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Oleksandr Soboliev[1], Tetiana Zatonatska[2], Dmytro Zatonatskiy[3]

The influence of migration processes on the energy policy of the EU countries

Abstract: The European Union's (EU) flagship packages – Fit for 55, REPowerEU and member-state National Energy and Climate Plans (NECPs) – aim to accelerate the shift toward renewables, yet they downplay two fast-moving demand drivers: digitalization and migration. Guided by the hypotheses that (H1) these forces have become central to governmental agenda- setting and (H2) they exert a strong, quantifiable impact on energy-policy trajectories, this study analyses annual data for France, Germany, Poland and Czechia from 2000 to 2021. Country-specific ordinary-least-squares models link electricity or primary-energy demand to household ICT penetration, net migration flows, investment and macro-controls. Results show that a 1-percentage-point rise in ICT access increases electricity use in Poland (+0.31%) and Czechia (+0.19%) but reduces primary-energy demand in Germany (–0.42%) and France (–0.25%). An additional 100,000 migrants consistently raises demand by 0.10–0.17% across the four countries. Scenario extensions that account for post-2022 Ukrainian refugee inflows and rapid data-centre growth indicate that current NECP benchmarks could understate 2030 electricity demand by roughly 4–6 TWh, complicating

✉ Corresponding Author: Oleksandr Soboliev; e-mail: oleksandr.soboliev@knu.ua

[1] Economic Faculty, Department of Management of Innovation and Investment Activity, Taras Shevchenko National University of Kyiv, Ukraine; ORCID iD: 0009-0002-4299-8334; e-mail: oleksandr.soboliev@knu.ua

[2] Economic Faculty, Department of Economic Cybernetics, Taras Shevchenko National University of Kyiv, Ukraine; ORCID iD: 0000-0001-9197-0560; e-mail: tetiana.zatonatska@knu.ua

[3] SSI "Institute of Educational Analytics", Ukraine; ORCID iD: 0000-0002-4828-9144; e-mail: dzatonat@gmail.com

renewable-capacity rollout schedules. Incorporating digital- and migration-related elasticities into the 2026 NECP revisions would make national RES targets and grid-investment plans more robust under heightened demographic and technological uncertainty.

Keywords: energy consumption, migration, digitalization, modeling, energy policy, macroeconomic indicators, GDP, investments, ESG-based investments

Introduction

Achieving the Sustainable Development Goals (SDGs), particularly Goal 7 – "Ensure access to affordable, reliable, sustainable and modern energy for all" – remains a central challenge for global energy policy. Despite formal commitments, the current trajectory suggests that many countries, including EU Member States, are unlikely to meet their renewable energy targets within the SDG timeframe (The World Bank 2023). While long-term strategies such as Fit for 55, REPowerEU, and national-level NECPs (National Energy and Climate Plans) define explicit goals for the share of renewables in final energy consumption, their implementation faces mounting obstacles. These include not only structural issues like underinvestment and regulatory delays but also a rapidly evolving landscape of external drivers that have, until recently, received insufficient attention.

Among these emerging factors are: (i) the widespread acceleration of digitalization, including the exponential growth in data-center energy demand and the integration of AI into everyday systems; (ii) geopolitical instability, particularly the full-scale invasion of Ukraine by Russia, which has led to one of the largest forced migration flows in modern European history (Eurostat 2024); and (iii) the mass uptake of electric vehicles and electrification of transport, which significantly alters the expected structure of final energy demand. Each of these trends contributes to substantial uncertainty around previously forecasted energy balances, especially on the demand side.

In this context, governments are increasingly compelled to revisit and, in many cases, revise their existing energy strategies, including the feasibility of their RES (Renewable Energy Sources) targets. Traditional planning frameworks often assume stable or moderately growing demand profiles; however, current conditions indicate that energy consumption may rise far more rapidly than projected, particularly in countries that have experienced sharp digital infrastructure expansion or large migration inflows.

This article is built on two core hypotheses. First (H1), digitalization and migration are no longer peripheral but have become central processes shaping governmental agendas in energy and climate policy. Second (H2), both factors exert a statistically significant and policy-relevant influence on national energy policy trajectories, particularly in shaping electricity demand and hence the feasibility of meeting RES targets.

To address these questions, the paper employs country-level econometric models using annual data for France, Germany, Poland, and Czechia from 2000 to 2021. These countries represent diverse energy profiles, digitalization levels, and exposure to migration flows. The models quantify the elasticity of electricity and primary energy consumption with respect to ICT penetration and migration dynamics, with the aim of generating empirical inputs that can inform the revision of RES targets and national energy planning frameworks. By doing so, this study contributes to a more realistic assessment of demand-side pressures under current geopolitical and technological conditions, offering practical tools for future policy recalibration.

1. Literature review

The European Union (EU) has long been a destination for migrants from various parts of the world, driven by economic opportunities, political stability, and social welfare. Over the past few decades, the EU has witnessed significant changes in migration patterns, with increasing numbers of people moving within and into the region. This influx of migration flows has profoundly affected various aspects of life in the EU, including the consumption of energy resources. Understanding the interplay between migration and energy consumption is crucial for developing effective policies supporting sustainable development and energy efficiency in the region.

Over the past three decades, global migratory flows have significantly increased, reflecting profound economic, political, and environmental changes worldwide. In 1990, the number of international migrants stood at approximately 153 million. This figure rose steadily, reaching about 161 million in 1995 and growing almost 1.5 times to 221 million in 2010. The trend continued over another decade, with the migrant population growing to 281 million by 2020. This substantial increase can be attributed to globalization, economic disparities, conflicts, climate change, and improved transportation and communication networks, making migration more accessible and necessary for many people seeking better opportunities and safety (United Nations Department of Economic and Social Affairs 2024).

This global trend has notably impacted Europe. In Eastern Europe, the migrant population slightly decreased from approximately 22 million in 1990 to around 21 million in 2020. Conversely, Northern Europe saw a significant rise from about 7 million to nearly 15 million over the same period, more than double the amount. Southern Europe's migrant population grew even more dramatically, from approximately 4 million in 1990 to nearly 18 million in 2020, being a 4.5-time increase, reflecting the region's role as a primary entry point for migrants from Africa and the Middle East. Western Europe experienced the most substantial increase, from around 17 million in 1990 to over 33 million in 2020, driven by intra-EU migration and arrivals from non-EU countries. These statistics underscore migration's diverse and dynamic nature in Europe, highlighting the region's central role in global migratory patterns (United Nations Department of Economic and Social Affairs 2024; Cummings et al. 2015).

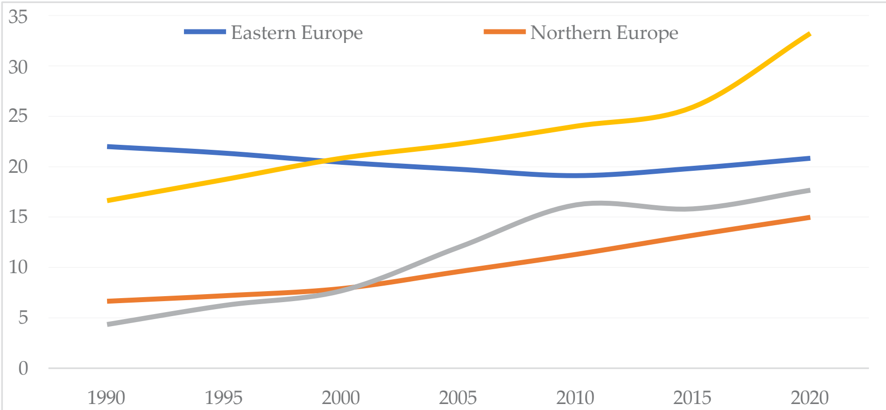

Fig. 1. International migrants in European regions over the last 3 decades [millions]
(United Nations Department of Economic and Social Affairs 2024)

Rys. 1. Migranci międzynarodowi w regionach europejskich w ciągu ostatnich trzech dekad [w milionach]

EU migration patterns significantly affect the region's demographic landscape and economic development. The influx of migrants, mainly from non-EU countries, has been driven by various factors, including economic opportunities, political instability, and environmental changes. These migration flows have increased cultural diversity and helped address labor shortages in various sectors, particularly in countries with ageing populations. However, migration also poses challenges, such as the need for effective integration policies and potential social tensions (Kumpikaite and Zickute 2012).

Migration has already been steadily increasing in Europe for a long time, but the Russian full-scale invasion of Ukraine in 2022 has significantly altered migration patterns in Europe.

As of May 31, 2024, over 4.25 million people (4,263,195) who fled Ukraine were under temporary protection in the EU. The countries hosting the most Ukrainian refugees were Germany (1,332,515 – 31.3% of the EU total), Poland (953,255 – 22.4%), and Czechia (356,405 – 8.4%). The EU's average was 9.5 refugees per thousand people, with the highest ratios in Czechia (32.9), Lithuania (27.2), and Poland (25.9). Compared to the beginning of 2024, the number of beneficiaries increased by 45,055 (+1.1%). Only France, Poland, and Latvia saw decreases, while Germany, Czechia, Romania, and Austria experienced significant increases. About 98.2% of those under temporary protection were Ukrainian. Other non-EU citizens included primarily Russians (12,690 – 0.3%), Nigerians (5,368 – 0.13%), and Azerbaijanis (4,504 – 0.11%). By the end of May 2024, 45.6% of beneficiaries were adult women, mostly aged 35 to 64. Children made up 32.5%, and adult men accounted for 21.9%. The proportion of adult men under temporary protection increased, reaching 34.4% in May 2024, up from 31.9% in early 2024. Conversely, the share of children decreased from 46.4% in early 2022 to 27.0% by early 2024. The share of adult women saw a slight decline, peaking at 50.1% in mid-2022 and dropping to 41.1% in early 2024 (Eurostat 2024).

This recent wave of migration comes on top of an already steady incline in migrant numbers in the EU, which has been a central topic of political debate. This prominence has grown even more due to the current crisis and has significantly changed many areas of life in the EU. For once, O. Oliinyk and co-authors, in their study on the impact of the migration of highly skilled workers on economic growth and national competitiveness (Oliinyk et al. 2021), investigated two main hypotheses: that migration can significantly influence the Global Competitiveness Index (GCI) and Gross National Income (GNI) per capita of a country. They employed a thorough methodology involving selecting and analyzing various global indices, such as the OECD talent attractiveness indicators, the Human Flight and Brain Drain Indicator, and the Global Talent Competitiveness Index. The study examined the relationship between migration factors and macroeconomic performance using correlation regression analysis with Pearson's correlation coefficients and the STATISTICA data analysis package. The findings confirmed strong links between the migration of highly skilled workers and enhanced competitiveness and economic growth. The study highlighted the importance of attracting highly educated immigrants and reducing brain drain to boost national competitiveness and GNI per capita.

Mihi-Ramirez and co-authors made a similar finding in (Mihi-Ramírez et al. 2016), investigating the impact of innovation on the migration of highly skilled workers. The research analyzes international data on patents, research and development funding, and scientific publications using regression analysis. The findings reveal a significant positive correlation between these innovation indicators and the influx of highly skilled immigrants, suggesting that countries with robust innovation ecosystems attract more talented individuals.

One study examines the motivations behind labor migration from the EU8+2 countries (newer EU members) to the EU-15 countries (older EU members). It finds that differences in earnings, productivity, and welfare state generosity play significant roles in migration decisions. Generous welfare states tend to attract "unfavorable" migrants, who may be less economically beneficial. In contrast, less generous states attract "favorable" migrants, who are more likely to contribute positively to the economy. The authors highlight the impact of welfare policies on migration patterns and suggest that more generous welfare states might need to address potential economic challenges associated with the influx of less favorable migrants. These combined insights suggest that economic incentives (like earnings and productivity) and social policies (like welfare generosity) are crucial in shaping migration flows. So, in order to be able to control these flows, especially aiming to attract high-skilled talent, countries need to consider not only creating favorable economic conditions and innovation ecosystems but also designing welfare policies that attract economically beneficial migrants while managing the potential downsides of generous welfare regimes (Josifidis et al. 2014).

However, there is even more nuance in the influence of migration on the labor market. Přívara and co-authors investigate the impact of migration processes on labor market indicators in selected European Union (EU) member-states (Přívara et al. 2023). Their primary goal was to estimate the effects of immigration, emigration, and migration of asylum seekers on unemployment rates, average annual wages, and overall labor market competitiveness. They employ panel data analysis using yearly data from 2003 to 2019 to achieve this. The results reveal that while immigration of highly qualified and skilled migrants positively influences the recipient country's labor market competitiveness, which was previously mentioned, conversely, an increase in asylum applicants has a negative impact. At the same time, emigration leads to lower competitiveness due to "brain drain" (Přívara et al. 2023). Zatonatska and co-authors analyzed how migration and shifts in the population's age structure affect government spending on education and health care in Ukraine (Zatonatska et al. 2023; Zatonatska et al. 2022a). Also, authors (Zatonatska et al. 2022b) predicted that the most significant increase in ICT employment would occur by 2023, after which employment growth in the sector would slow.

Additionally, a study by Cristea and Grabara (2019) investigates the fiscal impact of migration in six European Union (EU) member states, aiming to summarize the current situation regarding the evolution of the migration phenomenon and its relation to fiscal revenues and budget expenditures with social benefits. The research focuses on two categories of countries: emerging economies (Romania, Poland, and Slovenia) and developed economies (Germany, Italy, and Spain). The authors employ descriptive, comparative, and statistical techniques to achieve this, analyzing data over 11 years (2007–2017). Notably, the study finds that the population from emerging countries serves as a secure long-term labor force for developed countries. At the same time, emigrants represent a net fiscal and economic loss for their countries of origin. Taxes and fees, however, are not the primary factors influencing people's decisions on where to live and work (Cristea and Grabara 2019).

Most literature mainly explores the influence of migration on the labor market, which makes sense as it is one of the primary drivers for migratory behavior in the first place. We can confidently say that immigration positively affects national income within the European Union. The EU's free mobility among Member States has made certain countries attractive destinations due to favorable working conditions and employment opportunities for other migrants outside the EU borders. The concept of "immigration surplus" suggests that immigration can trigger a process of wealth redistribution, leading to increased production and national income. Immigrants' deeper integration into host countries contributes to higher economic success. That being said, depending on the kind of migrant inflow, the outcome for the recipient country can vastly vary (Gallardo et al. 2016; Dluhopolskyi et al. 2019; Koshulko and Dluhopolskyi 2022).

It is evident that migration significantly impacts the labor market. However, migration also substantially influences other sectors beyond labor markets, including healthcare. As migrants move across borders, they bring diverse health needs, cultural practices, and epidemiological risks. It places additional demands on healthcare systems, affecting resource allocation, service delivery, and overall population health. One article explores the impact of migration on European healthcare systems. The authors assess the complexity of migrant health needs and review healthcare provision models across Europe. They found that migration affects the demand and supply of healthcare services, but the impact varies widely among countries. The study concludes that while migration benefits public finances in some contexts, it also presents challenges for healthcare systems adapting to a more diverse population (Francesca and Petretto 2019).

Not only is there a problem with an additional strain on healthcare systems of country-recipients because of increased demand for healthcare service, but there is also a discrimination issue evident in these two articles, one of which investigated barriers faced by migrants in accessing healthcare in Europe by employing a mixed-methods approach, combining quantitative data from surveys and qualitative insights from interviews, whilst another used scoping review methodology, analyzing 77 papers published from 2011 onwards in various languages. Both articles concluded that there are significant issues with healthcare discrimination and a lack of adequate translation services, leading to disparities in healthcare access and quality for migrant populations compared to native populations. Results also highlight the prevalence of unmet healthcare needs, particularly in mental and dental health, as well as in preventive care and long-term care for the ageing migrant population (Gil-Salmerón et al. 2021; Lebano et al. 2020). As migration continues to shape the labor market and healthcare sector, it is crucial to consider its effects on another vital aspect of national economies: the housing sector. The influx of migrants creates a demand for jobs and healthcare services and a significant need for housing. It is well established that the movement of people influences housing markets in various ways worldwide, from altering demand dynamics to affecting housing affordability and availability. Multiple articles explore the intricate relationships between commuting patterns, migration, housing, and labor markets. Their findings reveal that migrants significantly impact the housing sector by increasing demand, leading to higher housing prices and altered housing availability. In turn, affects local labor markets by influencing where people live and work, highlighting the need for integrated housing and labor market policies to manage these interactions effectively (Haas and Osland 2014; Zabel 2012).

The interrelationship between migration and housing markets has been a critical area of study in understanding economic and social dynamics, specifically within countries in the EU, as this is one of the primary destination regions for migratory flows. In Germany, the study by N. Stawarz and co-authors examines the effect of rising housing costs on migration patterns. Utilizing fixed effects Poisson panel regression models on data from 2004 to 2017, the authors demonstrate that increasing housing costs significantly influence migration flows. Urban areas with high housing costs experience reduced in-migration and increased out-migration, especially among tenants with lower socio-economic status. This underscores the necessity for policy interventions to address housing affordability and manage internal migration more effectively, promoting balanced regional development (Stawarz et al. 2021).

Similarly, Larionescu's research investigates the effects of international migration on housing practices and living standards in a rural Romanian village. Through qualitative methods, including participant observation and semi-structured interviews conducted from 2009 to 2011, Larionescu reveals that migrants invest their earnings in constructing homes that symbolize social success and improved status. These homes reflect a blend of traditional and modern influences, highlighting the significant role of remittances in shaping the housing sector in rural Romania. These homes' construction improves living standards and stimulates the local industry (Larionescu 2012).

In Slovakia, Sika and Vidová (2017) explore the interaction between internal migration and housing dynamics. The authors use data from the Slovak Statistical Office, the National Bank of Slovakia, and ARIMA statistical modeling to understand how high private home ownership rates hinder labor mobility despite significant regional economic disparities. The study highlights that regional housing cost imbalances are a significant barrier to labor mobility, with high housing prices in economically developed areas preventing people from migrating there. The authors argue for the need to increase the availability of rental housing to enhance labor mobility and reduce unemployment.

These studies collectively illustrate several common themes. Rising housing costs and high home ownership rates pose significant barriers to migration, leading to socio-economic segregation and regional economic disparities. In Germany and Slovakia, the high cost of urban housing discourages immigration and traps lower-income residents in less economically vibrant areas. In Romania, while remittances from international migrants contribute positively to housing construction and local economies, they can also lead to housing market inflation, making it difficult for non-migrants to afford homes. Migrants influence housing markets both positively and negatively. On the positive side, the investment of remittances in housing construction boosts local economies and improves living standards, and redistributing population due to high housing costs can alleviate urban overcrowding. However, the negative impacts are also significant, where high housing costs drive out lower-income residents, leading to socio-economic segregation and potential housing shortages in affordable regions.

It has been proven that migration exerts multifaceted effects on various spheres of a country's life, impacting the labor market, healthcare, and housing sectors, to name a few, in complex and significant ways. These impacts can be positive and negative, reshaping economic opportunities, social services, and living conditions. However, one of the critical areas that remains vastly understudied is the impact of migration on energy consumption, especially in the European Union. This issue is particularly pressing given the EU's commitment to achieving maximum environmental sustainability, the recent influx of Ukrainian migrants into the EU, and the EU's role in exporting energy to Ukraine amidst the ongoing conflict and destruction of Ukrainian energy infrastructure by Russia.

There needs to be more studies exploring the impact of migration on energy consumption, particularly in the European Union and its member countries. This gap in research makes it challenging to develop comprehensive policies addressing the intersection of migration and energy use. However, several articles have made significant contributions to elucidating this matter. The article by S. Komatsu and co-authors used a propensity score matching method to compare energy consumption patterns between migrant and non-migrant households in Hanoi, Vietnam (Komatsu et al. 2013). They find that rural-to-urban migrants initially consume less energy but gradually adopt urban residents' higher energy consumption patterns. This transition highlights a positive effect in reducing energy use initially, but a potential negative long-term impact as consumption increases.

Similarly, another work employs statistical analysis and econometric modeling to examine how migration affects energy consumption and carbon emissions across Chinese regions. The authors find that urban areas experience increased energy demand and emissions due to population density increases driven by migration. This underscores the dual impact of migration, where urbanization initially leads to higher energy use and emissions but also brings opportunities for more efficient energy use through better infrastructure and urban planning (Bu et al. 2022).

Additionally, R. Winkler and D. Matarrita-Cascante analyze the energy consumption patterns of international lifestyle migrants in Costa Rica using multilevel models (Winkler and Matarrita-Cascante 2020). They observe that lifestyle migrants from the Global North introduce higher energy consumption behaviors, negatively influencing local consumption patterns. This study highlights how international migration can export high-consumption lifestyles, increasing energy use and environmental impacts in destination countries.

A group of researchers in the article (Zatonatskiy et al. 2024) analyzed the impact of foreign direct investment on global migration flows and their features with the implementation of ESG investment principles. Investment inflows have been found to create new jobs, accelerate economic growth and improve the business climate, helping to reduce outflows and increase inflows of migrants. ESG-based investments also reduce emigration because they improve the quality of life in the host country, provide better environmental protection and promote more transparent corporate governance. Also, in (Zatonatska et al. 2024) authors embark on a crucial exploration of the implementation and integration of environmental, social, and governance (ESG) criteria within the energy sector of European countries, with the ultimate objective of refining the energy legislation in Ukraine.

The analyzed research demonstrates that migration processes exert a complex and multidimensional influence across economic, social, and infrastructural domains. While much of the existing research focuses on labor market dynamics, competitiveness, and public services, the evidence also highlights indirect but significant consequences for sectors such as housing, healthcare, and particularly energy demand. These effects vary depending on the type of migration (e.g., skilled labor vs. asylum seekers), the destination country's economic structure, and policy context. Despite the diversity of impacts, a recurring conclusion across studies is the growing need for migration-aware public policy, especially in areas such as energy planning, where these factors are often overlooked. To consolidate these insights and clarify their policy relevance, Table 1 provides a structured summary of the observed trends, their implications for government decision-making, the direction of impact, and corresponding sources.

In line with the study's second hypothesis, that digitalization significantly influences national energy policy through its effect on energy consumption, recent research has increasingly focused on the environmental and infrastructural consequences of advanced digital technologies. While digitalization has often been framed as a tool for improving energy efficiency at the micro level (e.g., through smart systems and demand forecasting), macro-level evidence increasingly suggests that it drives substantial new electricity demand. Particularly relevant are studies that examine the growing energy needs of artificial intelligence (AI), hyperscale data centers, and cloud computing infrastructures, all of which are rapidly expanding in the EU and globally. The following section reviews recent literature that empirically or conceptually supports this claim.

Pathan et al. (2025) present a critical investigation of the environmental externalities linked to AI development, focusing specifically on the energy and thermal loads associated with training large-scale AI systems such as large language models (LLMs). Their analysis reveals that while

Table 1. Summary of migration-related trends and their policy implications

Tabela 1. Podsumowanie tendencji związanych z migracją oraz ich implikacji dla polityki

Trend / Observed dependence	Implications for government policy	Direction
Migration of highly skilled workers increases national competitiveness and GNI per capita.	Need to adopt selective migration policies to attract and retain skilled labour.	Positive effect
Countries with strong innovation ecosystems attract more high-skilled migrants.	Innovation policies should be integrated with migration policy to support knowledge-based growth.	Positive effect
Migrants increase energy consumption; elasticities vary by country and migrant type.	Energy policy should incorporate demand impacts of migration in NECP and RES target planning.	Positive effect
Welfare generosity affects migrant selection: generous systems attract less economically active migrants.	Governments should balance welfare design with labour market goals to manage migration quality.	Mixed effect
Migrants increase pressure on healthcare systems, especially in mental and preventive care.	Health systems should be adapted to account for culturally diverse and growing migrant populations.	Mixed effect
Housing demand and prices rise with migration; affordability worsens for low-income groups.	Urban planning and affordable housing initiatives must respond to migration-driven demand.	Mixed effect
Migration of asylum seekers may negatively affect labour market competitiveness.	Policies should distinguish between refugee and economic migration in labour planning.	Negative effect
Emigration reduces labour competitiveness due to brain drain.	Retention strategies are needed to prevent outflow of national talent.	Negative effect
Migrants from high-consumption regions transfer their energy-use behaviour to host countries.	Cross-cultural energy behaviour must be factored into residential energy demand models.	Negative effect
ESG-oriented investment reduces migration outflows by improving quality of life.	Encourage ESG investment to mitigate economic push-factors for emigration.	Negative effect

Source: Zatonatskiy et al. 2024; Bu et al. 2022;Winkler and Matarrita-Cascante 2020; Uranbold and Lima 2025; Coveri et al. 2025; Kaluarachchi et al. 2025.

AI technologies may offer localized energy efficiencies, the aggregate energy demand driven by computational intensity, hardware requirements, and cooling systems results in a net negative impact on energy systems. The authors conclude that the expansion of AI infrastructure, if left unregulated, could undermine sustainability objectives and call for tighter regulatory oversight of energy-intensive digital technologies (Pathan et al. 2025).

Uranbold and Lima (2025) develop a quantitative framework to assess global electricity demand from data centers, emphasizing how AI and digital business models are triggering nonlinear growth in consumption. Using case studies from the US, EU, and East Asia, the authors conduct a comparative analysis of the levelized cost of electricity (LCOE) and policy responses to digital load surges. Their findings suggest that, without structural policy reforms, the energy use of digital infrastructures, especially those powered by AI, could double by the end of the decade. The study strengthens the argument that digitalization is no longer an efficiency tool alone but a core driver of new energy demand (Uranbold and Lima 2025).

The Bureau of Economic Geology (2025) investigates hyperscale data center proliferation in Texas, revealing how energy consumption from AI, cloud computing, and cryptocurrency facilities is beginning to rival that of traditional heavy industries. Based on regional grid data, the authors demonstrate that these centers draw gigawatt-scale loads, placing significant stress on infrastructure and requiring advanced grid planning interventions. Their analysis underscores that, even in deregulated markets, the energy cost of digitalization is escalating rapidly, confirming the hypothesis that digital infrastructure is a central and growing component of national energy consumption (Bureau of Economic Geology 2025).

Coveri, Cozza, and Guarascio (2025) approach the issue from a political economy perspective, connecting the expansion of digital and AI-powered infrastructure to national energy profiles. The study focuses on publicly supported deployments such as AWS Modular Data Centers and defense-oriented cloud systems, showing how state-aligned digitalization accelerates energy usage through military and surveillance applications. The authors argue that such expansion introduces a dual pressure: increasing total energy demand while bypassing green constraints due to security exemptions. The research supports the hypothesis by showing that digitalization is not just a market-driven phenomenon but is also embedded in state policy, thereby amplifying its systemic energy footprint (Coveri et al. 2025).

In a more technical contribution, Kaluarachchi et al. (2025) develop a hybrid engineering framework to optimize data center energy efficiency. While the study's main aim is to propose cooling and power management strategies, the authors acknowledge from the outset that data centers already consume nearly 2% of global electricity, a share projected to rise due to AI-related workloads. Their modeling affirms that despite optimization potential, the overarching trend of surging digital demand is unlikely to reverse, thereby supporting the need for policy-level integration of digital infrastructure into energy planning frameworks (Kaluarachchi et al. 2025).

Collectively, these studies reinforce the conclusion that digitalization, particularly in its AI- and data-driven forms, is a powerful driver of energy consumption in modern economies. Rather than merely a sectoral innovation enabler, digital infrastructure expansion is now a macroeconomic force reshaping electricity demand profiles. As such, it warrants explicit integration into national energy policy, especially in the context of long-term forecasting, renewable energy share planning, and grid investment strategies. The cumulative evidence strongly supports the study's hypothesis that digitalization significantly contributes to rising energy demand across both private and public sectors.

In the context of rapidly increasing electricity demand – driven by digitalization, electrification of transport and heating, and industrial decarbonization – multiple studies have raised concerns about the EU's ability to meet its renewable energy deployment goals. Although strategic packages such as Fit for 55, REPowerEU, and updated National Energy and Climate Plans (NECPs) outline ambitious renewable energy targets, implementation remains constrained by regulatory, technical, and economic factors. The following studies offer recent evidence that supports the view that RES expansion is lagging behind the pace required to ensure energy system adequacy under high-demand growth scenarios, reinforcing the policy relevance of forecasting tools that account for new demand-side pressures.

European Commission (2023) assesses the gap between Member States' draft updated NECPs and the EU's more ambitious 2030 climate and energy objectives under the European Green Deal and RePowerEU. The assessment shows that the draft plans did not yet provide a sufficiently robust trajectory to meet the updated EU targets, particularly in relation to renewable energy and energy efficiency contributions. It also highlights the need for Member States to strengthen national policy frameworks, define clearer implementation pathways, and align their plans with the revised 2030 objectives. This indicates a credibility and implementation gap between EU-level ambition and national delivery, suggesting that RES deployment and related policy measures need to be accelerated to reduce risks to energy security and target achievement.

Bachner et al. (2024) investigate the implementation challenges of REPowerEU, focusing on the post-2022 acceleration of energy policy reforms in response to geopolitical instability. They identify structural obstacles such as permitting delays, grid connection backlogs, and limited technical labor capacity. According to their analysis, by 2024, less than 20% of RES capacity planned for 2030 had entered the investment phase. The study concludes that these implementation failures pose a strategic risk to EU climate goals – particularly under rising electricity demand driven by AI, electric vehicles, and heat electrification.

European Parliament (2025) highlights that increasing flexibility is a central condition for integrating renewable electricity sources and supporting the electrification of end uses in the EU. The study shows that the future electricity system will require flexible generation, demand response, energy storage, and reinforced transmission and distribution networks to manage growing variability in supply and demand. It also emphasizes that inadequate market rules, regulatory frameworks, and economic barriers may slow the deployment of flexibility solutions. Therefore, renewable energy strategies and NECP implementation should be accompanied by stronger system-flexibility planning, grid modernization, and policy measures supporting system adequacy and resilience.

Wolniak et al. (2023) explore political, administrative, grid-infrastructural, and socioeconomic barriers to renewable energy development across EU countries. Through a comparative empirical analysis covering all EU member states, they show that barriers to RES deployment are not uniform across the EU and that political, administrative, and market-related barriers can significantly constrain renewable energy development, especially in some country groups. The authors emphasize that overcoming these barriers requires more coherent policy design and better institutional and infrastructural conditions.

The European Environment Agency (European Environment Agency n.d.) presents an official assessment of SDG 7 progress in the EU, with a focus on the renewable energy share in final consumption. The report acknowledges improvements in energy efficiency and emissions reduction, but stresses that the pace of RES development is "insufficient under rising demand". The EEA highlights that consumption from digital infrastructure, transport electrification, and industry is outpacing RES rollout, leading to an optimistic bias in EU projections. It recommends reorienting policy from purely decarbonization-focused to one that also safeguards energy adequacy and resilience.

Taken together, these studies highlight a critical disconnect between policy ambition and on-the-ground implementation in the EU's energy transition. While the stated RES targets are aligned with climate goals, their achievement is complicated by accelerating electricity demand and systemic constraints in infrastructure, permitting, and political capacity. The consistent call across the literature is for national governments to integrate dynamic demand projections into RES and NECP planning. In this context, empirical tools such as elasticity-based models of energy consumption driven by digitalization and migration can offer valuable input for more realistic and adaptive energy policymaking.

The literature consistently shows that migration and digitalization are among the most influential processes shaping energy demand in the EU, aligning directly with the hypotheses of this study. Migration affects energy systems through changes in consumption patterns, infrastructure requirements, and sectoral demand, with the magnitude and direction of the effect depending on migrants' origin, skill level, and integration. Digitalization – particularly the expansion of AI, cloud computing, and hyperscale data centers – is driving structural increases in electricity demand, often outpacing the planned deployment of renewable energy sources.

These processes do not act in isolation. The evidence reveals that they interact with a broader set of structural and transitional drivers, including:

1. Migration trends (scale, origin, skill level, settlement patterns).
2. Digitalization (AI, cloud computing, hyperscale, and modular data centers).
3. Electrification of transport (EV adoption, charging infrastructure).
4. Heat pump deployment (residential and commercial heating electrification).
5. Green hydrogen production (electrolyzer capacity expansion).
6. Geopolitical instability (energy security priorities, refugee flows).
7. Industrial transformation (shift to low-carbon manufacturing, electrified processes).
8. Urbanization and infrastructure development (housing, public transport).
9. Climate adaptation and resilience measures (e.g., cooling demand during heatwaves).

Together, these factors form an interconnected framework of demand-side pressures that influence the feasibility of achieving EU renewable energy and climate targets. Recognizing this integrated set of drivers is essential for designing policies that are both resilient to future demand shocks and realistic in their target-setting. In this context, the present study contributes by providing an elasticity-based assessment of how migration and digitalization, within the broader constellation of influencing factors, should inform the revision of RES share targets and energy consumption forecasts in EU policy planning.

2. Materials and methods

To assess the impact of migration processes and digitalization on the consumption of energy resources in EU countries (France, Germany, Czechia, and Poland), we built regression models based on statistical data for 2000–2021, based on indicators collected from open source databases. The target variable is "Energy Consumption TJ" for France, Czechia, and Poland, and "Primary Energy Consumption in PJ" for Germany. The influencing factors were divided into four groups:

- those that outline digitization: level of access and use of ICT by households (%), level of access to computers from home (% of households);
- indicators of the energy sector: time required to obtain electricity (days), fuel and energy costs (% of GDP);
- migration;
- macroeconomic indicators: GDP and investments.

The following hypotheses will be tested during the research.

- H1: The level of electricity consumption increases when the population's access to ICT increases. This hypothesis is explained by the fact that the use of ICT requires more energy, the support of servers, and digital solutions should also increase the amount of electricity consumed.
- H2: The level of electricity consumption grows when the number of migrants increases. An increase in the number of the population should lead to an increase in the consumption of electricity. At the same time, migrants may accept worse living conditions than the main population of the country, and therefore, the increase in electricity consumption may be insignificant. The hypothesis should determine the impact of migration processes.
- H3: The level of electricity consumption increases when the time required to get electricity decreases. A delay in connecting to the power grid can significantly slow down business and economic processes. At the same time, fast connection procedures can allow significant development of industrial and service enterprises, and, accordingly, electricity consumption.

The data used in this analysis were compiled from reputable sources such as the World Bank for independent variables and the International Energy Agency (IEA) for energy consumption. These sources provided consistent and reliable datasets for the years 2000–2021. The dataset includes both dependent and independent variables relevant to the energy consumption in the studied countries. Each variable was carefully selected to ensure it adequately represented the trends in energy consumption and the potential impacts of migration and digitalization.

Key characteristics of the data include:

- temporal coverage: the dataset consists of annual data points for 22 years, providing sufficient data to conduct a robust regression analysis. The dataset spans over two decades, covering significant periods of technological advancement and migration patterns;
- geographical scope: the analysis focused on France, Germany, Czechia, and Poland, countries with diverse energy profiles and levels of digital infrastructure. The data encompasses four

EU countries, each with distinct economic structures and energy consumption patterns, which enhances the generalizability of the findings;

- variable types: the dataset includes continuous variables (e.g., GDP, energy consumption in TJ or PJ) and percentage-based indicators (e.g., level of ICT access).

All variables in the dataset were checked for stationarity using the Dickey-Fuller test in R-Studio. The results show that the data is non-stationary (p-value is higher than 0.05 for the original data and first differences). This conclusion indicates the growth trend in economic indicators and might influence the modeling results.

To model the relationship between the dependent variable (energy consumption) and the independent variables (digitalization, migration, and macroeconomic factors), we applied linear regression. Specifically, the method of Ordinary Least Squares (OLS) was used to estimate the parameters of the regression models.

OLS is a widely used method in regression analysis that minimizes the sum of the squared differences between the observed values and the values predicted by the model. This method is preferred due to its simplicity, interpretability, and efficiency in estimating linear relationships. The OLS method works by finding the line (in the case of a simple linear regression) or the hyperplane (in multiple regression) that best fits the data according to this criterion. The solution to this minimization problem gives the best-fitting linear relationship between the dependent and independent variables, ensuring the residuals (errors) are as small as possible in a squared sense.

$$\textit{Energy consumption} = \beta_0 + \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \beta_3 \cdot x_3 + \beta_4 \cdot x_4 + \beta_5 \cdot x_5 + \varepsilon \quad (1)$$

where:

Energy consumption – the dependent variable,
β_0 – the intercept,
$\beta_1, \beta_2, ..., \beta_N$ – the coefficients representing the impact of each independent variable $x_1, x_2,..., x_N$,
ε – the error term.

All models were thoroughly checked for adequacy, significance of factors. Additionally, we conducted several diagnostic tests to ensure their validity and reliability, including:

- **Multicollinearity:** checked using the Variance Inflation Factor (VIF) to ensure that the independent variables were not highly correlated with each other.
- **Stability:** assessed by examining the residuals for patterns that might indicate a misspecified model.
- **Autocorrelation:** assessed using the Durbin-Watson statistic to determine if residuals from the regression were independent of each other. It could indicate that the model errors are correlated over time.
- **Heteroskedasticity:** tested using the Breusch-Pagan test to check if the variance of the residuals was constant across observations.

These checks are crucial for confirming that the assumptions of linear regression are met and ensured the robustness and reliability of our regression models, providing confidence in the findings regarding the impact of migration and digitalization on energy consumption.

3. Results

We will consider the results for each of the countries below.

3.1. Poland

As can be seen from Table 2, according to the built model (adequate and with all significant factors with a probability 90%), the level of electricity consumption in Poland has a significant relationship with the level of migration and the level of access and use of ICT by households as a manifestation of the level of digitalization, which in turn confirms our hypotheses. Both indicators have a positive effect and, therefore, contribute to an increase in the country's electricity use level. In turn, it requires taking into account the further growth of the indicator and the increase in production capacity of the energy sector.

Table 2. Modeling results for the "Energy Consumption TJ" variable in Poland

Tabela 2. Wyniki modelowania dla zmiennej „Zużycie energii (TJ)" w Polsce

	Coefficients	Std error	T-statistics	P-value
Intercept	1,829 109.43	134 863.20	13.56	0.00
ICT access and usage by households	13,278.55	2,572.45	5.16	0.00
Migrants	1.31	0.68	1.93	0.07
Multiple R2				0.9522
R2				0.9066
Adjusted R2				0.8968
Std error				90,674.4617
Observations				22
F				92.219
P-value (F)				0.000

Source: authors' analysis based on the data (World Data Bank 2024; International Energy Agency 2024).

To build the outcome model for Poland, Formula (1) is used, but considering the fact, that some variables are insignificant, the final is presented in Formula (2):

$$Energy\ consumption = \beta_0 + \beta_1 \cdot ICT\ \ Access + \beta_2 \cdot Migrants + \varepsilon\varepsilon \tag{2}$$

The baseline energy consumption is estimated at 1,829,109.43 TJ when all other variables are zero. This coefficient is highly significant (p-value = 0.00). For every unit increase in ICT access and usage, energy consumption increases by 13,278.55 TJ. This effect is statistically significant, too (p-value = 0.00). Each additional migrant is associated with an increase of 1.31 TJ in energy consumption. This variable is not statistically significant at the 0.05 level but is close (p-value = 0.07). Considering the probability 90% the all variables are significant, so the model can be used for further analysis. The F-statistic is 92.219 with a corresponding p-value of 0.000, indicating that the model is statistically significant overall.

3.2. Czechia

As can be seen from Table 3, according to the built model (adequate and with all significant factors), energy consumption in Czechia has a significant relationship with the level of access and use of ICT by households, the level of access to computers (as manifestations of digitalization),

TABLE 3. Modeling results for the variable "Energy Consumption TJ" in Czechia

TABELA 3. Wyniki modelowania dla zmiennej „Zużycie energii (TJ)" w Czechach

	Coefficients	Std error	T-statistics	P-value
Intercept	1,042 619.875	115 791.956	9.004	0.000
ICT access and usage by households	4,376.742	2,285.840	1.915	0.073
Access to computers from home (% of all households)	–4,975.680	2,046.420	–2.431	0.026
Time required to get electricity (days)	789.804	510.602	1.547	0.100
Migrants	0.733	0.302	2.428	0.027
Multiple R2				0.795
R2				0.632
Adjusted R2				0.545
Std error				26,428.515
Observations				22
F				7.298
P-value (F)				0.001

Source: authors' analysis based on the data (World Data Bank 2024; International Energy Agency 2024).

the indicator of time to obtain electricity (in these days), as well as with the level of migration. The increase in migrants is one of the factors determining the increase in consumption in Czechia. It requires forecasting migration waves and considering their impact on the energy sector, ensuring an increase in production and investment in this sector.

To build the outcome model for Czechia, Formula (1) is used, but considering the fact, that some variables are insignificant, the final is presented in Formula (3):

$$\begin{gathered} Energy\ consumption = \beta_0 + \beta_1 \cdot ICT\ \ Access + \beta_2 \cdot Access\ to\ computers + \\ \beta_3 \cdot Time\ required\ to\ get\ electricity + \beta_4 \cdot Migrants + \varepsilon \end{gathered} \tag{3}$$

The baseline energy consumption is estimated to be 1042619.88 TJ when all other variables are zero. This coefficient is highly significant (p-value = 0.000). For every unit increase in ICT access and usage, energy consumption increases by 4376.74 TJ. However, this effect is not statistically significant at the 0.05 level (p-value = 0.073) but is close. Considering the probability 90% the all variables are significant, so the model can be used for further analysis with the current set of independent variables. Each percentage increase in households with access to computers is associated with a decrease of 4,975.68 TJ in energy consumption. This coefficient is statistically significant (p-value = 0.026). For every additional day required to get electricity, energy consumption increases by 789.804 TJ. This variable is statistically significant at 0.1 level (p-value = 0.100). Each additional migrant is associated with an increase of 0.733 TJ in energy consumption. This coefficient is statistically significant at the 0.1 and 0.05 levels (p-value = 0.027). The F-statistic is 7.298 with a p-value of 0.001, indicating that the model is statistically significant overall.

3.3. Germany

As can be seen from Table 4, primary energy consumption has a significant relationship with the level of access and use of ICT by households and the level of fuel and energy costs. The connection with the level of migration turned out to be insignificant. However, strengthening such a relationship is possible starting in 2022 due to a large migration wave in Europe, but there needs to be more data to confirm it. In general, the model is adequate; all variables are significant, with a reliability level of 95%, which makes it possible to argue the obtained conclusions.

To build the outcome model for Germany, Formula (1) is used, but considering the fact, that some variables are insignificant, the final is presented in Formula (4):

$$Energy\ consumption = \beta_0 + \beta_1 \cdot ICT\ \ Access + \beta_2 \cdot Fuel\ and\ energy\ expenditure + \varepsilon \tag{4}$$

The baseline primary energy consumption is estimated at 21830.06 PJ when all other variables are zero. This coefficient is highly significant (p-value = 0.000). For every unit

Table 4. Modeling results for the variable "Primary energy consumption in PJ" in Germany

Tabela 4. Wyniki modelowania dla zmiennej „Zużycie energii pierwotnej w PJ" w Niemczech

	Coefficients	Std error	T-statistics	P-value
Intercept	21,830.056	800.843	27.259	0.000
ICT access and usage by households	–91.256	8.984	–10.158	0.000
Expenditure on fuel and energy (% of GDP)	–239 855.920	73 815.926	–3.249	0.004
Multiple R2				0.919
R2				0.845
Adjusted R2				0.828
Std error				321.841
Observations				22
F				51.637
P-value (F)				0.000

Source: authors' analysis based on the data (World Data Bank 2024; International Energy Agency 2024).

increase in ICT access and usage, primary energy consumption decreases by 91.26 PJ. This effect is statistically significant, too (p-value = 0.000). A 1% increase in expenditure on fuel and energy as a percentage of GDP is associated with a decrease of 239,855.92 PJ in primary energy consumption. This coefficient is also statistically significant (p-value = 0.004). The F-statistic is 51.637 with a p-value of 0.000, indicating that the model is statistically significant overall.

3.4. France

As Table 5 shows, according to the built model (adequate and with all relevant factors), electricity consumption in France has a significant relationship with household access to and use of ICT, the indicator of time to receive electricity (in days), and migration and investment levels.

To build the outcome model for France, Formula (1) is used, but considering the fact, that some variables are insignificant, the final is presented in Formula (5):

$$\begin{gathered} Energy\ consumption = \beta_0 + \beta_1 \cdot ICT\ \ Access + \beta_2 \cdot Time\ required\ to\ get\ electricity + \\ \beta_3 \cdot Migrants + \beta_4 \cdot Investments + \varepsilon \end{gathered} \tag{5}$$

The baseline value of the dependent variable is estimated to be 7,350,726.999 units when all other variables are zero. This coefficient is highly significant (p-value = 0.000). For every unit increase in ICT access and usage, the dependent variable decreases by 28,792.574 units. This effect is statistically significant (p-value = 0.002). For every additional day required to get

Table 5. Modeling results for the "Energy Consumption TJ" variable in France

Tabela 5. Wyniki modelowania dla zmiennej „Zużycie energii (TJ)" we Francji

	Coefficients	Std error	T-statistics	P-value
Intercept	7,350 726.999	870 168.350	8.447	0.000
ICT access and usage by households	–28 792.574	7,725.171	–3.727	0.002
Time required to get electricity (days)	15 838.180	6,296.902	2.515	0.022
Migrants	1.405	0.941	1.494	0.053
Investments	4.086	1.343	3.042	0.007
Multiple R2				0.929
R2				0.864
Adjusted R2				0.832
Std error				129,379.582
Observations				22
F				26.981
P-value (F)				0.000

Source: authors' analysis based on the data (World Data Bank 2024; International Energy Agency 2024).

electricity, the dependent variable increases by 15,838.180 units. This coefficient is statistically significant (p-value = 0.022). Each additional migrant is associated with an increase of 1.405 units in the dependent variable. This variable is not statistically significant at the 0.05 level but is close (p-value = 0.053). With probability 90%, this variable is significant, so it is possible to use the model with the current set of variables. The dependent variable increases by 4.086 units for every unit increase in investments. This effect is statistically significant (p-value = 0.007). The F-statistic is 26.981 with a corresponding p-value of 0.000, indicating that the model is statistically significant overall.

So, summing up, most of the studied countries are characterized by a rapid increase in the level of energy consumption, in particular electricity. Modeling results suggest that the level of digitalization is delineated by the level of access and use of ICT by households and by the availability of computers to households. In addition, the level of migration has a significant impact, the importance of which has increased rapidly after 2022, after the start of the war in Ukraine, and has become one of the most significant migration crises. Models were estimated till the 2021, but there is a significant positive influence on migration (for example, in France, Poland, and Czechia), and we predict a significantly higher contribution of these factors to the dynamics of energy consumption since 2022. Under such conditions, an active state policy that considers the identified trends is an urgent task for the government. Considering the significant impact of the war and the energy crisis, the stimulation of the development of the energy sector and investment in it will ensure a solution to the problem and the country's stable development.

Forming an effective energy policy, considering the influence of the outlined factors, is necessary for developing the energy sector.

Thus, 3 key directions can be outlined:

- digitization: in all countries, the level of access to ICT is a significant factor affecting energy consumption. Indicates the growing role of digital technologies in everyday life and their impact on the energy sector;
- migration: a significant impact of migration processes on energy consumption is observed. It makes it necessary to take migration waves into account when planning energy policy;
- energy investments: investments in the energy sector are essential to meet the growing energy demand. It includes not only the expansion of production capacity but also the development of infrastructure that supports the efficient use of energy.

Discussion and conclusions

Based on the obtained results, it is possible to formulate the following conclusions in terms of the countries under study:

1. As for Poland, the results suggest that ICT access and usage strongly predict energy consumption, while the number of migrants has a more minor, less significant impact.
2. As for Czechia, the results suggest that access to computers and the number of migrants significantly impact energy consumption, with the model explaining a moderate proportion of the variability in energy consumption. ICT access and the time required to get electricity have more minor and less significant effects.
3. As for Germany, the results suggest that ICT access, usage, and expenditure on fuel and energy are significant predictors of primary energy consumption, with the model explaining a large proportion of the variability in energy consumption. Both variables hurt energy consumption, meaning that increases in these factors are associated with decreases in primary energy consumption.
4. For France, the results suggest that ICT access and usage, the time required to get electricity, and investments are significant predictors of the dependent variable. The model explains a large proportion of the variability in the dependent variable, with ICT access having a negative impact and the time required to get electricity and investments having a positive impact. The number of migrants is less significant but still shows a positive trend.

The analysis of the hypotheses put forward in the study showed that, in general, by country, they received some partial confirmation. In particular, electricity consumption increases when the population's access to ICT (hypothesis H1) increases in Poland but decreases in Czechia, Germany, and France. This situation can be explained by the fact that in more developed countries, the green transition and the use of alternative energy sources are happening at a faster pace than the growth of digital technologies. This is because the level of digitization of such societies is already quite high, and therefore, it is already difficult to expect a significant increase.

Testing of hypothesis H2 showed that migrants play a positive role in increasing electricity consumption in all countries except France. This result can be primarily related to the insignificant level of migration to France in comparison with Poland, Germany, and Czechia in the conditions of the European war.

Finally, when testing hypothesis H3, it was found that the time required to connect to electricity networks is a statistically significant indicator only in France, where each day of reduction in connection time will significantly increase electricity consumption. In other countries, this indicator does not play a significant role, which means that the business can find alternative sources of energy.

The study showed that the level of energy consumption significantly depended on the level of access to information and communication technologies (ICT) in previous periods, especially until 2020. This is because increased access to ICTs, such as the Internet and computers, has led to changes in consumption and production processes, which in turn affect energy demand.

However, with the saturation level of access to ICT, which has exceeded 90% in most EU countries, the role of this factor in the further dynamics of energy consumption will gradually decrease. Accordingly, the influence of other factors becomes more important, and they will determine future trends in energy consumption. Analysis of these factors will be the area of future research.

Potential factors affecting the future dynamics of energy consumption are energy efficiency and technological innovation, environmental policy and regulatory measures, migration processes and demographic changes, economic growth, and investment.

Increasing attention to energy efficiency, the introduction of new technologies, such as smart grids and energy-saving technologies, can have a significant impact on reducing energy consumption. Changes in legislation aimed at reducing gas emissions and switching to renewable energy sources may significantly change the structure of energy consumption in the coming years.

Demographic changes associated with migration and aging of the population can affect the demand for energy resources, both due to changes in the number of consumers and changes in the nature of consumption. Recovery and growth of the economy after periods of crisis, together with investment in production and infrastructure, will influence the increase in demand for energy, especially in the industrial sector.

Thus, the future dynamics of energy consumption in the EU countries will be determined not so much by the level of access to ICT, but by a complex of other factors that are becoming more and more important in today’s conditions.

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Oleksandr Soboliev, Tetiana Zatonatska, Dmytro Zatonatskiy

Wpływ procesów migracyjnych na politykę energetyczną państw UE

Streszczenie

Flagowe pakiety Unii Europejskiej (UE) – „Fit for 55", „REPowerEU" oraz krajowe plany energetyczno-klimatyczne (NECP) państw członkowskich – mają na celu przyspieszenie przejścia na odnawialne źródła energii, jednak pomijają dwa szybko zmieniające się czynniki wpływające na popyt: cyfryzację i migrację. Opierając się na hipotezach, że (H1) siły te stały się kluczowe dla ustalania agendy rządowej oraz (H2) wywierają one silny, wymierny wpływ na trajektorie polityki energetycznej, niniejsze badanie analizuje dane roczne dla Francji, Niemiec, Polski i Czech z lat 2000–2021. Modele uzyskane metodą najmniejszych kwadratów dla poszczególnych krajów łączą popyt na energię elektryczną lub energię pierwotną z penetracją technologii informacyjno-komunikacyjnych (ICT) w gospodarstwach domowych, przepływami migracyjnymi netto, inwestycjami oraz czynnikami makroekonomicznymi. Wyniki pokazują, że wzrost dostępu do technologii informacyjno-komunikacyjnych o 1 punkt procentowy zwiększa zużycie energii elektrycznej w Polsce (+0,31%) i Czechach (+0,19%), ale zmniejsza zapotrzebowanie na energię pierwotną w Niemczech (–0,42%) i Francji (–0,25%). Dodatkowe 100 000 migrantów konsekwentnie podnosi popyt o 0,10–0,17% we wszystkich czterech krajach. Rozszerzenia scenariuszy uwzględniające napływ uchodźców z Ukrainy po 2022 r. oraz szybki rozwój centrów danych wskazują, że obecne wskaźniki NECP mogą zaniżać zapotrzebowanie na energię elektryczną w 2030 r. o około 4–6 TWh, co komplikuje harmonogramy wdrażania mocy odnawialnych. Uwzględnienie elastyczności związanych z cyfryzacją i migracją w aktualizacjach NECP na 2026 r. sprawiłoby, że krajowe cele w zakresie odnawialnych źródeł energii oraz plany inwestycji w sieć energetyczną byłyby bardziej solidne w obliczu zwiększonej niepewności demograficznej i technologicznej.

Słowa kluczowe: zużycie energii, migracja, cyfryzacja, modelowanie, polityka energetyczna, wskaźniki makroekonomiczne, PKB, inwestycje, inwestycje oparte na kryteriach ESG