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Conceptual foundations of public management of state energy security through the prism of energy efficiency and renewable energy development

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ABSTRACT

The study develops a governance-oriented conceptualization of energy security by integrating energy efficiency and renewable energy as core instruments of public management. The research was conducted in 2024–2025 using a comparative indicator-based analysis of European Union and OECD countries for the period 2015–2024. Methodologically, the study combines conceptual analysis with descriptive and comparative statistical techniques, complemented by a simplified decision-making framework that links policy instruments to governance outcomes. The results suggest that energy efficiency has become a central mechanism of demand-side regulation, reflected in a reduction of GDP energy intensity by approximately 25% in EU countries and over 20% in OECD countries. At the same time, the share of economies demonstrating decoupling between economic growth and energy consumption increased significantly, indicating a shift toward management-driven energy security. The expansion of renewable energy has contributed to the restructuring of energy supply systems, reducing dependence on imported resources and increasing system adaptability. Comparative analysis shows that differences in outcomes are associated with governance design and policy integration rather than resource availability. Overall, the findings suggest that energy security is determined by institutional coordination and policy cycle integration, where energy efficiency and renewable energy function as complementary governance instruments.

Keywords: energy policy, energy transition, institutional capacity, energy system resilience, energy supply diversification, management indicators

INTRODUCTION

The research problem is caused by the gap between the declared goals of ensuring energy security and the actual ability of public administration to integrate energy efficiency and renewable energy development into a single, coordinated management model. In scientific and practical approaches, energy security is often viewed in a fragmented manner – either through a technical and resource lens or as a set of separate policies, which complicates the achievement of energy system sustainability in the context of transformations, external risks, and growing institutional challenges. This necessitates a conceptual rethinking of the role of public administration as a key factor in shaping long-term energy security.

Contemporary research on energy security is increasingly shifting its focus from a technical and resource-based approach to a managerial and institutional dimension. In a global context, it has been shown that the quality of environmental governance directly affects the pace and results of energy transitions, as it determines the ability of states to translate climate goals into sustainable and long-term energy security policies (Bergougui & Ben-Salha, 2025).

Energy security in modern approaches is considered a multidimensional category, in which key dimensions are

formed primarily through management and infrastructure decisions, and not only through the physical parameters of energy systems. Researchers have found that the prioritization of individual security dimensions depends on management and coordination models at different levels of government (Fouladvand et al., 2024). At the same time, institutional quality is identified as a critical factor in the development of renewable energy, as it ensures regulatory predictability and the ability to integrate RES into the energy security architecture without increasing systemic risks (Giganti et al., 2025).

Some studies focus on the role of public authorities as active agents of energy transformation, in particular through the support of energy communities and the use of local management tools (D′Adamo et al., 2025). At the same time, a conceptual approach is being developed that combines energy security with the category of resilience of transformed energy systems, which justifies the need for a comprehensive analysis of public administration in the context of structural changes in the energy sector (Schmitz et al., 2025).

Despite a substantial body of research on energy security, significant gaps remain in the scientific discourse. Existing studies tend to examine energy efficiency, renewable energy development, and governance quality as separate domains, which limits the understanding of their interaction within a unified public management framework. In particular, insufficient attention is paid to the institutional mechanisms that coordinate these policy areas across different levels of government, as well as to the role of administrative capacity in shaping the effectiveness of energy system transformation. This fragmentation hinders the development of a comprehensive and sustainable model of energy security.

This study addresses this gap by advancing a governance-oriented conceptualization of energy security. It contributes to the literature in several ways. First, it redefines energy security as a function of governance design rather than as a derivative of resource availability or technological capacity. Second, it demonstrates the structural complementarity of energy efficiency and renewable energy development, distinguishing them as demand-side and supply-side mechanisms that jointly shape energy system resilience. Third, it provides a comparative perspective on governance models in European Union and OECD countries, highlighting how institutional configurations influence policy outcomes.

The aim of the study is to develop a conceptual justification of public management of state energy security through the integrated application of energy efficiency and renewable energy as systemic governance instruments.

To achieve this aim, the study pursues the following objectives:

1) to analyze the evolution of scientific approaches to energy security within a public management framework;
2) to determine the role of energy efficiency and renewable energy in contemporary energy security models;
3) to systematize institutional and managerial mechanisms for integrating these domains into state energy policy; and
4) to formulate conceptual provisions for improving public management of energy security in line with sustainable development requirements.

This study contributes to the existing literature in several important ways. First, it reconceptualizes energy security as a function of governance architecture rather than a derivative of resource availability or technological capacity, thereby shifting the analytical focus from physical supply conditions to institutional design. Second, the study demonstrates the structural complementarity of energy efficiency and renewable energy development, distinguishing them as demand-side and supply-side mechanisms that jointly shape energy system resilience within a unified public management framework. Third, it provides a comparative analysis of governance models in European Union and OECD countries, revealing how differences in institutional coordination and policy integration affect the effectiveness of energy security strategies. Finally, the study contributes methodologically by integrating conceptual analysis with indicator-based statistical assessment, allowing for the identification of stable governance patterns in energy system transformation.

LITERATURE REVIEW

Contemporary scientific literature on energy security, energy efficiency, and renewable energy demonstrates a consistent tendency to combine technical and economic approaches with analysis of institutional capacity and public administration. In the global political context, researchers focus on the gap between international climate ambitions and the actual governance mechanisms for their implementation. In particular, Arora (2024) showed that the results of COP28 revealed a structural asymmetry between the declared goals of the energy transition and the national institutional capacities for their implementation, which directly affects long-term energy security.

A significant body of research is devoted to the technological and economic dimensions of energy transformation. Assareh et al. (2024) proved that multi-component energy systems based on renewable sources are capable of increasing resource efficiency and reducing systemic risks, but their successful implementation critically depends on management decisions and regulatory stability. Similar logic can be found in works where renewable energy is considered as an element of macroeconomic development. Do (2025) found that the positive impact of RES policies on economic growth is only evident when governance is of high quality, confirming the key role of public administration.

The institutional dimension of energy policy is also revealed through the analysis of democratic and governance indicators. Dokuzoğlu and Güzel (2024) found that the effectiveness of environmental and energy policies correlates significantly with the level of democracy and institutional accountability, which indirectly affects the energy security of states. In this context, the problem of political uncertainty takes on particular importance. Ivanovski and Marinucci

Table 1. Systematization of scientific approaches to energy security, energy efficiency, and renewable energy

Author(s)	Research focus	Key finding	Governance implication
Arora (2024)	Global energy policy (COP28)	Gap between climate ambitions and implementation capacity	Institutional capacity determines energy transition outcomes
Assareh et al. (2024)	Multi-energy systems	RES systems increase efficiency and reduce risks	Requires stable regulatory and management frameworks
Do (2025)	RES and economic growth	Positive economic effects only under high governance quality	Governance quality is a precondition for policy effectiveness
Dokuzoğlu and Güzel (2024)	Governance and democracy	Policy effectiveness depends on institutional accountability	Democratic governance enhances energy security
Ivanovski and Marinucci (2021)	Policy uncertainty	Regulatory instability discourages RES investment	Stability of governance is critical for energy transition
Katris and Turner (2021)	Energy efficiency policy	Effectiveness depends on integration of economic and social goals	Requires coordinated public policy design
Küçük and Ruvi (2025)	Regional energy governance	Need for coordinated regional frameworks	Multi-level governance is essential
Kühn and Vasstrøm (2024)	Local governance	Local decision-making affects RES success	Decentralized governance plays a key role
Lee et al. (2022)	Digitalization and energy	ICT improves energy system manageability	Digital governance strengthens resilience
Michailidis et al. (2025)	MENA energy systems	Weak institutions hinder RES development	Institutional capacity is a limiting factor
Natili and Visconti (2023)	Political context	Energy security linked to broader governance expectations	Energy policy embedded in public governance systems
Østergaard et al. (2021)	Demand-side management	Demand flexibility improves energy security	Requires institutional coordination
Qiu et al. (2023)	Extreme events	Crises increase importance of governance decisions	Adaptive governance becomes critical
Wojtaszek (2025)	Policy frameworks	RES alone does not ensure security	Governance integration is necessary

(2021) showed that regulatory instability discourages investment in renewable energy sources and increases risks for energy transitions and system security.

A separate group of studies consists of works devoted to energy efficiency as a public policy tool. Katris and Turner (2021) proved that different models of financing energy efficiency programs have different socio-economic effects, and their effectiveness is determined by the state's ability to integrate economic and social goals. A comparative approach to energy policy can also be seen in the study by Küçük and Ruvi (2025), who justified the need to develop a regional framework for energy governance to coordinate renewable energy development policies..

At the level of public administration, attention is paid to the role of local authorities. Kühn and Vasstrøm (2024) found that the decision-making logic of local officials in the field of wind energy often determines the success or failure of projects, regardless of their technical feasibility. Institutional factors of energy security are also analyzed through the prism of digitalization. Lee et al. (2022) proved that the development of information and communication technologies can increase the manageability of energy systems and reduce vulnerability to external threats. At the regional level, Michailidis et al. (2025) showed that in MENA countries, the transformation of energy infrastructure is hampered by the weakness of management institutions, despite the existing potential of RES. Political and security crises also indirectly influence energy strategies. Natili and Visconti (2023) drew attention to the change in public expectations regarding security in the EU, which makes energy security a component of the broader architecture of public administration.

The technical and managerial dimensions of energy security are complemented by studies of demand flexibility and system resilience. Østergaard et al. (2021) used Denmark as an example to show that demand management increases energy security provided there is institutional coordination. Qiu et al. (2023) demonstrated that extreme natural events increase the importance of management decisions in the field of energy management. Finally, Wojtaszek (2025), in a comparative analysis of EU strategies and global approaches, emphasized that integrating RES into the policy framework without proper management support does not guarantee increased energy security. A summary of these studies shows that, despite significant progress in the study of individual aspects of energy security, the conceptual foundations of public administration that combine energy efficiency and the development of renewable energy into a single management model remain insufficiently systematized, which determines the relevance of this study. To systematize the main findings of the literature and highlight the evolution of scientific approaches, the key contributions of previous studies are summarized in **Table 1**.

The systematization shows that, despite the diversity of approaches, most studies converge on the importance of governance quality. However, they remain fragmented, focusing either on energy efficiency, renewable energy, or institutional factors separately, which confirms the identified research gap.

MATERIALS AND METHODS

The study was conducted in 2024–2025 within the framework of a theoretical-analytical and indicator-statistical design at the supranational and intergovernmental levels. The spatial framework of the study was selected to include

European Union member states and OECD countries, due to their common institutional standards of public administration and unified approaches to the formation of energy security, energy efficiency, and renewable energy development policies (European Commission, 2015, 2021a, 2022).

The unit of analysis was a country in a separate time slice (country-year). The sample was formed as a targeted non-random sample and covered 27 European Union countries and 11 OECD countries for which complete and comparable statistical data are available for the period 2015–2024. The total data set for analysis consisted of more than 350 country–year observations, which provides sufficient representativeness for indicator-based cross-country analysis (Organisation for Economic Co-operation and Development, 2024; World Bank, 2024).

The material basis for the study was formed by official statistical and regulatory sources at the international and supranational levels. The statistical data set included aggregated energy and macroeconomic indicators published by the International Energy Agency, Eurostat, OECD Statistics, and World Bank Data, in particular indicators of energy intensity, energy consumption, renewable energy development, and related sustainable growth indicators (Eurostat, 2024; International Energy Agency, 2024a, 2024b; Organisation for Economic Co-operation and Development, 2023a, 2023b; World Bank, 2024). The regulatory and managerial framework for the analysis was based on European Union strategic documents and OECD and IEA analytical materials that define the framework for public management of energy transition and security (European Commission, 2015, 2021b; International Energy Agency, 2023; Organisation for Economic Co-operation and Development, 2025).

In addition to the indicator-based analysis, the study incorporates a simplified decision-making framework to interpret energy security as a governance process. This framework is based on a sequential policy cycle consisting of four stages:

1) problem identification (energy vulnerability and dependence on external resources),
2) selection of policy instruments (energy efficiency measures and renewable energy support),
3) implementation through regulatory and institutional mechanisms, and
4) evaluation using indicator-based outcomes such as energy intensity, decoupling effects, and diversification of energy supply.

Within this framework, energy efficiency and renewable energy are interpreted not only as policy areas, but as decision-making instruments embedded in the governance cycle. This allows the study to move beyond descriptive analysis and to assess how different configurations of policy instruments contribute to energy security outcomes.

The sampling procedure was carried out in several consecutive stages. At the first stage, countries were selected with full coverage of key indicators of energy security, energy efficiency, and renewable energy development over a specified time interval. In the second stage, a list of indicators was formed that represent the managerial dimension of energy security, in particular the level of energy intensity of GDP, the share of renewable energy sources in final consumption, the dynamics of total energy consumption, and indicators of energy balance diversification. The logic of indicator selection was based on methodological recommendations for the construction of indicator systems and composite assessments (Organisation for Economic Co-operation and Development, 2008). Data with fragmentary or incompatible time coverage were not included in the sample.

The statistical component of the study is based on descriptive and comparative analysis. In addition to trend analysis, countries were grouped according to the level of energy efficiency improvement and renewable energy penetration, which allowed the identification of differences in governance performance across institutional contexts. This comparative grouping approach provides a simplified empirical basis for assessing how variations in policy design and coordination affect energy security outcomes, without relying on formal econometric modeling.

The chosen methodological approach ensured the reproducibility of the study, the transparency of the sample formation, and the consistency between the conceptual foundations and the statistical indicators used, creating a reliable empirical basis for the formation of results and further discussio. The combination of indicator-based analysis and a simplified decision-making framework ensures that the study captures both empirical patterns and governance logic, strengthening the analytical validity of the results.

RESULTS

Dynamics of Energy Efficiency Indicators as a Managerial Measure of Energy Security

The results of the indicator-statistical analysis show that energy efficiency during 2015–2024 has transformed from an auxiliary technical and economic parameter into a basic management measure of energy security for European Union member states and OECD countries. Within the sample studied, it was the dynamics of GDP energy intensity, final energy consumption intensity, and energy efficiency that proved to be most sensitive to changes in public policy, confirming their managerial nature (Eurostat, 2024; International Energy Agency, 2024a; World Bank, 2024).

An analysis of the average values of the GDP energy intensity indicator (toe/thousand US dollars at PPP) shows a steady downward trend in all country subgroups. While in 2015 the average value for EU countries was around 0.120–0.125, in 2024 it fell to 0.090–0.095, corresponding to a reduction of approximately 25–30%. For OECD countries, the trend was less intense but also stable, with a decline from 0.135–0.140 to 0.105–0.110 over the same period. This trajectory indicates not only technological advances, but also institutional consistency in regulatory decisions, particularly in terms of energy efficiency standards, budgetary incentives, and long-term planning (European Commission, 2021a; Organisation for Economic Co-operation and Development, 2008).

At the same time, final energy consumption per unit of GDP showed a more differentiated picture. In countries with

Table 2. Dynamics of key energy efficiency indicators in EU and OECD countries (2015–2024)

Indicator	2015	2018	2021	2024	Change, %
Energy intensity of GDP, EU	0.123	0.113	0.102	0.092	−25.2
Energy intensity of GDP, OECD	0.138	0.128	0.116	0.108	−21.7
Final energy consumption/GDP, EU	100 (index)	96	92	85	−15.0
Share of economies with decoupling, %	4	61	72	78	+30

Source: based on data from the IEA, Eurostat, OECD, World Bank (Eurostat, 2024; International Energy Agency, 2024a; Organisation for Economic Co-operation and Development, 2024; World Bank, 2024b)

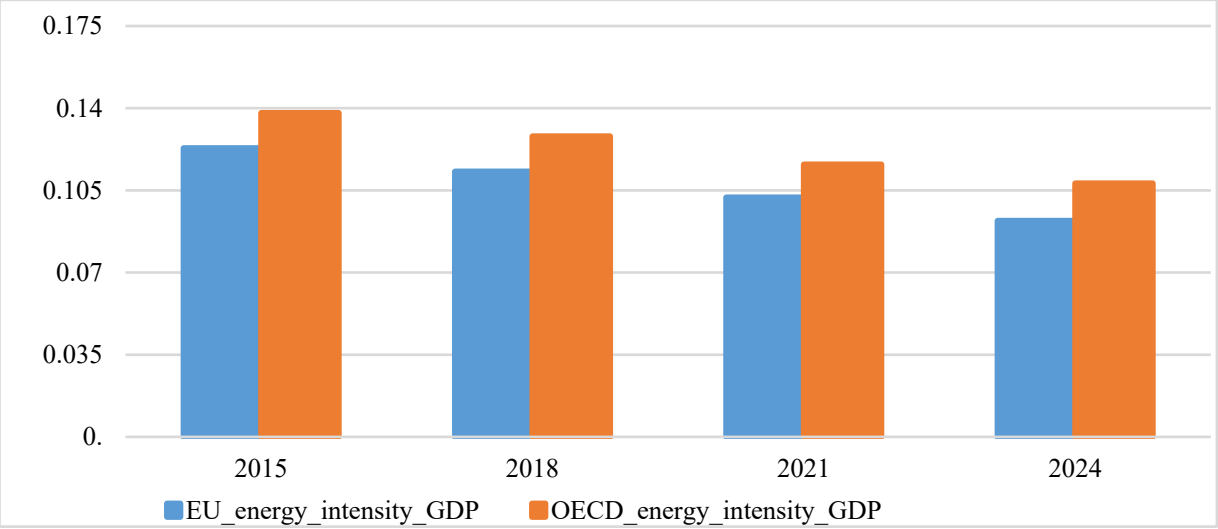

Figure 1. Dynamics of energy intensity of GDP in EU and OECD countries, 2015–2024 (Source: Authors' own elaboration, based on data from Eurostat, 2024; International Energy Agency, 2024b; Organisation for Economic Co-operation and Development, 2024; World Bank, 2024)

developed mechanisms for strategic management of the energy transition (mainly Northern and Western European countries), the reduction in consumption intensity was 15–20% in real terms. In contrast, in countries with fragmented management coordination, the rate of decline did not exceed 5–8%, indicating uneven management effects even in the presence of unified supranational goals (Eurostat, 2024; International Energy Agency, 2024b).

The results of the analysis of the growth rates of primary and final energy consumption in relation to economic growth are particularly revealing. On average, the EU has seen a gradual decoupling: average annual GDP growth rates in 2017–2024 ranged from 1.5% to 2.0%, while energy consumption remained stable or decreased by 0.3% to 0.7% per year. This result is a characteristic feature of management-driven energy security, where reducing dependence on imports and price shocks is achieved not by increasing supply, but by controlling demand (European Commission, 2015; International Energy Agency, 2023).

To summarize the identified trends and ensure the clarity of the indicator-statistical results, it is advisable to systematize the key energy efficiency indicators in a comparative time series.

Table 2 reflects the dynamics of basic indicators representing the management dimension of energy security in the European Union and OECD countries in 2015–2024 and allows for a comparison of the scale and intensity of structural shifts in the field of energy efficiency. Through aggregated indicators of GDP energy intensity, final energy consumption intensity, and the prevalence of the decoupling effect, the table records the results of public policies aimed at reducing energy vulnerability and increasing the resilience of energy systems.

Before presenting the graphical material, it is advisable to note the general trend in energy intensity as one of the key indicators of energy efficiency and management capacity in the field of energy security. During 2015–2024, European Union and OECD countries saw a steady decline in the energy intensity of gross domestic product, reflecting the gradual decoupling of economic growth from energy consumption growth. This dynamic indicates the institutional consolidation of energy efficiency policies, the consistent implementation of regulatory and programmatic instruments for energy transition, and the growing role of public administration in shaping the structural prerequisites for energy security. These trends are clearly illustrated in **Figure 1**, which shows the comparative dynamics of GDP energy intensity in EU and OECD countries over a specific time period.

Figure 2 illustrates the relationship between gross domestic product growth rates and final energy consumption (decoupling) in EU and OECD countries between 2015 and 2024. The graph shows that economic growth occurred with a significantly moderate increase in energy consumption, indicating a gradual decoupling of economic activity and energy expenditure. This trend reflects the consistent implementation of energy efficiency policies, the stability of governance mechanisms at the national and supranational levels, and the effectiveness of energy transition and renewable energy development strategies.

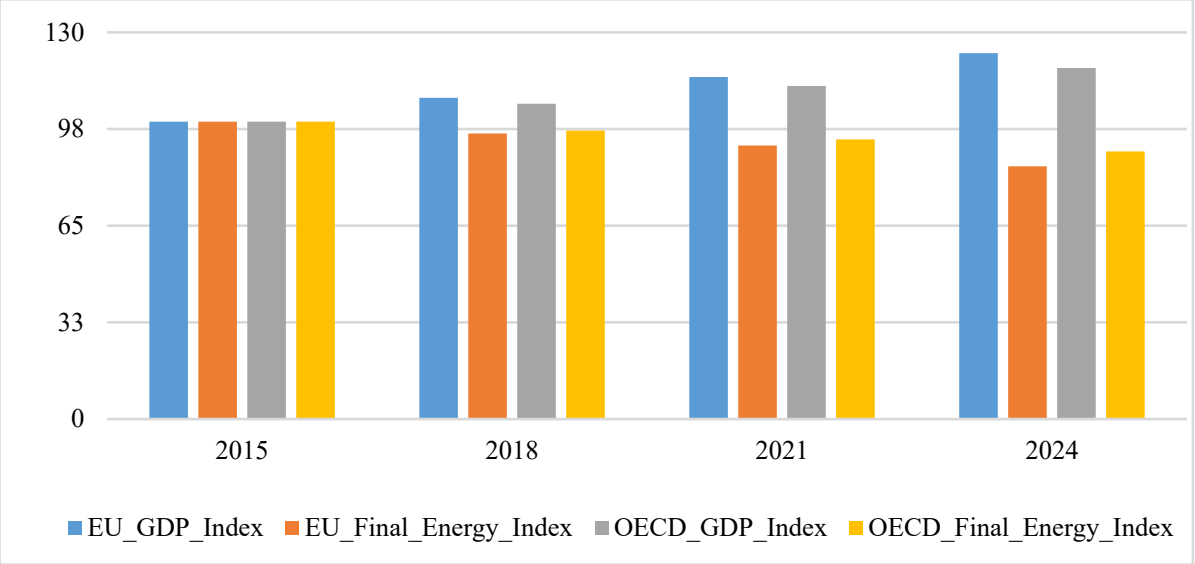

Figure 2. Ratio of GDP growth rates to final energy consumption (decoupling) (Source: Authors' own elaboration, based on data from Eurostat, 2024; International Energy Agency, 2024b; Organisation for Economic Co-operation and Development, 2024; World Bank, 2024)

To complement the aggregated analysis, a simplified case comparison highlights differences in governance performance. For example, Germany demonstrates a consistent reduction in energy intensity and a strong decoupling effect, reflecting stable policy coordination and long-term regulatory planning. By contrast, countries with weaker institutional coordination show significantly slower progress in energy efficiency indicators, despite operating within similar economic and technological conditions. This contrast suggests that governance design, rather than resource availability, is a decisive factor in achieving energy security outcomes.

The results obtained allow us to conclude that energy efficiency in the period under review served a dual function: firstly, as a quantitative indicator of policy effectiveness; and secondly, as a tool for managing energy security risks, reducing vulnerability to external suppliers and price volatility. In this sense, energy efficiency is not a derivative of the energy transition, but its structural core, integrated into the system of public administration at the supranational level (European Commission, 2021b; Organisation for Economic Co-operation and Development, 2025). Despite the overall positive dynamics, the analysis also reveals limitations in policy implementation. In several countries, the reduction in energy intensity remains modest, indicating fragmented coordination and inconsistent application of energy efficiency measures. In such cases, policy instruments are present but not fully integrated into the governance cycle, which reduces their effectiveness. This suggests that the existence of policy tools alone does not guarantee improved energy security outcomes without institutional alignment and coordination.

The Role of Renewable Energy Development in Transforming the Structure of Energy Security in Countries

The results of the indicator-statistical analysis show that in 2015–2024, the development of renewable energy became one of the key factors in the structural transformation of energy security, complementing but not replacing the effects of energy efficiency. Unlike the previous section, which focused on demand management, this section records the results of the restructuring of the supply side of energy systems and changes in the configuration of the energy balance. These changes can be interpreted within the decision-making framework outlined in the methodology, where renewable energy functions as a key instrument at the policy implementation stage, directly affecting the configuration of the energy supply system.

In European Union countries, the share of renewable sources in gross final energy consumption increased from around 16–18% in 2015 to over 23–25% in 2024. In OECD countries, the dynamics were less intense but stable, reaching a level of around 19–21%. This evolution reflects a gradual shift from an energy security model focused on fossil fuel imports to one based on domestic renewable production (International Energy Agency, 2024a; Organisation for Economic Co-operation and Development, 2024).

The growing role of RES was accompanied by a change in the structure of primary energy supply (See **Table 3**). On average across the EU, the share of fossil fuels in the primary energy balance fell by 8–12 percentage points between 2015 and 2024, while the contribution of renewable sources increased almost symmetrically. For OECD countries, this process was more gradual, but also showed a steady trend towards reducing dependence on traditional imported resources (Eurostat, 2024; World Bank, 2024). To systematise structural changes in the renewable energy sector, it is advisable to summarise key indicators in a comparative time series. This pattern suggests that structural changes in the energy balance are closely associated with governance choices rather than purely technological factors. Countries that demonstrate a more pronounced shift are typically characterized by more coherent regulatory frameworks and long-term policy consistency.

The data obtained show that the growth of RES had not only a quantitative but also a qualitative management effect.

Table 3. Structural shifts in the energy security of EU and OECD countries under the influence of RES development (2015–2024)

Indicator	2015	2018	2021	2024	Change
Share of RES in final energy consumption, EU, %	17	19	22	24	+7 p.p.
Share of RES in final energy consumption, OECD, %	15	17	18	20	+5 p.p.
Share of fossil resources in primary balance, EU, %	72	68	64	60	−12 p.p.
Countries with RES > 25% in the balance, EU, %	22	33	48	59	+37 p.p.

Source: Eurostat (2024), International Energy Agency (2024a), Organisation for Economic Co-operation and Development (2024), World Bank (2024)

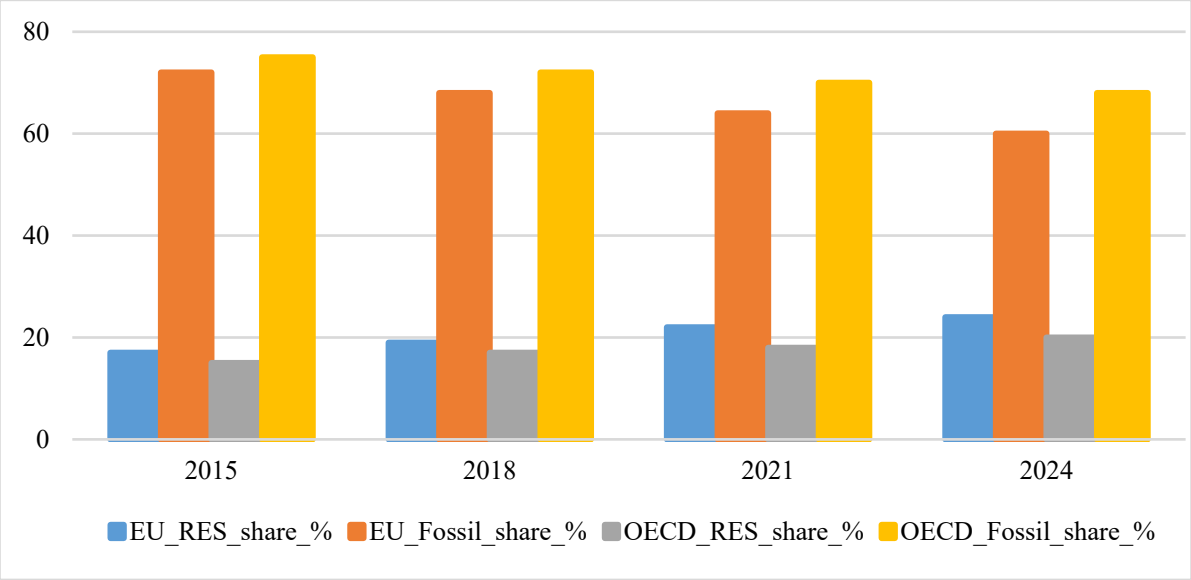

Figure 3. Change in the structure of primary energy supply in EU and OECD countries due to the growth in the share of RES, 2015–2024 (Source: Authors' own elaboration, based on data from Eurostat, 2024; International Energy Agency, 2024b; Organisation for Economic Co-operation and Development, 2024; World Bank, 2024)

Countries with a higher share of renewable sources were characterized by a more diversified supply structure, lower concentration of import risks, and higher adaptability of energy systems to external shocks, particularly after 2021 (European Commission, 2022; International Energy Agency, 2023).

During 2015–2024, European Union and OECD countries saw a steady increase in the share of renewable energy sources, accompanied by a simultaneous reduction in the share of fossil fuels. This trend reflects a shift from a quantitative model of energy security to a structural one, in which diversification of sources, reduction of import dependence, and long-term stability of energy systems are of key importance.

To illustrate the observed trends, a simplified comparison can be made between countries with different levels of renewable energy penetration. For example, Germany demonstrates a rapid increase in the share of renewable energy and a corresponding reduction in fossil fuel dependence, reflecting consistent policy support, regulatory stability, and long-term planning.

By contrast, in countries where policy coordination is weaker, the growth of renewable energy remains slower and less structurally embedded in the energy system. This suggests that differences in governance design significantly influence the effectiveness of renewable energy integration into energy security frameworks.

These shifts vary in intensity across the groups of countries studied. The EU is characterized by a more rapid increase in the share of RES and a deeper reduction in the fossil fuel segment, which correlates with a stricter regulatory framework and target commitments in the field of climate and energy policy. In OECD countries, the transformation is more gradual but maintains a stable direction, indicating a universalization of approaches to energy transition at the supranational level. These processes are visualized in **Figure 3**, which shows the change in the structure of primary energy supply due to the growth in the share of renewable energy sources in 2015–2024.

Despite the positive dynamics, the analysis reveals several limitations in renewable energy policy implementation. In some countries, the growth of renewable energy does not lead to a proportional reduction in systemic vulnerability, particularly where integration into existing infrastructure is insufficient or regulatory frameworks remain inconsistent. In such cases, renewable energy expansion occurs without full incorporation into the governance cycle, limiting its impact on energy security. This indicates that policy effectiveness depends not only on the expansion of renewable capacity but also on the quality of institutional coordination and system integration.

Thus, the results confirm that the development of renewable energy is an independent structural dimension of energy security, which complements demand management through energy efficiency and shapes the long-term sustainability of energy systems. In this context, RES perform not only an environmental function, but also a key security role, integrated into the public administration system at the

supranational level (European Commission, 2015; Organisation for Economic Co-operation and Development, 2025).

Interstate Differences in Management Models for Ensuring Energy Security in EU and OECD Countries

The indicative and analytical results provide grounds for identifying not only general trends in energy efficiency and structural shifts in the energy balance, but also persistent differences in the management models within which these changes are achieved. According to the logic of the study, the unit of analysis was a country in a time slice, and the comparison was made between 27 EU countries and 11 OECD countries within the period 2015–2024, which allows us to separate the management effect from purely technological or conjunctural fluctuations (Organisation for Economic Co-operation and Development, 2024; World Bank, 2024). In this dimension, energy security is interpreted as a political and managerial category that includes accessibility, reliability of supply, resilience to shocks, and demand management, rather than just a balance of resources (International Energy Agency, 2023, 2024a). These differences can be interpreted within the decision-making framework outlined in the methodology, where variations in governance outcomes reflect differences in how policy instruments are integrated across the stages of the policy cycle.

For EU countries, the key factor is policy coordination within a supranational framework: energy security is embedded in a set of EU strategic decisions that directly link decarbonisation, energy efficiency and reduced import dependence with uniform planning and regulation rules (European Commission, 2015, 2021b, 2022). The managerial specificity of this model lies in the fact that security instruments are not limited to responding to risks, but construct a long-term "transition architecture": standards and targets set the framework for national programs, and their implementation is reinforced by procedural requirements for the regulatory cycle and policy justification (European Commission, 2021a).

In terms of results, this manifests itself as the primacy of rules and procedures over situational decisions. That is why inter-state differences in the EU are more often associated not with the absence of goals, but with varying quality of: (i) political coordination between sectors, (ii) regulatory design, (iii) indicator monitoring systems, which must be comparable and reproducible (Organisation for Economic Co-operation and Development, 2008; World Bank, 2024). In other words, what is critical for the EU is not the availability of instruments as such, but their manageability in a standardized policy and legal cycle (European Commission, 2021b).

For OECD countries outside the EU, polycentricity is more pronounced: energy security is ensured through a combination of national regulatory decisions, market mechanisms, and infrastructure management institutions, where the key issue is the quality of coordination and the state's ability to manage complex network systems (Organisation for Economic Co-operation and Development, 2023a, 2023b, 2025). In terms of results, this model manifests itself in greater variability of "tool kits": OECD countries often differ in what is considered a priority for energy security in a given period (network reliability, price stability, demand flexibility, import diversification, speed of RES integration). Accordingly, management performance here depends more on institutional mechanisms of infrastructure governance and the ability to translate strategic goals into manageable programs (Organisation for Economic Co-operation and Development, 2023a, 2023b, 2008). Compared to the EU, where a "rigid framework" is part of the model itself, for the OECD, policy coordination at the intersection of sectors (energy, industry, transport, budgetary incentives) and the quality of data and methods for aggregating indicators for comparison are often key (Organisation for Economic Co-operation and Development, 2008; World Bank, 2024).

A comparison between the EU and the OECD shows that differences between countries center on a management dilemma: how to simultaneously increase resilience to risks and accelerate the transformation of the energy system. In the EU's energy transition documents, this dilemma is resolved through the consistent development of regulatory and programmatic instruments that link security goals with climate neutrality and energy efficiency goals (European Commission, 2015, 2021b, 2022). The OECD's approach shifts the focus to the quality of infrastructure governance and institutional capacity to implement the "green transition" without compromising reliability and accessibility, as explicitly stated in analytical materials on governance indicators and Net Zero policies (Organisation for Economic Co-operation and Development, 2023a, 2023b, 2025).

In terms of results, this means that instruments with the same name (energy efficiency targets, support for renewable energy sources, network modernisation programmes) can have different "management returns" depending on whether they are integrated into the full policy cycle: problem definition, evaluation of alternatives, regulatory justification, monitoring, and correction (European Commission, 2021a). It is important here that the study is based on comparable indicator sets and principles for constructing composite assessments that minimize methodological arbitrariness (Organisation for Economic Co-operation and Development, 2008; World Bank, 2024).

A simplified comparison between countries further illustrates these differences. For example, Germany demonstrates a highly coordinated governance model, where energy efficiency and renewable energy policies are integrated into a standardized regulatory cycle, resulting in stable and predictable outcomes. In contrast, in countries with more fragmented governance structures, policy instruments are often implemented inconsistently, leading to weaker integration of renewable energy and less pronounced improvements in energy security indicators. This contrast highlights the importance of institutional coordination in shaping policy effectiveness.

To summarize the identified inter-state differences and move from indicator analysis to institutional interpretation of the results, it is advisable to compare the key features of energy security management models. **Table 4** systematizes the structural differences between European Union countries and non-EU OECD countries, focusing on policy-making logic,

Table 4. Comparative profile of energy security management models in the EU and OECD (structural differences)

Management model criterion	EU (27 countries)	OECD outside the EU (11 countries)
Policy framework	Supranational coordinated "transition architecture"	Nationally polycentric configuration with high variability
Regulatory cycle	Procedurally standardized policy design	Greater dependence on national institutional practices
Reliance on infrastructure governance	Embedded in policy but reinforced through alignment of objectives	Often a key driver of effectiveness
Logic of measurement and comparison	Greater need for unified indicators and comparability	Greater need for alignment of composite assessments and indicator sets
Dominant interpretation of "energy security"	Security as a result of transition (efficiency, decarbonization, sustainability)	Security as a balance between system stability and the pace of transformation

Source: summarized based on approaches to energy security and infrastructure governance and green transition (European Commission, 2015, 2021b, 2022; International Energy Agency, 2023; Organisation for Economic Co-operation and Development, 2023a, 2023b, 2025), with methodological consideration of the principles of indicator comparison (Organisation for Economic Co-operation and Development, 2008; World Bank, 2024)

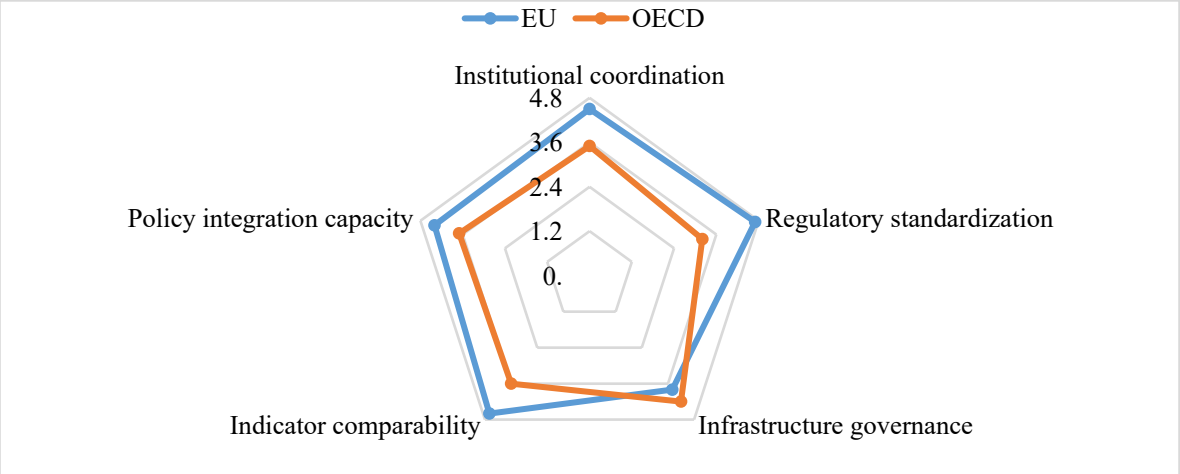

Figure 4. Comparative profile of energy security management models in EU and OECD countries (radar chart) (Source: Authors' own elaboration, based on data from European Commission, 2021a; International Energy Agency, 2023; Organisation for Economic Co-operation and Development, 2008, 2023a, 2023b, 2025; World Bank, 2024)

the regulatory cycle, approaches to infrastructure governance, indicator measurement, and dominant interpretations of energy security as a management category.

Before presenting comparative graphic material, it is advisable to note the differences in the configuration of energy security management models at the supranational and intergovernmental levels. European Union countries have a more balanced and structurally aligned management profile, which is reflected in high levels of institutional coordination, regulatory standardization, comparability of indicators, and capacity for political integration. In contrast, OECD countries are characterized by an asymmetrical model, in which relatively strong positions are concentrated in the area of infrastructure management, with a lower level of coordination and unification of regulatory approaches. This correlation reflects different approaches to public energy security management and provides an empirical basis for comparative analysis, as illustrated in **Figure 4**.

Despite the advantages of both models, the analysis reveals several limitations. In the EU, a high level of regulatory standardization may reduce flexibility and slow down the adaptation of policies to national specificities. In OECD countries, polycentric governance can lead to fragmentation and inconsistent policy implementation, reducing the overall effectiveness of energy security measures. These findings suggest that both governance models face trade-offs between coordination and flexibility, which directly affect the outcomes of energy security policies.

Taken together, the results show that cross-country differences in the EU and OECD in 2015–2024 should be described not as a difference in the "presence or absence" of policies, but as a difference in management design, i.e., how energy efficiency and RES development policies are integrated into the public energy security management cycle and how they are supported by institutional mechanisms of infrastructure governance and performance measurement.

Policy Recommendations for Energy Efficiency and Renewable Energy Development in the Context of Sustainable Development Goals (SDGs)

The empirical results of the study, combined with the proposed governance-oriented framework, provide a basis for formulating policy recommendations aimed at strengthening energy security through the integrated development of energy efficiency and renewable energy. In line with the findings, policy effectiveness depends not on the isolated implementation of instruments, but on their integration into coherent governance cycles and institutional coordination

mechanisms. The recommendations below are structured in accordance with the logic of the decision-making framework and aligned with key Sustainable Development Goals, particularly SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

First, governments should prioritize the institutional integration of energy efficiency and renewable energy policies within a unified policy cycle. This implies aligning strategic planning, regulatory design, implementation, and monitoring mechanisms across sectors and governance levels. The results demonstrate that countries with coordinated policy frameworks achieve more consistent reductions in energy intensity and more stable growth in renewable energy shares. This recommendation directly contributes to SDG 7 and SDG 13 by ensuring the long-term sustainability and resilience of energy systems.

Second, it is necessary to strengthen regulatory stability and predictability as a precondition for effective energy transition. Empirical patterns identified in the study show that countries with stable regulatory environments demonstrate higher rates of renewable energy integration and more pronounced decoupling effects. Policy instruments such as long-term targets, binding standards, and transparent support schemes should therefore be embedded within consistent regulatory frameworks. This aligns with SDG 9 by supporting innovation and infrastructure development, as well as SDG 13 through enhanced climate policy effectiveness.

Third, governments should develop integrated indicator-based monitoring systems to assess the performance of energy policies. The study confirms that the availability of comparable and reproducible indicators, such as energy intensity, renewable energy share, and decoupling metrics, is critical for evaluating policy outcomes and adjusting strategies. Such systems should be standardized across governance levels to ensure transparency and comparability. This recommendation contributes to SDG 12 by promoting responsible resource use and evidence-based decision-making.

Fourth, policy design should emphasize demand-side management through energy efficiency as a central element of energy security. The results indicate that reductions in energy intensity and the decoupling of economic growth from energy consumption are key drivers of resilience to external shocks. Governments should therefore expand programs aimed at improving energy efficiency in industry, buildings, and transport sectors, while ensuring their integration into broader energy transition strategies. This supports SDG 7 and SDG 11 by enhancing energy accessibility and sustainability in urban systems.

Fifth, the expansion of renewable energy should be accompanied by measures ensuring its systemic integration into energy infrastructure. The analysis reveals that increases in renewable capacity do not automatically translate into improved energy security without adequate institutional coordination and infrastructure adaptation. Policies should therefore focus on grid modernization, storage solutions, and regulatory frameworks that facilitate the integration of decentralized energy sources. This recommendation aligns with SDG 9 and SDG 13 by promoting resilient infrastructure and climate mitigation.

Sixth, it is important to address governance trade-offs between coordination and flexibility. As demonstrated in the comparative analysis, highly standardized governance models may limit adaptability, while polycentric systems may lead to fragmentation. Effective policy design should therefore balance these dimensions by combining clear regulatory frameworks with mechanisms for adaptive policy adjustment. This contributes to SDG 16 (Peace, Justice and Strong Institutions), which underpins the effectiveness of all sectoral policies.

Finally, policymakers should consider the social dimension of energy transitions, including public acceptance and stakeholder engagement. Although not directly captured by aggregated indicators, the effectiveness of energy policies depends on their legitimacy and societal support. Integrating participatory mechanisms into the governance cycle can enhance policy implementation and long-term sustainability, contributing to SDG 11 and SDG 12.

Taken together, these recommendations emphasize that achieving energy security in the context of sustainable development requires a shift from fragmented policy approaches to integrated governance models. Energy efficiency and renewable energy should be treated not as separate domains, but as interconnected instruments within a comprehensive public administration framework aligned with the Sustainable Development Goals.

DISCUSSION

The results obtained allow us to interpret energy security not as a derivative of resource availability, but as a function of public administration, in which institutional coordination, energy efficiency policy design, and the pace of renewable energy integration play a key role. The trends identified in the study – a decrease in energy intensity of GDP, a sustained decoupling effect, and structural growth in the share of RES – are systemic in nature and are replicated in most EU and OECD countries, indicating their managerial rather than random nature (Palamarchuk et al., 2024, 2025).

In this context, the results are consistent with the approach of Sen and Jamasb (2024), who view renewable energy as a new form of "quasi-natural resource" that requires specialized public management regimes, particularly for offshore RES. The increase in the share of RES in primary energy supply identified in our study confirms that it is the quality of governance, and not just technological accessibility, that determines the speed and stability of energy transformations (Sen & Jamasb, 2024). A comparative analysis of governance models also correlates with the findings of Söylemez and Söylemez (2024), who emphasize the crucial role of governance frameworks in ensuring the integrity of the energy transition. Our results substantiate this conclusion, showing that countries with integrated multi-level governance models demonstrate not only higher rates of RES growth but

also lower vulnerability to energy and price shocks (Söylemez & Söylemez, 2024).

At the same time, the results of the indicator analysis partially complement, but do not fully coincide with, the approach proposed by Taghipour et al. (2025), who emphasize the need for new universal policy models for RES development. Our research shows that the effectiveness of such models largely depends on the national institutional context, and their mechanical transfer without adaptation does not provide the same results in EU countries and non-European OECD countries (Taghipour et al., 2025). Particular attention should be paid to comparing the results obtained with the empirical conclusions of Tansuchat and Yosthongngam (2026) regarding the G7 countries. As in their study, it was found that the combination of energy efficiency policies, renewable energy development, and environmental regulation creates a synergistic effect for economic growth. However, the results of our analysis expand on this thesis, demonstrating that public administration is the key mediator of this effect through the stability of rules, predictability of regulation, and institutional coordination (Tansuchat & Yosthongngam, 2026).

The results are also consistent with the concept of political learning proposed by von Malmborg (2024). The gradual but steady decline in energy intensity of GDP observed in EU countries indicates the accumulation of managerial experience and institutional consolidation of energy efficiency practices, especially at the corporate and sectoral levels. This confirms that energy security is not achieved through one-off reforms, but through a long process of adaptation and learning (von Malmborg, 2024). In a broader macro-management dimension, the results of the study correlate with the conclusions of Wang et al. (2024), who emphasize the role of public administration and public support in ensuring a sustainable energy transition. Our analysis specifies this relationship, showing that even with a high level of public support, the lack of coordinated management mechanisms reduces the effectiveness of RES and energy efficiency policies (Wang et al., 2024).

Thus, the study has important theoretical and practical significance. Theoretically, it confirms the validity of interpreting energy security as an institutionally determined category of public governance, rather than merely a technical and resource-related phenomenon. In practice, the results show that countries that invest in the quality of governance – through strategic planning, policy coordination, and indicator monitoring – achieve more sustainable and predictable results in the field of energy security.

CONCLUSIONS

The study demonstrates that energy security in contemporary economies is determined primarily by the structure and quality of public administration, rather than by resource availability or the technological level of energy systems alone. The research objective – to conceptualize the management principles of energy security through the integration of energy efficiency and renewable energy development – was achieved by identifying stable indicator-based patterns across European Union and OECD countries.

The scientific contribution of the study lies in redefining energy security as a function of governance design, where energy efficiency and renewable energy act as structurally distinct yet complementary instruments embedded in the policy cycle. This approach extends existing literature by showing that policy effectiveness depends not on the presence of instruments themselves, but on their institutional integration and coordination.

From a practical perspective, the results suggest that countries achieving more consistent outcomes in energy security prioritize policy coherence, regulatory stability, and indicator-based monitoring, rather than isolated or fragmented policy interventions. This has direct implications for the design of public energy policy, particularly in the context of ongoing energy transitions and external shocks.

At the same time, the study has several limitations that should be taken into account when interpreting the results. First, the use of aggregated country-level data limits the ability to capture intra-national institutional variations and differences in regional governance practices. Second, the reliance on descriptive and comparative analytical methods does not allow for establishing causal relationships between governance variables and energy security outcomes. Third, the focus on EU and OECD countries constrains the generalizability of the findings to economies with different institutional structures and levels of development.

These limitations highlight important directions for further research. Future studies should focus on micro-level governance mechanisms, including sectoral and regional policy implementation, as well as on the role of financial instruments and investment frameworks in supporting energy transitions. In addition, greater attention should be paid to the interaction between institutional design and social acceptance of energy policies, which may significantly influence the effectiveness of governance interventions in the field of energy security.

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