drivers and trends presented above, most sub-sectors will face the challenge of new qualification needs within different areas. The companies' answers to this challenge will undoubtedly affect their chance of survival and growth in regional, national, or even international competition.

3.12.1 Need to Change Qualification

The changes in the sector result in a broad range of qualification needs. These needs will have to be addressed in the curricula of general vocational training, as well as in company-specific retraining and supplementary vocational education and training courses. Retraining and other courses address the concrete new challenges within developments in technology, the building process, and the market, etc.

- knowledge about and training in the use of new technologies – new generic technologies such as ICT, new materials, chemicals, etc.
- health and safety issues should be emphasised, particularly in general vocational training and education, and training in relation to specific technologies, machinery, and materials. This aspect should reduce accidents in the sector and further reduce the number of workers leaving the sector after a few years. The social partners are aware of this problem and address it in a joint work program.
- communication, teamwork skills, etc. This aspect is still more important with new construction methods such as lean construction, where productivity is reached by tight time schedules, just in time, etc.

3.12.2 Importance of Qualification Levels

At the organisational level among the social partners, there is a clear understanding about the importance of higher qualification levels and further investment in education and training in the sector. It is considered partly as a sectoral issue to achieve general growth, respond to international competition, and satisfy public demand for higher productivity and improved quality. It is also a company issue in a drive to stay competitive and an issue for the individual employee to remain competent and employable.

Large companies are usually ready to act on qualification needs, since employee development is – and will be – high on the priority list as a central success factor in the future. Employee development is essential not only in terms of new qualifications (via education and training) but also to improve work motivation and organisation of work (teamwork, etc) within construction companies.

3.12.3 Training Courses in SMEs

In most of the small and medium-sized construction companies (SMEs), focus on education and training tends to be low. Day-to-day tasks and problem solving take all the attention. This is often related to a lack of strategic direction or plans for the development of the company in general. Consequently, there is no framework provided within which training courses could drive company development. The social partners at national and EU level, as well as awareness campaigns at government level try to address this issue. Furthermore, improving managers' skills sets and providing tools to handle this challenge would also support more and broader training in small and medium-sized construction companies.

3.12.4 Short-Term Labour Contracts

Construction projects often use short-term labour contracts (with national differences). This seems to be a growing trend. The use of short-term contracts makes the sector more dynamic: hiring labour only for the period when it is needed may have a positive impact on the profitability of the project and the company. It also enables the use of non-local labour on short-term contracts. However, from a skills perspective this can be counter productive. Short-term contracts offer less job security for the employee and may diminish the recruitment of highly qualified labour to the sector. Also, short-term contracts are not compatible with the individual/company and sector interests in furthering education and training.

3.12.5 Financing of Education and Training

Financing training costs represents a further challenge to achieving a higher level of qualification in the sector. Whereas large companies are in a better situation to accomodate training costs, which constitutes a competitive advantage, smaller companies are finding it difficult to finance education and training for their staff other than what is laid down by law.

These financial challenges must be met to improve qualification levels across the sector in general. How these costs should be shared between individual workers, companies, the sector, and governments will depend on the national framework,

the existing national educational organisation and approach to lifelong learning, as well as the actual strength of the social partners.[58]

3.13 CONSTRUCTION 4.0 TECHNOLOGY

Construction 4.0 Technologies is described as a revolutionary paradigm in which three transitions occur: industrial production and construction, cyber-physical system, and digital technologies. BIM (building information system), CDE (common data environment), cloud-based systems engineering, AR/VR (augmented reality/virtual reality), big data and analytics, blockchain, and laser scanners are all instances of emerging innovations. Robotics and automation, sensors, the internet of things, industrial manufacturing, off-site and on-site construction, employees using wearable sensors, and devices fitted with sensors all fall into the category of cyber-physical systems. As a result, it's crucial to comprehend the developments that make this transition possible.[59]

3.13.1 Drones

Drones are mostly used in the construction industry for observation and tracking purposes during survey work, construction, and facilities operations. In the past, they were primarily used for military purposes. Using drones in buildings and other industries has risen steadily over the years.

3.13.2 Virtual Reality (VR)

VR is a step further than AR (Augmented Reality) on the spectrum of virtuality. VR creates a virtual and immersive experience for the user through headsets with 360-degree visions, allowing the user to experience a completely different environment. Since 1990, it has experienced remarkable growth, undergone development, and been applied in areas such as education and training. When using VR in training related to the construction industry, it reduces the risks people may be exposed to, optimizes procedures, and makes it possible to identify danger zones.

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[58] Processed by: European Foundation for the Improvement of Living and Working Conditions, 2005. *Trends and Drivers of Change in the European Construction Sector.* Mapping report, available at: http://www.eurofound.eu.int

[59] IRIZARRY, J. and COSTA, D. B., 2020. Exploratory Study of Potential Applications of Unmanned Aerial Systems for Construction Management Tasks. *Journal of Management in Engineering*, 32 (3).

3.13.3 3D Printing

The method of making a dynamic, physical 3D structure from a CAD model is known as 3D printing or additive manufacturing. 3D printing has been the focus of 25 years of research and development, and it is now used in several fields, including aerospace, vehicles, and medicine. The construction industry is still looking at 3D printing, but mostly for small to medium-sized projects right now. These technologies have recently ignited attention in the Construction 4.0 sector, particularly with cement, lending to its potential to substitute human workers with automated manufacturing, enabling substantial saving of time as well as personalized and scalable construction manufacturing. The result is heavily influenced by the printing quality, material behavior, speed, and printing duration between layers.[60]

3.13.4 Building Information Modeling (BIM)

BIM is a computer program that allows all stakeholders in the construction process to generate, transfer, exchange, and communicate data. BIM has been critical in the building industry's digitalization. Overall, BIM – specifically 5D planning and budget integration – is supposed to result in substantial cost savings (direct costs, efficiency, delays, protection, and image) across the entire construction value chain (design, construction, operations, and destruction). In other words, BIM (Building Knowledge Modeling) can enhance operating processes over the lifespan of a construction project.[61] Today, Building Information Modeling (BIM) is the central technology for the digitization of the construction manufacturing environment.

3.13.5 Robotics

This technology is widely used in the construction industry, particularly in the assembling of high-rise buildings. For example, the SMART machine built by SHIMIZU in Japan was also used to create a 30-story office tower. Furthermore, robots can execute various building operations like painting, brick overlaying, and earthwork.

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[60] PAUL, S. C., TAY, Y. W. D. PANDA, B. and TAN, M. J., 2018. Fresh and Hardened Properties of 3D Printable Cementitious Materials for Building and Construction. *Archive of Civil and Mechanical Engineering*, 18, 311–319 pp.

[61] WYMAN, O., 2018. *Digitalization of the Construction Industry: The Revolution Is Underway.*

3.13.6 Artificial Intelligence (AI)

AI is a concept that refers to a computer that mimics human cognition. Throughout the construction industry, 4.0 AI can be used in adaptive vision systems to distinguish different aspects of a construction site, as well as voice and recognize patterns to track the progress of construction workers in full detail. It's still being analyzed to see how it can forecast several anomalies involved in building architecture, construction, and service. Furthermore, intelligent manufacturing is a viable technique.

Robotics, AI, and the Internet of Things can reduce building costs by up to 20 percent. Engineers can don virtual reality goggles and send mini-robots into buildings under construction. These robots use cameras to track the work as it progresses. AI is being used to plan the routing of electrical and plumbing systems in modern buildings. Companies are using AI to develop safety systems for worksites. AI is being used to track the real-time interactions of workers, machinery, and objects on the site and alert supervisors of potential safety issues, construction errors, and productivity issues.

Despite the predictions of massive job losses, AI is unlikely to replace the human workforce. Instead, it will alter business models in the construction industry, reduce expensive errors, reduce worksite injuries, and make building operations more efficient.
Leaders at construction companies should prioritize investment based on areas where AI can have the most impact on their company’s unique needs. Early movers will set the direction of the industry and benefit in the short and long term.[62]

3.13.7 Internet of Things (IoT)

Using built-in sensors and wireless technology, the Internet of Things allows for fast storage, processing, and sharing of data. It's generally acknowledged as one of the most critical fields of future technology, and it's gaining a lot of interest from sectors. In the context of construction 4.0, the

[62] RAO, S., 2022. *The Benefits of AI in Construction*. [online] published April, 2022 [cited September 2022]. Available at: https://constructible.trimble.com/construction-industry/the-benefits-of-ai-in-construction

Internet of Things (IoT) is being used to incorporate goods (Wireless sensor networks, middleware, cloud computing and IoT application software).

Many of these advancements in technology today present new opportunities for businesses who wish to enhance their competition, operations quality, project delivery punctuality, as well as new services delivered to customers Also, several of these technologies, such as BIM, sensors, and the Internet of things, have proved to be useful in accomplishing the objectives for a prosperous future (Along with the enormous potential and promise of sustainable decision-making in the field of construction technology. In other words, investing in new technology contributes to improved efficiency, and that's what companies like construction are looking for.[63]

Many times, the construction industry resists implementing Industry 4.0 technologies and undergoes digital transition; the result is the shortage of theory knowledge. Therefore, Extra efforts among academicians and industry players are required to implement the innovative concept of Industry 4.0 in the complicated environment of the construction industry and push its traditional borders.

3.14 ETHICAL AI – BUILDING FAIR AND SUSTAINABLE WORKPLACES

Ethical AI in the workplace refers to well-defined guidelines related to individual values, which involve adhering to non-discriminatory practices, non-manipulation, respecting individual rights, privacy and fair AI practices at the workplace to improve AI job quality.

It prioritizes fundamental importance to ethical considerations in determining the legitimate use of AI in the workplace.

Here's a breakdown of some key areas of focus within **AI legal compliance**:

1. Data Privacy

AI revolves around data collection, storage, and analysis where issues related to data breaches have been observed. While stringent regulations like GDPR and

[63] ALALOUL, W. S., LIEW, M. S., ZAWAWI, N. A. B. and KENNEDY, I. B., 2020. *Industrial Revolution 4.0 in the Construction Industry: Challenges and Opportunities for Stakeholders.* Science Direct Journal, 11, 225-230 pp.

CCPA exist, stricter enforcement is crucial to ensure robust data privacy protections.

2. Algorithmic Bias

AI algorithms are only as fair as the data they're trained on. Unfortunately, bias can creep in at various stages: from skewed datasets to programmer assumptions and even the metrics used to evaluate success. This can lead to discriminatory outcomes, favoring specific groups unintentionally. To combat this, fairness audits and mitigation techniques are crucial. These tools help identify and address bias, ensuring AI promotes equality and inclusivity in the workplace.

3. Transparency

Transparency in responsible AI development is paramount. A thorough comprehension of AI mechanisms is essential to foster trust and accountability. By understanding how AI arrives at decisions, both employers and employees are empowered, enhancing their reasoning abilities and ensuring outcomes free from errors or biases.

4. Intellectual Property

The question of original creatorship arises when AI is employed to produce artistic works. Unlike humans, AI systems are not acknowledged as legal creators. Determining ownership hinges on the creator of the AI system. However, complexities arise when individuals contribute their creativity to AI-generated content without retaining ownership rights. Therefore, meticulous attention and clear ownership policies are essential to address this issue.

3.14.1 AI Workplace Governance

The integration of AI in the workplace promises efficiency, productivity, and innovation. However, alongside these benefits lie challenges that require careful consideration. A recent Deloitte survey underscores this concern, revealing that 70 % of HR leaders are worried about the ethical implications of AI in the workplace. This section will delve into these challenges and explore strategies to ensure responsible AI integration that fosters trust and maximizes benefits for all stakeholders.

► Employee Monitoring

Employers are seen monitoring their employees using AI-powered tools which have raised privacy concerns significantly. This could lead to a distrustful work environment, data misuse, or biased decision-making. Employers need to find balance by defining the purpose of monitoring, seeking employee consent, ensuring transparency and data security, and respecting employee rights to privacy.

► Decision-Making

AI algorithms give results based on the data it is trained on. For instance, if a certain algorithm is created to favor specific types of resumes in the hiring process, then it will discriminate against qualified candidates, raising ethical concerns. The complexity of algorithms will further create difficulty in ascertaining how AI has got certain results making it tough to hold anyone accountable. Businesses need to define human oversight mechanisms, focus on fairness, and establish clear accountability for AI-driven decisions.

► Job displacement and reskilling

Automation driven by AI is projected to significantly impact the workforce. A 2022 McKinsey Global Institute report estimates that automation could displace up to 800 million jobs globally by 2030. This raises concerns about job security, retraining needs, and potential income inequality. Companies have a responsibility to communicate transparently about automation and its impact on the workforce. Proactive measures like reskilling initiatives can help equip employees with the necessary skills to navigate the changing job landscape. Additionally, fair practices like severance packages and assistance with job searches can ease anxieties and ensure a smoother transition for displaced workers.[64]

3.15 BUILDING AI INFRASTRUCTURES

In a way artificial intelligence isn't unlike other new technologies, where rapid implementation and proliferation at all levels of society has led to the revelation of many potential flaws and risks. But what makes AI unique is that it has long occupied the human mind. While discussions about the risks of social media only

[64] Hibernian Recruitment, 2024. *Ethical AI: Buildind Fair and Sustainable Workplaces.* [online] [cited October, 2025]. Available at: https://www.aicerts.ai/blog/ethical-ai-building-fair-and-sustainable-workplaces/

began happening after we were already feeling its effects, the field of AI ethics emerged long before AI tangibly entered the mainstream consciousness.

As a result, we already have a considerable body of literature to fall back on to guide us in establishing guiding principles and concrete protocols. By now many such guideline sets are available, published by national and international bodies, from government organisations to NGOs.

AI is becoming essential across industries to help boost human productivity and decision-making, but do the benefits to the bottom line outweigh the potential impact to society? We have seen AI's disruptive potential, as well as negative consequences from its underuse, misuse and abuse.

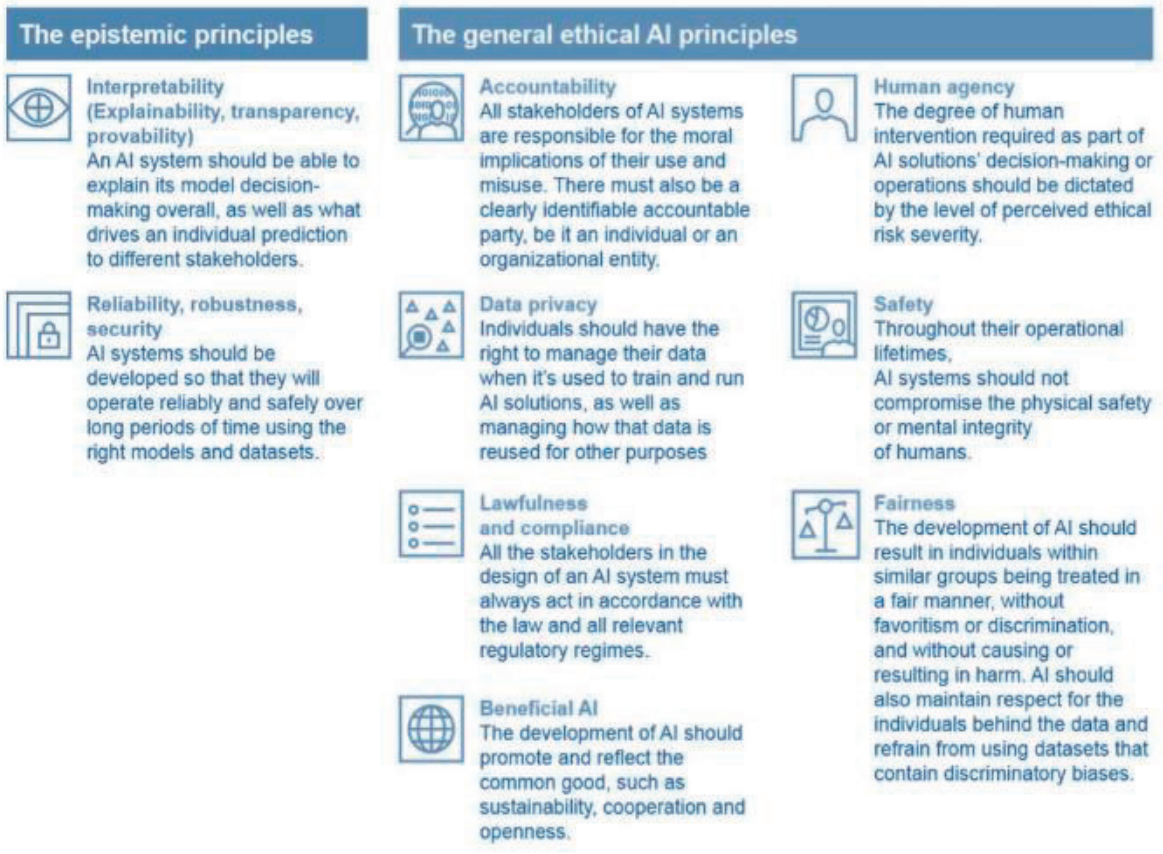

Figure 14: Ethical AI Principles[65]

[65] Hibernian Recruitment, 2024. *Ethical AI: Buildind Fair and Sustainable Workplaces.* [online] [cited October, 2025]. Available at: https://www.aicerts.ai/blog/ethical-ai-building-fair-and-sustainable-workplaces/

Consumers and the media have drawn attention to biased recruitment and financial tools, concerns around discrimination5 and more, raising awareness of the moral dilemmas surrounding the deployment of AI. Developers, users and organizations need clear guidance and principles to apply AI to real-world problems responsibly and to handle all identified moral implications. The landscape of ethical AI principles that PwC has researched is expansive and rich, but there are commonalities. We took more than 100 sets of ethical principles — amounting to 200 in total — and consolidated them into nine core ethical AI principles (Figure 14).

So, what is the takeaway about AI Ethics and Risk?

Like with every new technology there are a lot of issues to be hammered out still, and problems we haven't quite understood. There are risks at the technological level and at the business/national level, which can have tangible consequences.

While the field of AI ethics is still in its infancy, it already has produced a lot of literature – within academic circles, government contexts and from business perspectives. And while a lot of ethical guidelines can seem lofty and hard to translate into concrete action, there also are many resources for practical frameworks and protocols.

Artificial Intelligence will likely suffuse every part of our future, whether we like it or not, whether we are aware of it or not. The potential benefits to harnessing AI are great, but to reap those benefits we must have a robust understanding of, and protocols for dealing with all its pitfalls.

As consumer expectations for trust and transparency grow, comprehensive data ethics frameworks are needed to explicitly embed values into the entire data supply chain. This will build on the data privacy and protection compliance processes that start maturing in organizations because of data privacy legislation, like the European Union's GDPR and the California Consumer Protection Act (CCPA).

In fact, these legislative acts provided the first step toward adoption of ethical data practices, as data privacy was selected as one of the more important ethical principles by our survey respondents. With the increase in data use across organizations, especially for AI systems, the need for an ethical approach to data management is critical. Data ethics might be the most robust approach toward achieving ethical AI, by confirming that the right ethical principles are considered in the context of data supply chain, and by building a robust, responsible foundation for future AI applications and uses.

In the absence of regulatory frameworks, assessing the quality of AI systems' output against set standards emerges as one of the more accessible ways to govern AI responsibly — even though few standards are defined. The field of AI assurance is described as "governance mechanisms for third parties to develop trust in the compliance and risk of a system or organization."
Formal definitions surrounding assurance require robust, industry-agreed- upon standards. The community is advancing other approaches, including bias audits, certifications, accreditations and impact assessments in lieu of (or in anticipation of) standards. An international ecosystem is required to facilitate the consistency and interoperability of approaches across jurisdictions to enable a global perspective on AI governance.

There is a growing role for Second Line functions (Privacy, Compliance and Data Governance) to come together for better AI and data governance. Despite this need, there is also recognition that there likely should be a designated owner to oversee the rollout of AI governance and coordinate collaboration between teams. Some organizations might choose the Privacy group to own AI governance, given the increased requirements beyond just compliance that some are adopting with respect to data and data use.

3.16 FUTURE OF AI IN CONSTRUCTION

The future of artificial intelligence in the construction industry looks promising, with new developments continuously emerging. As AI technology advances, its applications in construction are expected to become even more sophisticated, offering a range of innovative solutions that could transform how the industry operates.

One area of potential growth is using autonomous machinery. AI-driven robots and drones are already used on some construction sites for tasks such as bricklaying, site surveying, and material transportation. These machines can operate continuously and with high precision, reducing human error and increasing overall productivity. The Boston Consulting Group predicts that by 2025, up to 30 % of construction work could be automated, significantly impacting labour productivity and project timelines.

Another emerging trend is the use of AI for predictive maintenance. Construction equipment and machinery are critical assets that require regular maintenance to avoid breakdowns and costly downtime. AI tools can analyze data from sensors installed on machinery to predict when maintenance is needed, based on factors such as usage patterns, wear and tear, and environmental conditions. This shift from reactive to predictive maintenance can help construction firms minimize downtime, reduce repair costs, and extend equipment lifespan.

AI is also expected to play a key role in creating smarter, more sustainable infrastructure. As concerns about climate change and resource scarcity grow, the construction industry faces increasing pressure to adopt sustainable practices. AI can assist in this transition by optimizing material use, reducing waste, and improving energy efficiency.

Moreover, AI-driven tools could enhance project collaboration and communication further. Future developments might include AI-powered platforms that automate routine administrative tasks, such as scheduling meetings or generating reports, freeing project managers to focus on more strategic aspects of their roles.
As AI technology continues to evolve, its integration into construction is likely to expand, providing new opportunities for innovation and growth. The construction industry, which has traditionally been slower to adopt digital tools, may find itself increasingly reliant on AI solutions to stay competitive in a rapidly changing landscape.

Artificial intelligence is emerging as a transformative force in the construction industry, offering tools and applications that improve efficiency, enhance safety,

and drive innovation. While there are challenges to AI adoption, such as cost, workforce adaptation, and technological infrastructure, the potential benefits make it a worthwhile investment for forward-thinking companies. By embracing AI and its related technologies, construction firms can position themselves to thrive in an increasingly digital future, building smarter, safer, and more sustainable projects.

The continued development of AI technologies presents an opportunity for the construction sector to fundamentally reimagine its processes and operations. As more companies recognize the value of these tools, the industry will likely see a shift toward more data-driven, efficient, and innovative ways of working, ultimately benefiting both businesses and their clients.[66]

[66] Construction Today, 2024. *The Rise of Artificial Intelligence in Construction.* [online] published September 17, 2024 [cited October 10, 2025]. Available at: https://construction-today.com/news/the-rise-of-artificial-intelligence-in-construction/

CONCLUSION

To obtain the greatest benefits from AI systems while protecting fundamental rights, health and safety and to enable democratic control, AI literacy should equip providers, deployers and affected persons with the necessary notions to make informed decisions regarding AI systems. Those notions may vary with regard to the relevant context and can include understanding the correct application of technical elements during the AI system's development phase, the measures to be applied during its use, the suitable ways in which to interpret the AI system's output, and, in the case of affected persons, the knowledge necessary to understand how decisions taken with the assistance of AI will have an impact on them. In the context of the application this Regulation, AI literacy should provide all relevant actors in the AI value chain with the insights required to ensure the appropriate compliance and its correct enforcement.

Furthermore, the wide implementation of AI literacy measures and the introduction of appropriate follow-up actions could contribute to improving working conditions and ultimately sustain the consolidation, and innovation path of trustworthy AI in the Union. The European Artificial Intelligence Board (the 'Board') should support the Commission, to promote AI literacy tools, public awareness and understanding of the benefits, risks, safeguards, rights and obligations in relation to the use of AI systems. In cooperation with the relevant stakeholders, the Commission and the Member States should facilitate the drawing up of voluntary codes of conduct to advance AI literacy among people dealing with the development, operation and use of AI.[67]

The Ministry of Investments, Regional Development and Informatization of the Slovak Republic (MIRDI) is submitting a key legislative proposal for the Artificial Intelligence Act to the interdepartmental comment procedure, which is intended to ensure the fair and responsible introduction of AI technologies in accordance with European law.

[67] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence. (20) Available at: https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng

The aim of the draft Act on Artificial Intelligence is to ensure the implementation of key provisions of Regulation (EU) 2024/1689 of the European Parliament and of the Council, known as the Artificial Intelligence Act (AIA). This Act sets the framework for the institutional arrangement and supervision of AI systems in Slovakia.[68]

We are seeing emerging discussions on what the best practices for AI policy are, especially following the ratification of the EU AI Act. We expect that more regulations will aim to govern AI, and we are seeing strong policy ideas emerge that focus on balancing innovation with risk management, creating sandboxes for testing, tailoring rules by sector, and ensuring cross-border interoperability aligned with OECD AI Principles.

It is important that the ethics and governance of artificial intelligence are integrated into the curricula of relevant universities and technical institutes. We need to see more of this kind of activity and more public awareness campaigns by governments, NGOs and educational institutions to equip people with the knowledge needed to manage the risks of AI.[69]

[68] *Responsible Digitalization: MIRDI Presents Draft Laws on Artificial Intelligence and Data Management.* [online] published August 8, 2025, [cited September 8, 2025]. Available at: https://mirri.gov.sk/aktuality/digitalna-agenda/zodpovedna-digitalizacia-mirri-predstavilo-navrhy-zakonov-o-umelej-inteligencii-a-sprave-udajov/

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Published and printed Tribun EU, Ltd.
Cejl 892/32, 602 00 Brno, Czech Republic
www.librix.eu

First edition of Tribun EU

Brno 2025

ISBN 978-80-263-1857-6