Polish Economic Institute

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Content:

Macroeconomics:

Jakub Rybacki
@ jakub.rybacki@pie.net.pl
@jakubrybacki2
+48 512 275 365

Marcin Klucznik
@ marcin.klucznik@pie.net.pl
@MarcinKlucznik
+48 503 457 274

Sergiej Druchin
@ sergiej.druchyn@pie.net.pl
@druchin_s
+48 792 766 265

Sebastian Sajnóg
@ sebastian.sajnog@pie.net.pl
@BastianSajnog
+48 501 837 748

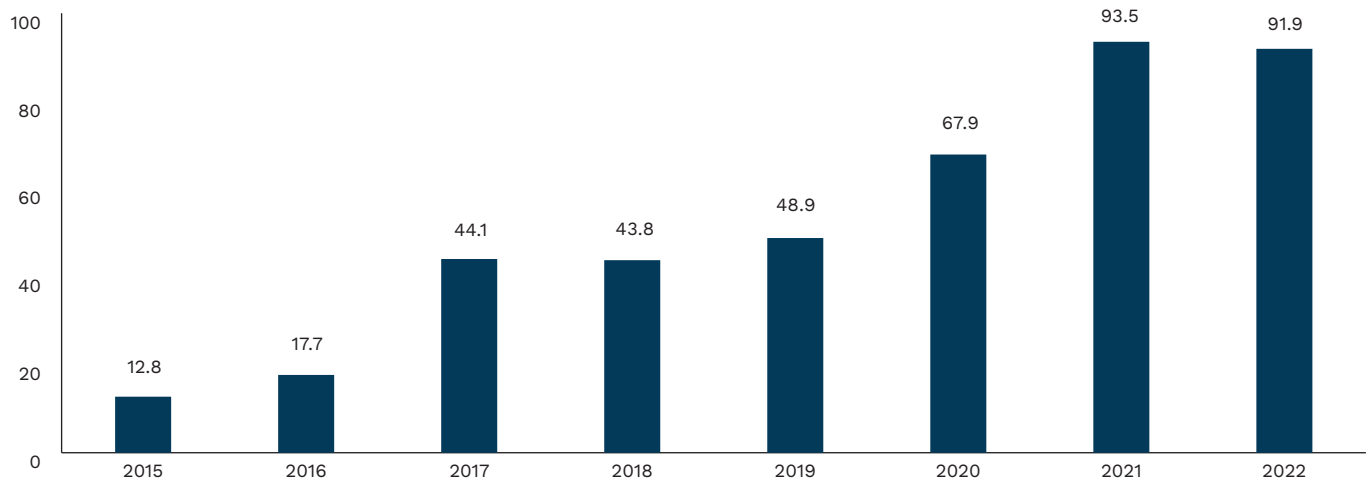
Dawid Sułkowski
@ dawid.sulkowski@pie.net.pl
@Dawid_Sulkowski
+48 885 062 001

Energy:

Maciej Miniszewski
@ maciej.miniszewski@pie.net.pl
@macminiszewski
+48 799 126 992

Michał Szewczyk

Global total corporate artificial intelligence (AI) investment from 2015 to 2022 (in billion U.S. dollars)

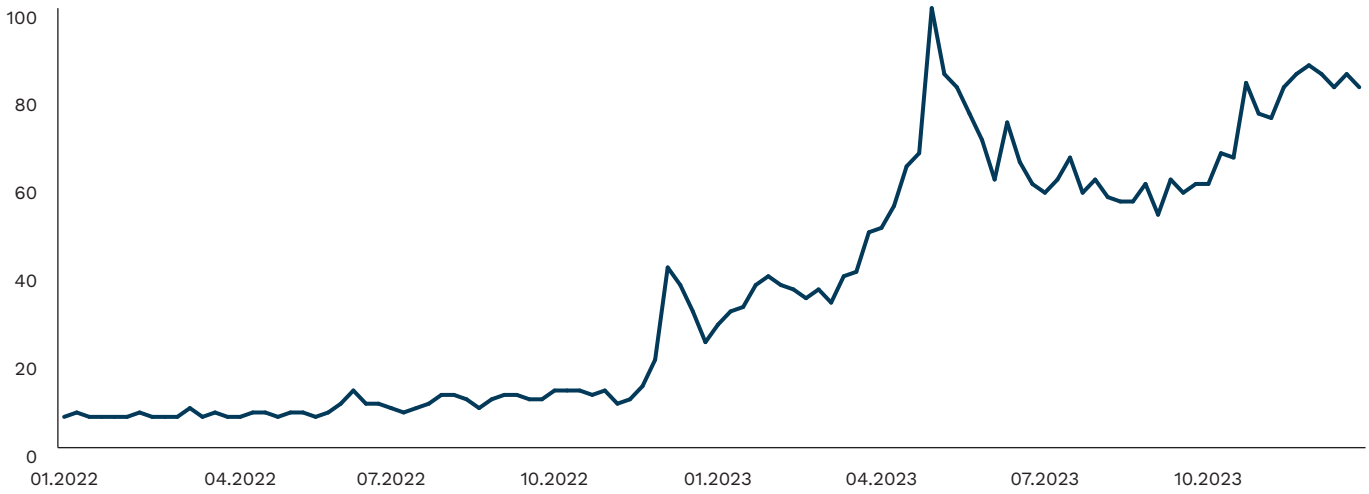


Source: 2022 AI Index Report.

AI is widespread, expectations in the macroeconomic statistics

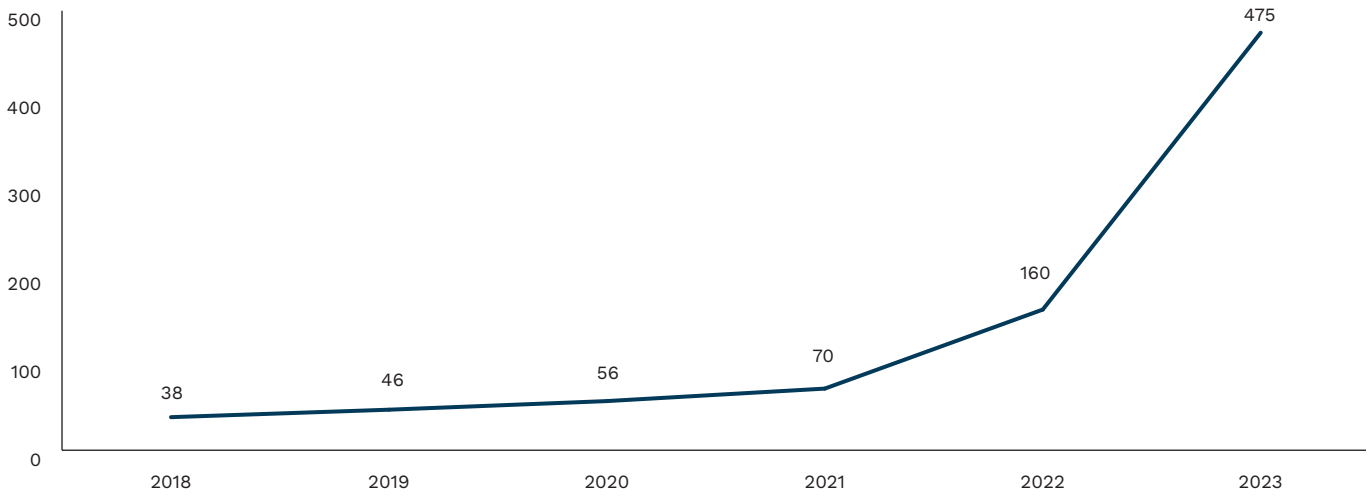
▶ **Artificial intelligence made a significant impact on the media landscape in 2023.** The number of Google searches related to AI increased tenfold since 2022. The initial surge in interest was observed towards the end of 2022, following the public launch of ChatGPT. The peak interest correlates with the highest number of active users. However, a second wave of interest has recently emerged, driven by increased publicity surrounding generative audio and video makers such as Sora. We are yet to see its economic effects.

Figure 1.1. Search frequency for the keyword "AI" in Google (index)



Source: Google trends.

Figure 1.2. Approximate number of results for the keyword 'AI' in Google's News results (in millions)



Note: Data obtained by extracting the number of search results for the phrase "AI" on Google's News. Numbers can fluctuate due to matching the results to a user profile

Source: PEI calculations based on Google News.

▶ The surge in media interest in AI is evident in the number of articles. **However, the discussions around AI seem to express mixed feelings about the technology.** Analysis of articles form the Guardian and Forbes (Delab, 2023), illustrate this dichotomy. On the one hand, there is a techno-optimistic viewpoint based on the belief in the productive and equalizing potential of new solutions, while on the other hand, a techno-sceptical viewpoint expresses concern about how humans will realize this potential. Text mining analysis of article headlines (Roe & Perkins, 2023) on the topic, reveals a dichotomy between voices warning of impending danger (37% of headlines) and presenting concerns about automatic misjudgements (11%), as opposed to explanatory and informative content (26%) and reporting on the possibilities of AI (13%).

▶ **Nevertheless, there is a general expectation that this technology will influence productivity.** Crunchbase reports that AI is responsible for 20 out of the 95 stock market unicorns of 2023. Notably, OpenAI, the creator of ChatGPT (largely supported by Microsoft), stands out as one of the most valuable startups in this domain. Their current valuation ranges from USD 80 to 90 billion and, according to experts at Bloomberg, is expected to exceed USD 100 billion this year. Consequently, it seems certain that there will be much to talk about in the world of AI this year as well.

AI patents suggest China's dominance, but the picture is not clear

116,000

Number of patents related to AI granted in China

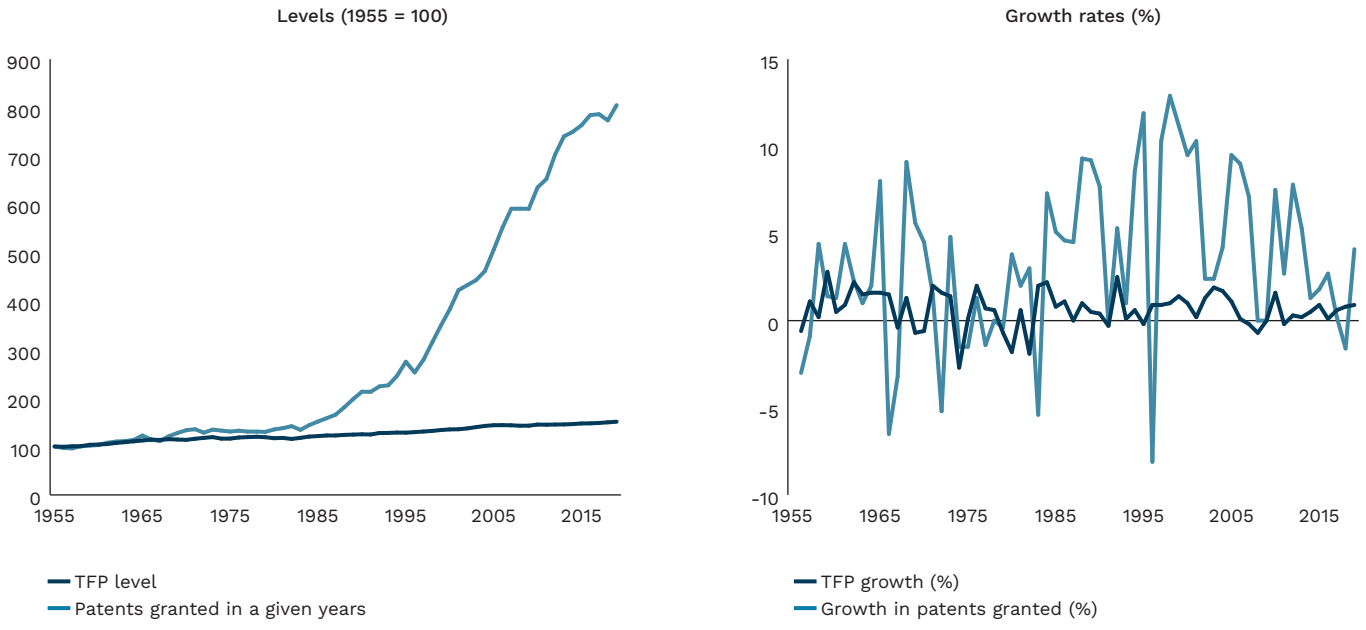
Over 50%

Research teams building AI models are doing so for business applications

▶ Patent applications are one of the measures of technological progress and could be used to assess the pace of AI technology development. However, this approach faces several challenges. The overall relationship between patents and productivity growth is debatable – the increase in patents is also due to legal changes and companies wanting to protect their property. Plain patent data would suggest China's primacy in the AI race. However, using alternative metrics, such as investment spending, gives a completely different picture – the US remains the leader, although the competition with China will intensify – Europe is lagging behind.

▶ **The number of patent applications is weakly related to productivity growth.** Data for the U.S. shows that total productivity growth, as measured by Total Factor Productivity (TFP), was up by 51.2% between 1955 and 2019. During the same period, the total number of patents granted for inventions increased from 77,200 to 597,200 per year. Theoretically, the rise in patenting was supposed to lead to an increase in the productivity of economies – in reality, the period of the highest number of newly granted patents was characterized by a rather moderate increase in productivity.

Figure 2.1. Patent applications and productivity growth are not strongly related – USA data

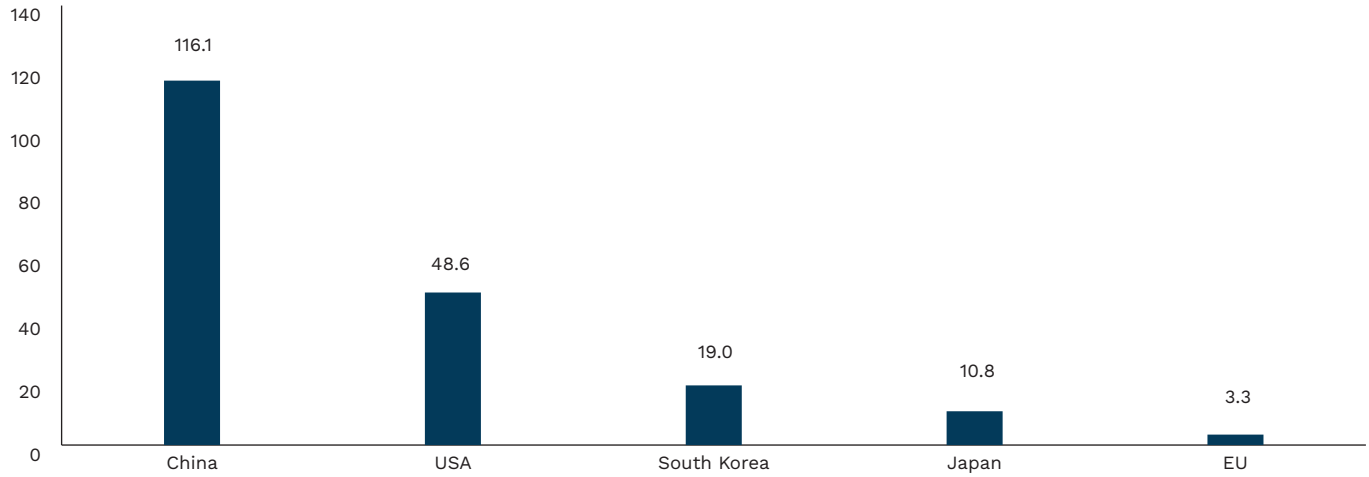


Note: Patents for inventions only (i.e. utility patents).
Source: US Patent and Trademark Office, University of Groningen via FRED.

▶ **Patents are not a very robust measure of technological progress.** Changes in the regulatory framework (e.g., OECD) also have an effect on the increase in the number of patents. Such changes do not have a significant impact on the productivity of economies – sometimes they have even led to negative effects like patent wars (see: Apple-Samsung Patent War). Some researchers have also pointed to changes in the way companies manage innovation (Kortum & Lerner, 1997) – for instance, semiconductor companies consciously decided to strengthen their

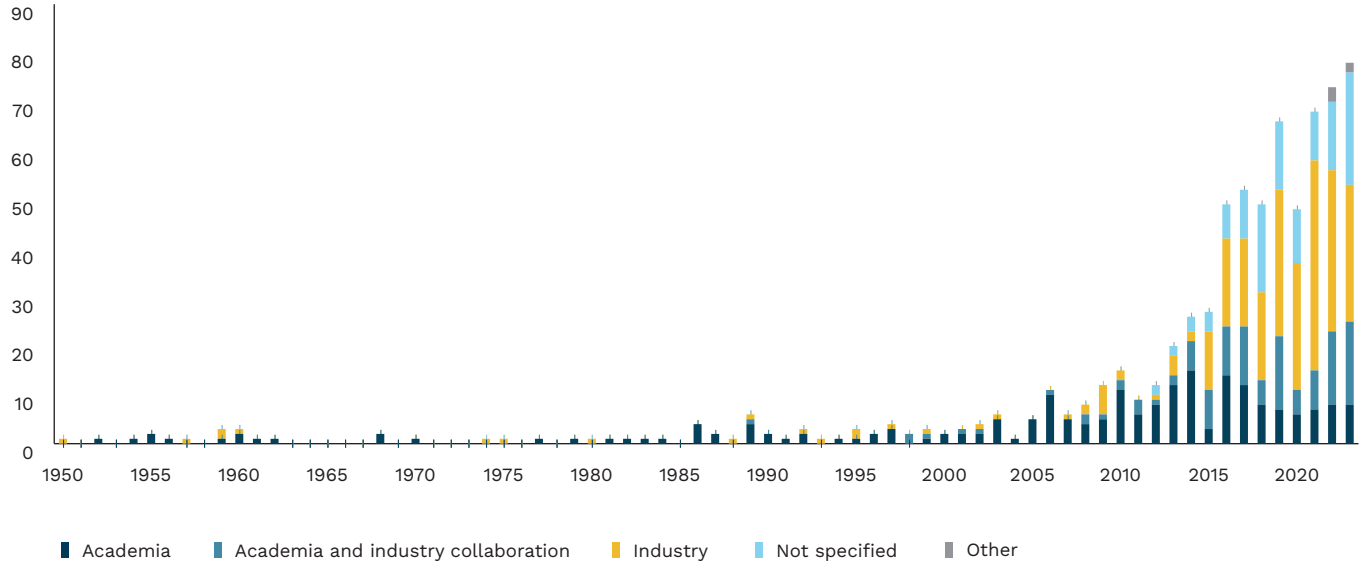
patent rights in the 1980s to block competition (Hall & Ziendonis, 2001). The quality of patents matters – researchers tend to construct measures of the impact of particular technologies depending on the number of patent citations, the prevalence of use, or complementarity with other technologies, among other factors (e.g., Hall & Trajtenberg, 2004; Petralia, 2020).

Figure 2.2. Patent applications related to AI granted since 2010 (in thousands)



Source: Center for Security and Emerging Technologies.

Figure 2.3. Affiliation of research teams building notable AI models



Note: by year of publication.
Source: Epoch via Our World in Data.

▶ **AI may be an example of the difference in patent quality.** CSET data shows that China is the absolute leader when it comes to the number of AI-related patent applications obtained. Since 2010, China obtained 116,000 patents – nearly 240% more than the United States. However, this is partly the result of the patent war with the US and not all patents reflect factual technologies (e.g., Bloomberg). In fact, NetBase Quid data shows that the U.S. is still the leader in AI spending

– e.g. in 2021, private investment in AI was USD 73.4 billion in the U.S. and USD 22.9 billion in China. Also anecdotally, the scale of the success of the U.S. OpenAI and the projects of the major corporations (Google, Meta, etc.) suggest that patent data clearly overestimates China's advantage; however, technology competition between the two countries will intensify in the future.

▶ **At the moment, the main loser of the AI race is Europe.** The problem is primarily the lack of major technology companies to fund and implement new research. The problem becomes even more acute as AI work has ceased to be academic in nature and is moving seamlessly into business applications. Epoch data shows that until around 2014, most AI models were developed exclusively by universities and academic researchers – now it is only 10%. More than half of the large AI models currently under construction are being developed either by business or by business in collaboration with universities.

Intellectual capital boosts the CEE's GDP growth

▶ Digitalization and automation play a significant role in GDP growth, including in the CEE region. We conducted a KLEMS decomposition of economic growth with a strong focus on intangible capital. During the decade of 2011-2020 Intellectual capital contributed to GDP growth in the Visegrad Groupin the range of 4.8 pp in Czechia to 9.4 pp in Poland.

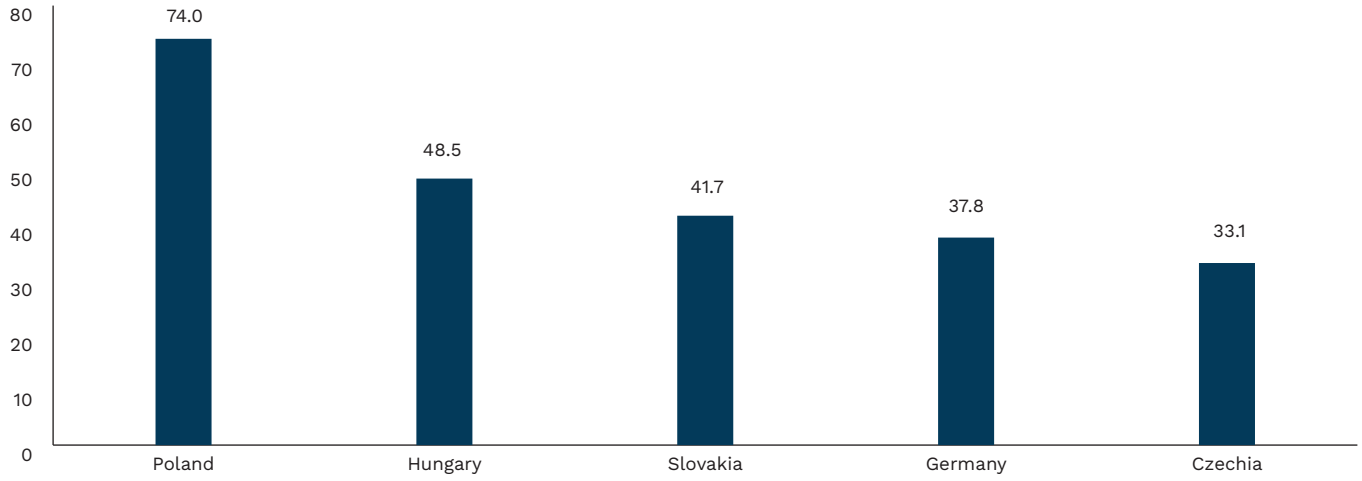
▶ We decomposed GDP growth based on modified Cobb Douglas function with three production inputs: labour (L), physical capital (K) and intangible capital (C). Parameters α, δ, γ are calibrated elasticities to these inputs. The equation is based on multiplicative model given as follows:

$$Y = (AL)^{1-\alpha} C^{\delta} K^{\gamma} \quad (1)$$

▶ We calibrated the parameter δ to 0.179 based on estimates provided by Bontempi and Mairesse (2008). Remarkably similar values for this parameter were also reported by Damioli et al. (2021) and Belderbors et al. (2015). Parameter α was established at 0.35, aligning with findings presented in the CEE Monthly publication from June 2023. Additionally, we set parameter γ to 0.25 to maintain consistency with our previous decomposition methodology. However, it is worth noting that the contributions of physical capital and total factor productivity (TFP) may not be entirely identical. Data regarding capital and intangible assets was sourced from the EUKLEMS & INTANProd database, managed by the Luiss Lab of European Economics, spanning the period from 2010 to 2020.

▶ The past decade witnessed a remarkable surge in intangible assets across the CEE region. Poland experienced the most substantial expansion, with an increase of nearly 75%. In Hungary and Slovakia, this growth ranged between 40% and 50%. However, Czechia exhibited the weakest performance, with a modest 33% increase, even trailing behind Germany, which saw a rise of nearly 38%.

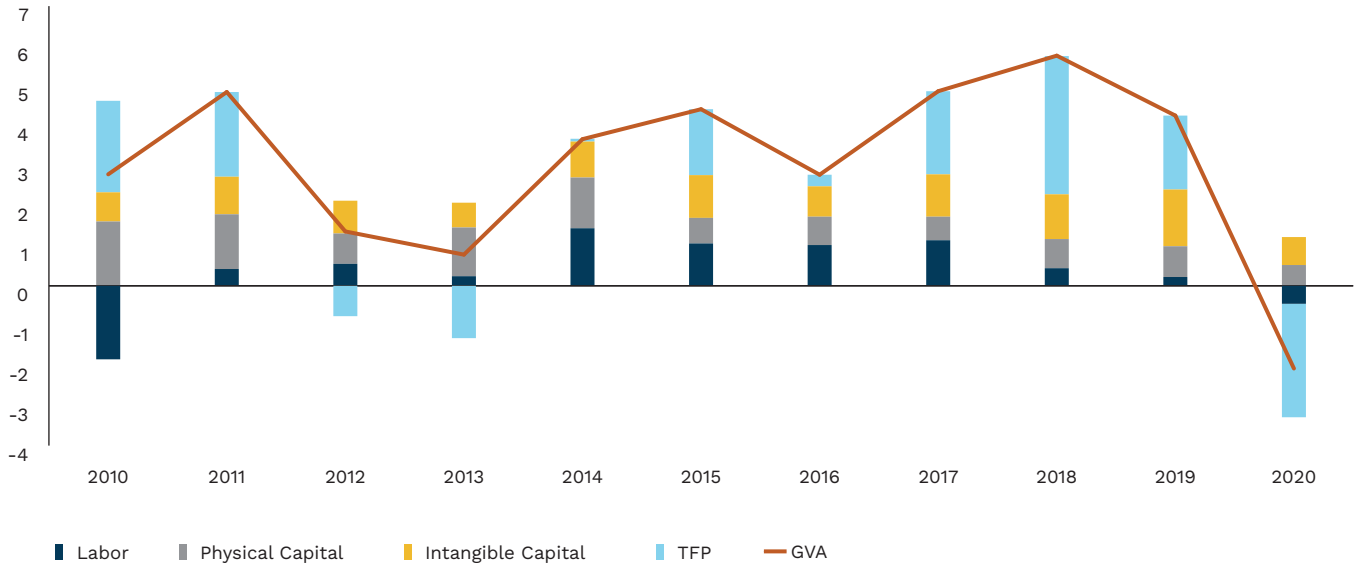
Figure 3.1. Increase of intangible assets since 2010 (%)



Source: EUKLEMS & INTANProd database.

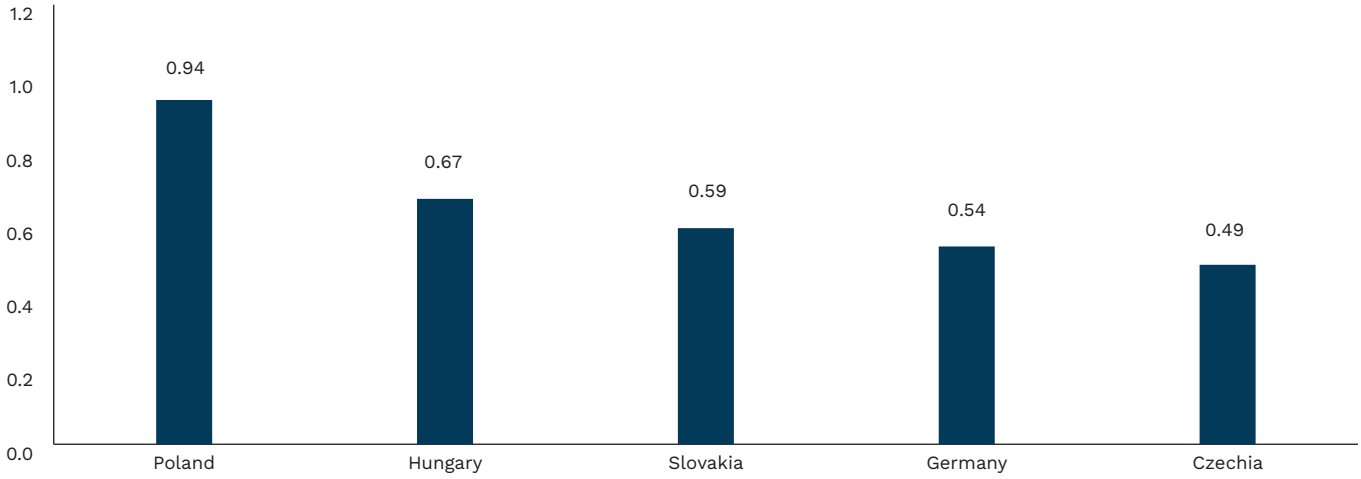
▶ The increase remained stable over time with fluctuations related to the business cycle. We see slightly higher contributions during the expansion phase of the business cycle and lower contributions during slowdown. We decomposed the GDP growth in Poland. The average contribution to GDP growth during the years 2017 – 2019 amounted to 1.2 pp. On the other hand, during a downturn in the years 2012 – 2013 contribution was 50% lower. The same evidence was visible in the case of Covid-19 pandemic.

Figure 3.2. GDP growth decomposition in Poland on production factors (%)



Source: PEI calculations based on the EUKLEMS & INTANProd database.

Figure 3.3. Average contribution of intangible assets to GDP growth in 2011-2020 (%)



Source: EUKLEMS & INTANProd database.

▶ Overall, the contribution of intellectual capital to GDP growth tends to outperform the contribution from physical capital in the second half of the last decade. This phenomenon is consistent across most CEE countries, except Hungary. In Hungary, the contribution of intellectual capital usually amounts to less than 50% of the contribution from physical capital. This evidence

9.4 pp

Total contribution of intangible assets to GDP growth in Poland in 2011-2020

suggests a sluggishness in potential output when the country reaches convergence on basic infrastructural investments.

▶ However, convergence remains slow. The average contribution of intangible assets to GDP growth in Visegrad countries is comparable to that of Germany. Slightly higher readings are visible in Hungary, but these are attributed to the starting point. So far, only Poland outperforms its peers.

CEE is lagging behind Western Europe in the development of the digital society

92.3%

A percentage of Europeans with an access to the internet in 2023

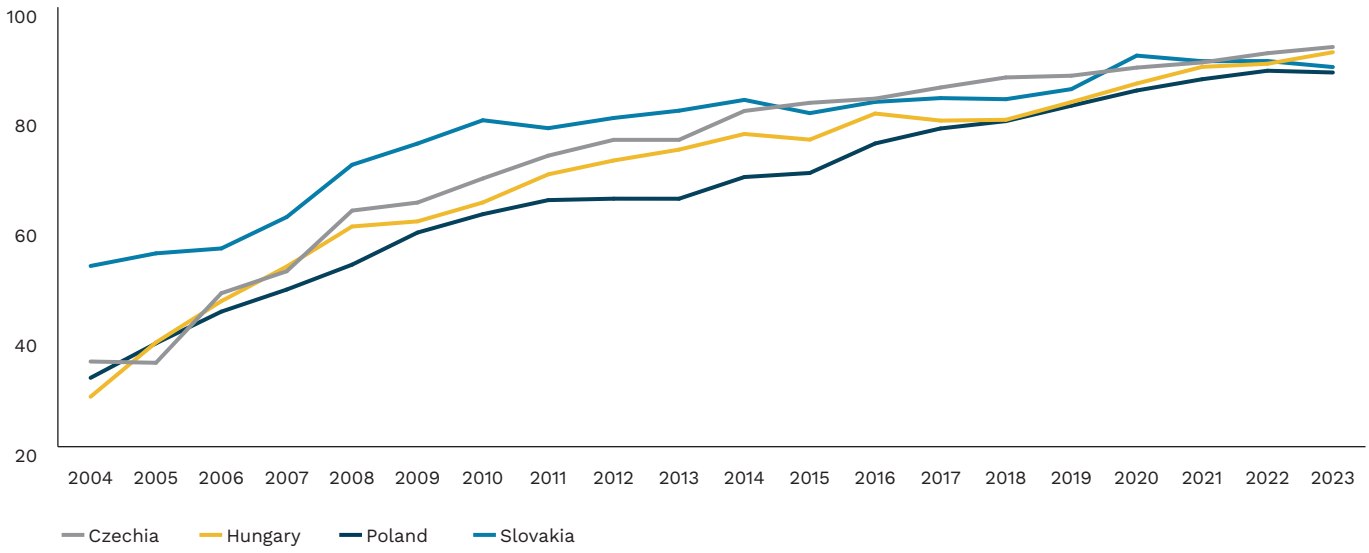
30.8

SMEs reached an advanced level of digital intensity in 2022

▶ In Europe, there is a systematic increase in digitization and the use of advanced technologies. Presently, the percentage of people using the Internet exceeds 90%, with advanced technologies becoming increasingly prevalent both at home and in the workplace. Statistics highlight a clear divide between European countries, with Western European nations typically exhibiting higher levels of digitization.

▶ **The use of the Internet among Europeans is steadily increasing.** Over the past decade, the percentage of people with Internet access rose from 75.3% to 92.3% in 2023. Even Bulgaria, though still at the bottom of European statistics, significantly improved its Internet access rate, climbing from 56.2% to 84.0%. Among Central and Eastern European countries, the Czech Republic stands out with the highest percentage of Internet users, reaching 92.8% in 2023. Furthermore, cross the European Union, the proportion of those who have never used the internet is steadily declining, reaching 6% in 2023, with the highest in Central and Eastern European countries in Poland, where it stands at 9.8%.

Figure 4.1. Internet penetration rate in CEE countries



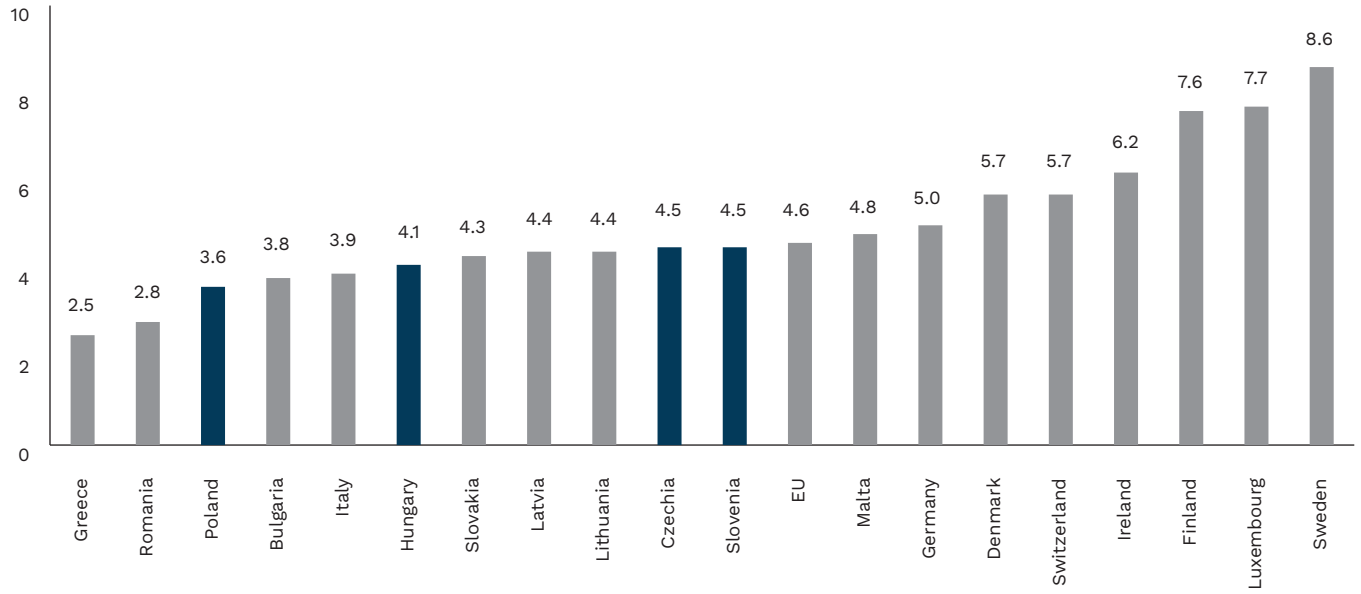
Source: EUROSTAT.

▶ **The rise in the popularity of technology is correlated with an increase in employment in the ICT sector.** From 2012 to 2022, the number of ICT specialists in the European Union surged by 57.8%, reaching over 9 million, which accounts for 8.8% of total employment. However, the share of employment in CEE countries remains below the EU average, at 4.6%. The majority of ICT specialists in the EU hold higher education degrees (65.2%). In 2022, men comprised 81.1% of those employed in this sector.

▶ Recruitment of ICT specialists poses a challenge for companies, with 62.8% of them in the EU reporting difficulties in filling vacancies. This issue is particularly pronounced in the Czech Republic, where 77% of businesses reported difficulties in recruiting, the second highest result.

In contrast, the situation is relatively better in Poland, with the third lowest result – 46.5% of companies reported difficulties in recruiting ICT specialists.

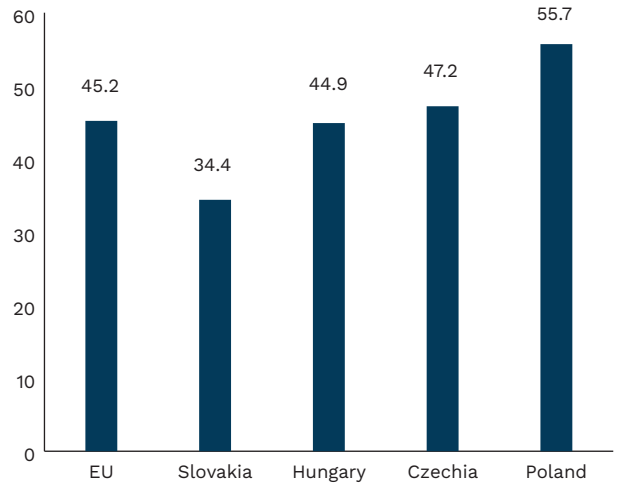
Figure 4.2. Share of ICT specialists in total employment in selected EU countries



Source: EUROSTAT.

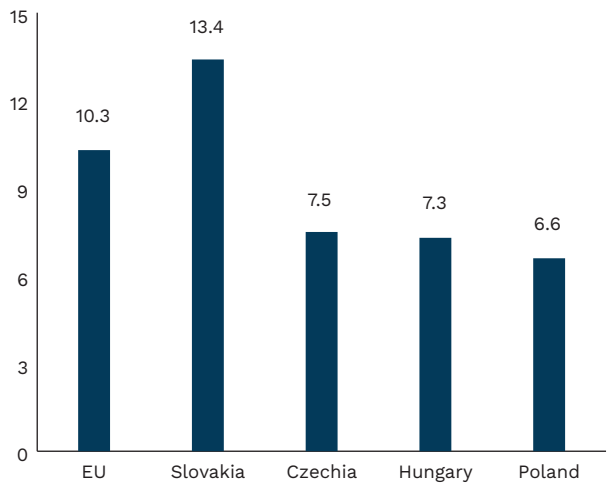
▶ **Poland lags behind in the development of e-government compared to both the European Union as a whole and Central and Eastern European countries.** In 2023, 18% of Europeans applied for official documents or certificates online. However, in Poland, this percentage was only 6.6%, which places us third lowest in the European Union. In comparison, the rates were 9.4% in the Czech Republic, 9.7% in Slovakia, and 15.3% in Hungary. Luxembourg recorded the highest percentage at 50.7%.

Figure 4.3. Percentage of companies using cloud computing service



Source: EUROSTAT.

Figure 4.4. Percentage of people using Internet-connected household appliances



Source: EUROSTAT.

▶ **Advanced technologies are increasingly becoming part of our daily lives, both at work and at home.** Digital intensity in EU companies is monitored through the Digital Intensity Index (DII), which assesses companies' use of 12 different digital technologies, including artificial intelligence and e-commerce. In 2022, 70% of enterprises in the European Union reached a basic level of digital intensity, 20 pp lower than the EU target for 2030. Moreover, 45.2% of companies in the EU use cloud services, mainly for managing email. In the same year 72% of EU internet users went online using internet-connected devices or systems, mainly for entertainment purposes (64%). Only 10% used smart home appliances, such as vacuum cleaning robots, refrigerators, ovens, or coffee machines, and a similar percentage used advanced technologies related to home security. These statistics show a clear divide between technologically advanced Western Europe and the less technologically developed Eastern Europe.

The future of smart meters in Poland

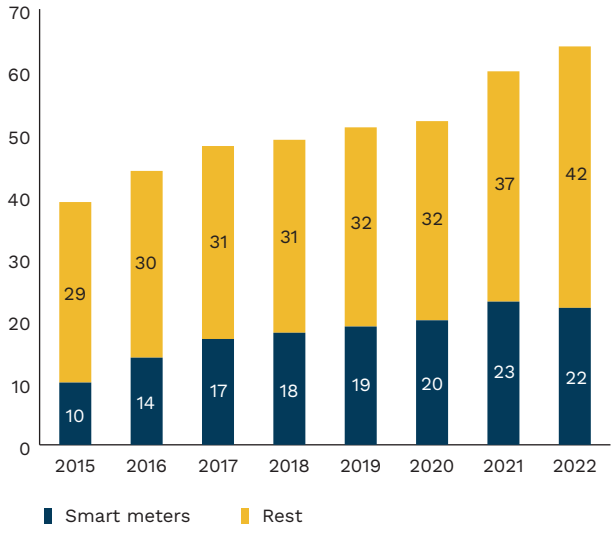
34%

share of smart meters in total investment in digital infrastructure in electricity grids in 2022

▶ **The global smart grid market is projected to increase by 162% to USD 130 billion USD between 2022 to 2028.** This growth is primarily driven by the rapid expansion of renewable electricity generation, with the usage of smart meters playing a significant role in facilitating the increased adoption of renewable energy resources. The availability of accurate and real-time information supports the need to reduce demand or shift consumption to times when it is more beneficial to the energy system. Unfortunately, eleven EU Member States, including Poland, have barely begun the process of implementing smart meters' infrastructure.

▶ **Global investment in smart meters increased by 120% to 22 billion USD from 2015 to 2022.** They made up a third of the total investment in digital infrastructure in electricity grids in 2022. The market is rapidly growing due to the developing energy transition, which increased the need for more data for optimal grid management. The smart grid technology market, which we understand as a wide range of technologies including Advanced Metering Infrastructure, network and distribution management, and electricity supply security, was estimated at almost USD 50 billion in 2022 and is forecast to reach USD 130 billion by 2028 with a CAGR of 17.4%.

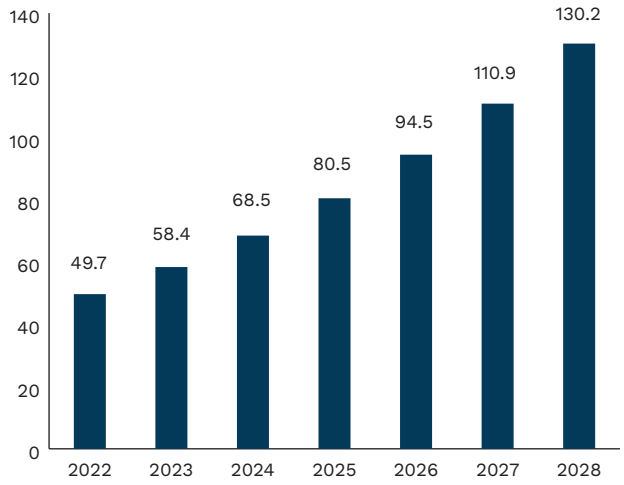
Figure 5.1. Investment in digital infrastructure in transmission and distribution electricity grids from 2015 to 2022 (in billion USD)



Note: The rest consists of automation and management systems, networking and communications, analytics, transformers and EV public charging infrastructure.

Source: IEA.

Figure 5.2. Smart grid technology market size worldwide from 2022 to 2028 (in billion USD)



Source: ReportLinker and Statista.

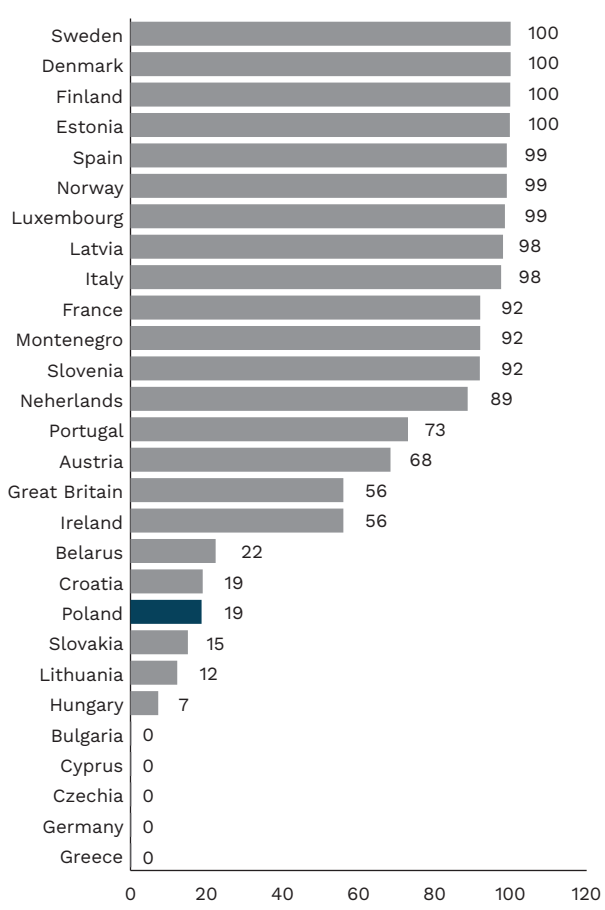
▶ **In 2022, 18.7% of Polish households were equipped with a smart meter.** ACER noted that thirteen EU Member States had successfully completed the roll-out of smart meters, achieving a minimum penetration of 80%, while five countries reported no roll-out. As of 2023, Poland had a total of 5.26 million remote meters installed. According to the timetable established in the amendment to the Energy Law, operators in Poland were to install remote electricity meters at

18.7%

share of household consumers equipped with a smart meter in Poland in 2022

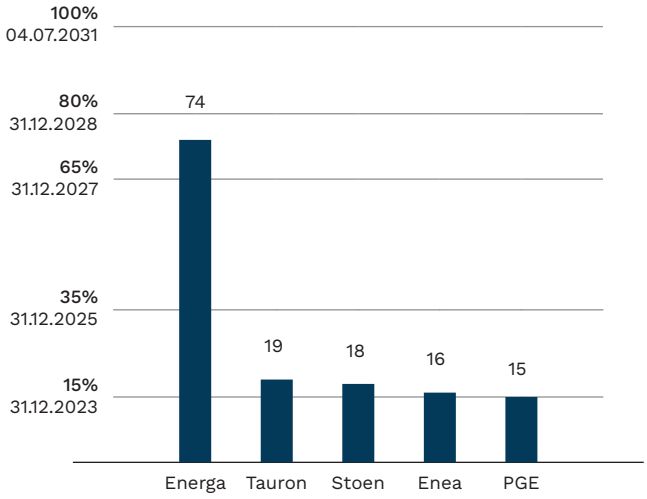
15% of energy consumption points by the end of 2023. Energa, Tauron, Stoen, Enea, and PGE all met this target for 2023. The target for the end of 2025 is 35%, followed by 65% in 2027, 80% in 2028, and 100% by July 4, 2031. Currently, the leader in implementing smart meters in Poland is Energa, with 2.5 million remote meters installed by the end of 2023, covering 74% of its customers connected to the grid and 48% of all remote meters in the country. Energa aims to provide all its customers with remote metering by the end of 2026. It appears feasible for all of companies mentioned to achieve the stated goals of 100% in 2031 at this point.

Figure 5.3. Share of households equipped with a smart meter in Europe in 2022 (%)



Source: ACER and CEER.

Figure 5.4. The level of achievement of the statutory objectives for the installation of remote electricity meters (%)



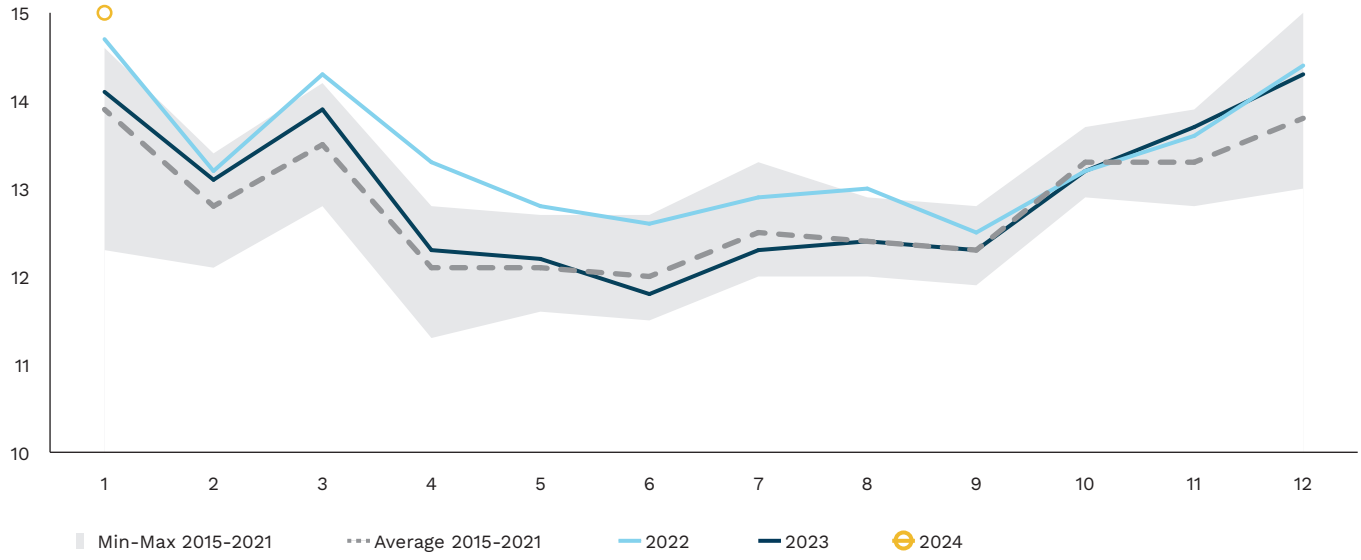
Source: WysokieNapiecie.pl based on companies' data.

6%

YoY increase in electricity demand in Poland in January 2024

▶ **Electricity demand in January 2024 in Poland was nearly 15 TWh, according to Ember. This was 6% more than in 2023 and 8% more than the average for 2015-2021.** One of the most important benefits of smart meters is their ability to enable demand response programmes, which are designed to dynamically reduce demand during peak periods. According to market analysts, the communication between energy suppliers and customers ensured by smart meters appears to have helped overcome the energy crisis. According to ACER, a full roll-out of smart meters with additional solutions will create a more active and flexible market. It can lead to a greater reduction in household electricity demand. Grid investment in Poland could reach PLN 500 billion by 2040. With smart meters, the distribution grid can be better planned and the costs for installation can be reduced.

Figure 5.5. Monthly electricity demand in Poland (in TWh)



Source: Ember.

The Polish Economic Institute

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Polish Economic Institute

Contact
Jakub Rybacki
Head of the Macroeconomics Team
jakub.rybacki@pie.net.pl
phone: 48 512 275 365