FREE ECONOMIC ZONES AS AN INSTRUMENT OF STATE GOVERNANCE IN ENSURING ENERGY SECURITY: COMPARATIVE ANALYSIS OF INTERNATIONAL PRACTICE AND IMPLICATIONS FOR UKRAINE

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Abstract

The growing vulnerability of national energy systems to geopolitical instability, climate change, and volatile energy markets prompted states to seek non-conventional governance instruments to reinforce energy security. Simultaneously, free economic zones (FEZs) are undergoing a paradigm shift – from trade-logistical enclaves to sophisticated tools of structural industrial and infrastructure policy.

This article aims to identify and systematise mechanisms through which FEZs can purposefully shape national energy security architecture and to develop conceptual approaches to adapting the most effective international models to Ukrainian conditions, particularly in the context of post-war reconstruction.

The study employs comparative public administration analysis, institutional design theory, systems analysis, and case study methodology. Three distinct governance models – the Asian dirigiste model (China, South Korea, UAE), African context case, the North American market-oriented model (USA, Canada), and the European regulated transformation model (Poland, Estonia, Netherlands) – are examined through structured cross-case comparison.

The analysis reveals a key typological feature of effective FEZ solutions in the energy security domain: the principle of "dual asymmetry" – combining asymmetric regulatory conditions (preferential regimes for investment attraction) with asymmetric obligations for residents regarding localisation and technology transfer. A conceptual model of "Energy Special Recovery Zone" (ESRZ) for Ukraine is proposed, incorporating a three-tier governance structure, differentiated incentive packages, and an "energy obligation" mechanism.

Post-war Ukraine possesses a unique "window of opportunity" to create next-generation FEZs simultaneously oriented toward foreign investment attraction, technology transfer, and energy autonomy reinforcement. The ESRZ model bridges EU accession commitments with urgent national energy resilience imperatives.

Keywords:

Free economic zones; energy security; renewable energy; post-war reconstruction; institutional design; technology sovereignty

Authors' individual contribution:
Conceptualization — L.A.; Methodology — O.A.; Data Collection — O.A.; Data Analysis — L.A., O.A.; Interpretation — L.A., O.A.; Writing — Original Draft — L.A., O.A.; Writing — Review & Editing — L.A., O.A.; Visualization — L.A.

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The Author declares that there is no conflict of interest.

1. Introduction

The intersection of energy security and special economic zone governance represents one of the most underexplored territories in contemporary public administration scholarship. While the literature on free economic zones (FEZs) is extensive, the overwhelming majority of studies conceptualise these instruments primarily through the lens of trade facilitation, foreign direct investment (FDI) attraction, and employment generation (UNCTAD, 2019). Conversely, energy security research traditionally focused on supply diversification, strategic reserves, and geopolitical risk management, rarely engaging with the spatial and institutional dimensions of FEZ governance (Yergin, 2020).

This analytical gap acquired particular practical urgency in the wake of several converging global developments. First, the global energy transition is generating massive demand for localised manufacturing of renewable energy equipment – solar panels, wind turbines, battery storage systems, and hydrogen production facilities – creating new comparative advantages for countries capable of offering competitive industrial platforms. Second, Russia's full-scale invasion of Ukraine in 2022 demonstrated, with unprecedented severity, how energy infrastructure vulnerability can be weaponised as an instrument of coercion, fundamentally reshaping ‘calculations’ and concerns of energy security among European states and beyond (IEA, 2022). Third, accelerating decarbonisation agenda embedded in the European Green Deal creates both obligations and opportunities for candidate countries like Ukraine, where FEZ policy must be reconciled with EU state-aid rules and sectoral decarbonisation targets (European Commission, 2021).

Against this backdrop, the central research question of this article is formulated as follows: under what conditions and through what mechanisms can free economic zones function as effective instruments of state governance aimed at reinforcing national energy security? To address this question, we conduct a comparative analysis of international FEZ practice across three distinct governance models, identify the structural characteristics of successful energy-oriented FEZs, and develop an original conceptual framework – the Energy Special Recovery Zone (ESRZ) – tailored to Ukraine's post-war institutional and energy context.

Accordingly, the purpose of this article is to identify the institutional mechanisms through which free economic zones can contribute to national energy security and to develop an adaptive governance model suitable for Ukraine's post-war reconstruction and energy transition. The study tests the hypothesis that free economic zones contribute to energy security not merely through investment attraction but through institutional arrangements that combine preferential regulatory regimes with mandatory obligations regarding localisation, technology transfer, and infrastructure participation. Such a configuration creates stronger energy-security outcomes than conventional investment-oriented FEZ models.

Scientific novelty of the study lies in the development of the concept of dual asymmetry and its operationalisation through the proposed Energy Special Recovery Zone (ESRZ) model designed specifically for post-war reconstruction conditions. The article makes three principal contributions to the literature. First, it proposes and operationalises the concept of "dual asymmetry" as the defining governance characteristic of effective energy-oriented FEZs. Second, it develops a structured comparative typology of FEZ-energy security linkages across governance systems that have not been previously analysed in conjunction. Third, it articulates a policy-relevant institutional model specifically designed for post-conflict energy infrastructure reconstruction contexts.

2. Literature Review

The theoretical foundations of this study draw from three intersecting bodies of scholarship: comparative public administration, energy governance theory, and institutional economics. The economics of special economic zones (SEZ) generated a substantial and contested discourse. In particular, the recent work of Aggarwal (2022) represents one of few attempts to theorise FEZs as instruments of industrial policy, yet energy dimensions remain peripheral. Some earlier, Farole and Moberg (2017), within African context, presented the evidence that special economic zones evolved into integrated, tech-driven regional economic hubs in the twenty-first century from cheap-labor, export-processing enclaves. Global value chains (GVCs), digital innovation, and sustainable development goals are driving this transition, while many zones still have trouble generating spillovers into larger local economies. Pigliucci et al. (2025), in their monographic work, made a strong attempt to summarise challenges and benefits of SEZs for territorial development. Zeng (2021) traces the evolution of Special Economic Zones (SEZs) and asserts that since the first modern zone was established in Shannon, Ireland, SEZs have undergone numerous changes, from their original "enclave" nature to the current "Economic Zone 5.0", which is well-integrated with urban development and built on emerging digital technologies. Zeng (2021) asserts that although special economic zones are commonplace around the world, their effects on the economy and structural

transformation are not always consistent. Among the many lessons learned from successful special economic zone programmes, the key elements include a strategic location, integration of zone strategy with the overall development strategy, understanding the market and leveraging comparative advantage, and, most importantly, ensuring that zones are 'special' in terms of a business-friendly environment - especially a sound legal and regulatory framework and an embodiment of sustainability and resiliency towards various external shocks (Karolyi, et al., 2026). This is particularly crucially important at the background of recent global energy security shocks generated by war in Ukraine and to even higher extent – hostilities in the Middle East and Iran' international politics. Al-Sarihi (2026) argues that the 2026 conflict involving Iran and the resulting disruption in the Strait of Hormuz are reshaping the global energy landscape.

Energy security scholarship, actually, developed several influential conceptual frameworks. Yergin (2020) emphasises the primacy of supply diversity and market resilience. Strojny et al. (2023) offer a conceptual overview of energy security. The primary disparities in how energy security is perceived have been identified, and it has been noted that the "supply concept" of energy security is being replaced by an approach that views energy as a factor that initiates profound changes in social systems by altering consumption patterns, lowering energy consumption, and compelling changes in economic systems by enforcing environmental and energy efficiency standards.

Figure 1 below shows quantitative statistical data for publications on energy security, broken down into two time periods within the range of 2005-2022. As can be seen from the diagram, after 2015 discussions of energy security intensified sharply.

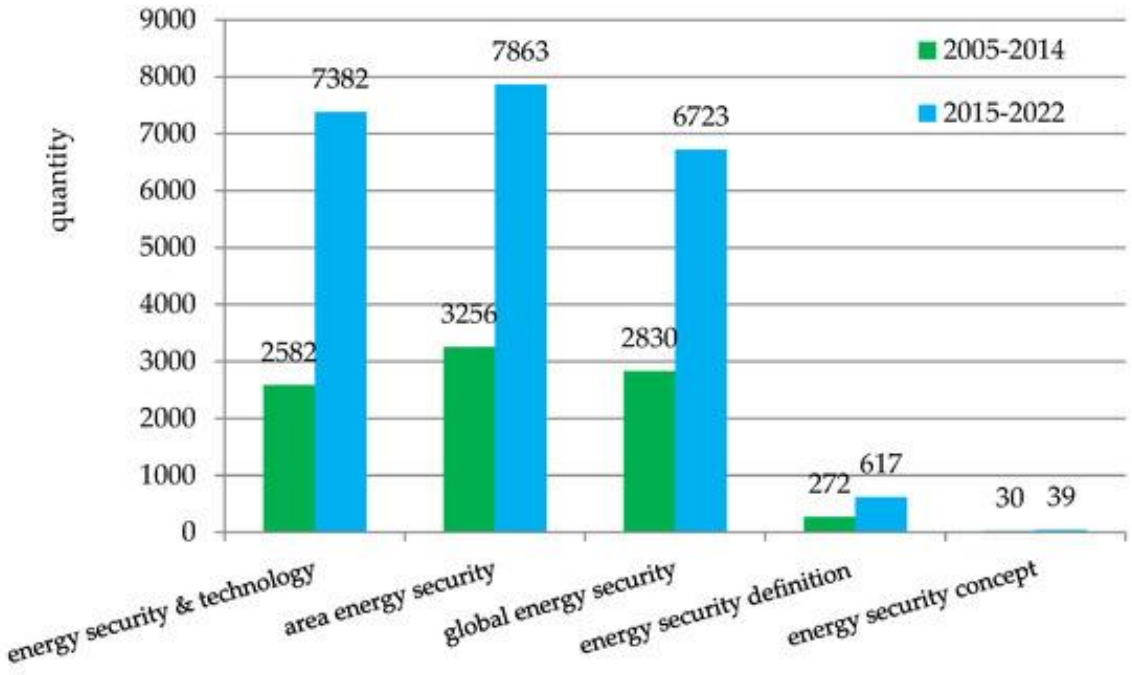

Figure 1. Publications on energy security, broken down into time periods adopted

Source: Strojny et al. (2023)

An interesting approach was suggested by Siksnelyte-Butkiene (2023). The author found that the current perception of energy security consists of seven main components, namely: Availability, Affordability, Environmental Impact, Social Impact, Geopolitical Relationships, Government Effectiveness and Technological Development. Moreover, it is asserted that interdisciplinary approach has replaced a traditional understanding of energy security in recent years.

The theoretical bridge between FEZs and energy governance is most compellingly constructed through the lens of institutional economics. Gong and Tiague (2026) conducted empirical analysis based on a panel of 53 African countries for the period of 2000-2022. The authors found that SEZs significantly reduce energy poverty. Moreover, technology parks and industrial zones are claimed as those having the most effects on lowering energy poverty. The intersection of geographically bound economic development and energy security highlights a need for policy innovation. Key dynamics actually include the following three domains (Michoud & Hafner, 2021; Dagar et al., 2024):

1. Infrastructure Bottlenecks: Many emerging economies struggle to maintain uninterrupted power supplies within economic enclaves, which undermines investment benefits.

2. Renewable Integration: SEZs are increasingly acting as testing grounds for green energy projects, such as solar microgrids, designed to reduce dependency on volatile fossil fuel markets.

3. Energy Transition: The modernization of grid infrastructure and the expansion of interconnectors help distribute power efficiently to energy-intensive industries.

The argument that industrial policy succeeds when it creates mechanisms for strategic collaboration between the state and the private sector (Landesmann, 2025; Giordano et al., 2025) – embedding reciprocal performance obligations – provides the theoretical foundation for the "dual asymmetry" concept developed in this article.

The post-conflict economic reconstruction literature adds an additional analytical layer relevant to the Ukrainian case. Addison et al. (2002) demonstrate that post-conflict settings present both severe institutional challenges and unique windows for structural transformation, as the destruction of legacy infrastructure may actually remove incumbent resistance to new technological and regulatory frameworks. This "reconstruction advantage" is a key premise of the ESRZ model proposed below.

Taken together, the reviewed literature demonstrates that FEZs were examined predominantly through the lenses of investment attraction, industrial development, governance efficiency, and regional economic transformation, while energy-security research has primarily focused on infrastructure resilience, diversification, energy transitions, and institutional coordination. A separate body of post-conflict reconstruction research emphasizes institutional rebuilding, investment mobilization, and regulatory adaptation under conditions of fiscal and infrastructural constraints.

However, these strands of scholarship remain insufficiently integrated. In particular, the existing literature does not provide a governance framework that simultaneously considers the institutional design of free economic zones, energy-security objectives, and the specific requirements of post-conflict recovery. This gap is especially significant namely for countries such as Ukraine, where reconstruction, energy-system resilience, investment mobilisation, and European regulatory alignment must be addressed concurrently. The present study addresses this gap by bringing these previously separated analytical dimensions into a common comparative framework and by using the identified institutional patterns to develop the Energy Special Recovery Zone (ESRZ) model.

3. Materials and Methods

This study employs a qualitative comparative case analysis (QCCA) methodology, supplemented by systematic document analysis and policy mapping. The methodological design is intended to identify and compare institutional mechanisms through which free economic zones (FEZs) can contribute to energy security rather than to estimate a statistically generalisable causal effect of FEZs across countries. Accordingly, the unit of analysis is the institutional configuration of a FEZ or FEZ-related development regime and its mechanisms of interaction with energy-security objectives.

Case Selection Strategy

Case selection strategy is purposive, and theory driven. Cases were selected to represent analytically distinct governance archetypes in the relationship between FEZ policy and energy security while providing sufficient documentary evidence for systematic comparison. Four inclusion criteria were applied. First, the selected case had to involve a geographically or institutionally differentiated economic-zone regime, including special economic zones, free zones, investment zones, or functionally equivalent spatial development arrangements. Second, the case had to demonstrate an identifiable connection between zone governance and energy-related objectives, infrastructure, investment, technology development, or energy resilience. Third, sufficient primary and secondary documentary evidence had to be available to reconstruct the institutional arrangements of the case. Fourth, the case had to provide evidence relevant to at least three of the analytical dimensions specified in Table 1, thereby enabling meaningful cross-case comparison. Cases were excluded when the zone was designed exclusively for conventional trade or customs facilitation without an identifiable energy-related dimension, when publicly available evidence was insufficient to establish the relevant governance mechanisms, or when the available evidence did not permit the case to be examined using the common analytical framework. The selection prioritised analytical relevance and institutional variation rather than the representativeness of individual countries.

The Asian dirigiste model is represented by China (Shenzhen Special Economic Zone and Hainan Free Trade Port), South Korea (Saemangeum Special Economic Zone), and the UAE (Masdar City Free Zone). These cases were selected because they exemplify state-led, strategically designed FEZs with explicit energy-security or energy-transition objectives embedded in their development strategies and institutional arrangements.

The North American market-oriented model draws on the United States (Opportunity Zones with energy investment components under the Tax Cuts and Jobs Act 2017) and Canada (Atlantic Canada regional development zones and related investment-support arrangements). These cases illustrate how fiscal incentive architectures can mobilize private capital toward energy infrastructure in designated spatial units without the same degree of direct state industrial programming characteristic of the Asian model.

The European regulated transformation model is analyzed through Poland (Special Economic Zones transformed under the 2018 Act on Supporting New Investments), Estonia (Ülemiste City technology zone) and the Netherlands (Rotterdam Climate Bond and Maasvlakte II port-industrial complex). These cases demonstrate the integration of zone-related development policy with supranational decarbonization frameworks and provide a particularly relevant reference architecture for Ukraine's EU accession trajectory.

Data Sources and Analytical Procedure

Primary data sources include official zone legislation and development plans, investment promotion agency reports, regulatory documents, and energy-sector filings. Secondary sources encompass peer-reviewed academic publications, reports of international organizations, and policy evaluations produced by governmental and intergovernmental institutions. The use of multiple source categories enabled triangulation of institutional characteristics and reduced reliance on single-source interpretations. Comparative analysis followed a structured multi-stage procedure. In the first stage, documentary materials for each case were reviewed to identify institutional arrangements connecting FEZ governance with energy-related objectives. In the second stage, relevant evidence was coded according to a common analytical matrix derived from the literature on energy governance, institutional economics, public administration, and special economic zone management. Coding was conducted at the level of institutional mechanisms rather than isolated descriptive facts. For each case, the analysis recorded the presence, form, and relative strength of governance arrangements corresponding to the dimensions presented in Table 1.

Table 1. Analytical Framework for Comparative Case Analysis

Dimension	Operational Indicator
Governance architecture	Degree of state involvement, governance structure, coordination mechanisms
Energy mandate explicitness	Presence of energy-security objectives in legislation and development strategies
Incentive design	Tax incentives, regulatory preferences, infrastructure support mechanisms
Technology obligation mechanisms	Local content requirements, technology transfer provisions, R&D commitments
Energy security outcomes	Contribution to energy resilience, localisation effects, renewable generation capacity, grid stability

Source: developed by the authors

In the third stage, within-case analysis was used to reconstruct how the identified mechanisms operated in their respective institutional environments. Particular attention was given to the relationship between regulatory incentives offered to zone residents and obligations imposed on them in exchange for preferential treatment. In the fourth stage, the coded cases were compared across governance models in order to identify recurring mechanisms and meaningful differences. The comparison, therefore, proceeded from case-level coding to within-model synthesis and subsequently to cross-model comparison.

The comparison protocol was based on a common set of questions applied to every case: (1) Who exercises strategic and operational authority within the zone? (2) Are energy-security or energy-transition objectives explicitly incorporated into the zone's institutional mandate? (3) What forms of regulatory, fiscal, or infrastructural incentives are available to residents? (4) Are residents subject to localization, technology-transfer, infrastructure, renewable-energy, or energy-efficiency obligations? (5) What observable energy-related outcomes or mechanisms are documented? Applying the same questions across cases provided a consistent basis for comparison despite differences in national institutional systems.

Analytical framework was designed to ensure systematic comparability across heterogeneous governance environments. The selected cases differ substantially in institutional traditions, state-market relations, regulatory regimes, and energy-policy architectures; consequently, the purpose of comparison was not to establish direct causal equivalence between countries but to identify recurring institutional mechanisms and configurations. This approach follows the logic of qualitative comparative case analysis by examining how similar governance mechanisms operate under different institutional conditions.

Analytical Dimensions and Operationalization

The comparative analysis is structured around five dimensions: (1) governance architecture; (2) energy mandate explicitness; (3) incentive design; (4) technology obligation mechanisms; and (5) measurable energy-security outcomes. These dimensions were selected according to two criteria: their relevance for explaining how FEZ governance can influence energy-security objectives and their applicability across different governance systems. For coding purposes, each dimension was examined through observable institutional indicators. Governance architecture was assessed through the degree of state involvement, the distribution of decision-making authority, and the presence of coordination mechanisms. Energy mandate explicitness was identified through references to energy security, renewable energy, energy transition, infrastructure resilience, or related objectives in legislation, master plans, and development strategies. Incentive design was examined through tax incentives, regulatory preferences, infrastructure support, financing arrangements, and permitting advantages. Technology obligation mechanisms were identified through local-content requirements, technology-transfer provisions, R&D commitments, skills-development requirements, renewable-energy obligations, and infrastructure participation requirements. Energy-security outcomes were assessed through documented contributions to energy resilience, localization, renewable-generation capacity, technology diffusion, grid stability, or energy-access improvement.

The operationalization of the analytical framework is presented in Table 2.

Table 2. Case Selection and Coding Protocol for Comparative Analysis

Analytical element	Specification
Unit of analysis	Institutional configuration of a FEZ or functionally equivalent zone-related development regime and its mechanisms of interaction with energy-security objectives
Case inclusion criteria	(1) differentiated economic-zone regime; (2) identifiable connection with energy security, energy infrastructure, energy transition, or related objectives; (3) sufficient documentary evidence; (4) applicability of at least three dimensions of the analytical framework
Case exclusion criteria	Zones limited to conventional trade/customs facilitation without an identifiable energy dimension; cases with insufficient documentary evidence; cases for which the common analytical framework could not be applied
Coding approach	Structured qualitative coding of documentary evidence using the five dimensions and operational indicators specified in Table 1
Coding focus	Institutional mechanisms, including governance arrangements, energy mandates, incentives, resident obligations, technology-transfer mechanisms, and documented energy-related outcomes
Within-case analysis	Reconstruction of the institutional configuration and identification of mechanisms linking FEZ governance to energy-related objectives
Cross-case comparison	Comparison of coded mechanisms across cases and subsequent synthesis by governance model; emphasis on recurring institutional patterns rather than direct causal equivalence

Comparison protocol	The same five analytical dimensions and common questions regarding authority, energy mandate, incentives, obligations, and outcomes were applied to each case
Evidence triangulation	Cross-checking of legislation, development plans, governmental and institutional reports, regulatory documents, peer-reviewed studies, and international-organisation reports where available
Construct validity	Analytical dimensions derived from established FEZ, energy governance, institutional economics, and public administration literature and applied consistently across cases
Reliability	Use of a predefined coding matrix, common operational definitions, and a standardised comparison protocol
Scope of inference	Analytical transferability rather than statistical generalisation; findings are interpreted as recurring institutional mechanisms conditioned by national institutional and regulatory contexts

Source: developed by the authors

Validity, Reliability and Scope of Inference

Several procedures were used to strengthen comparative analysis' validity and reliability. Construct validity was supported by deriving the analytical dimensions from established literature on FEZ governance, energy security, institutional economics, and comparative public administration, and by applying the same operational definitions across cases. Source triangulation was used to cross-check institutional claims against legislation, official development documents, institutional reports, and peer-reviewed research wherever such sources were available. Reliability was enhanced through the use of a predefined analytical matrix and a common comparison protocol. The coding framework was applied consistently across the selected cases, with evidence recorded according to the same five dimensions and corresponding indicators. Interpretive judgments were retained at the mechanism level and were not converted into numerical effect sizes unless numerical estimates were reported in the underlying empirical studies. This distinction is important because the cases and supporting empirical studies differ in their dependent variables, samples, model specifications, and estimation techniques.

The study consequently implies analytical rather than statistical generalization. Its findings identify institutional mechanisms that may be transferable across settings, but they do not imply that individual FEZ models produce identical effects in different countries. Transferability depends on institutional capacity, regulatory architecture, fiscal resources, infrastructure conditions, energy-system configuration, and geopolitical context. This distinction is particularly relevant to the proposed Energy Special Recovery Zone (ESRZ), which is developed as a context-sensitive institutional model for Ukraine rather than as a universally applicable FEZ template.

The analytical framework allows identification of institutional patterns that transcend national differences while preserving the contextual specificity of individual cases. Rather than evaluating the overall economic performance of individual FEZs, the study focuses specifically on mechanisms

linking zone governance arrangements to energy-security objectives. The findings derived from this framework form the basis for the development of the proposed Energy Special Recovery Zone (ESRZ) model for Ukraine.

4. Results

The Asian Dirigiste Model: Strategic Energy Sovereignty through FEZs

The Asian dirigiste model represents the most explicit deployment of FEZs as instruments of energy security architecture. China's approach is paradigmatic: the Shenzhen SEZ and its successors were progressively reoriented from labour-cost arbitrage platforms toward high-technology manufacturing clusters, with renewable energy equipment – particularly photovoltaic panels and lithium-ion battery supply chains – constituting the dominant industrial focus by the 2010s (Naughton, 2021). By 2023, China's SEZ-hosted manufacturers accounted for approximately 80% of global solar panel production capacity (IRENA, 2023), representing a deliberate state strategy to achieve technological sovereignty in the energy transition supply chain.

South Korea's Saemangeum zone articulates a more explicit energy security mandate: the zone's master plan designates 2,100 hectares specifically for offshore wind manufacturing and hydrogen energy infrastructure, with resident obligations including minimum local content ratios of 40% for components and mandatory contribution to the national grid through a feed-in arrangement (KOTRA, 2022). This architecture embodies what we term "dual asymmetry": preferential tax treatment and streamlined permitting (asymmetric regulation favouring investors) are paired with supply-chain localisation and grid contribution requirements (asymmetric obligations creating national energy security benefits).

Table 3. Long-term Regression Coefficients (\(\beta \)) of Public Governance Quality within SEZs on Energy Infrastructure Investments

Public Governance Metric within SEZ	Long-term Regression Coefficient (\(\beta \)) on Energy Infrastructure Investment	Statistical Significance (\(p\)-value)
Government Effectiveness	+0.385	<0.01 (highly significant)
Regulatory Quality	+0.312	<0.01 (highly significant)
Corruption Control	+0.241	<0.05 (significant)

The UAE's Masdar City Free Zone offers particularly instructive case of energy security objectives embedded in zone design at the physical infrastructure level. The zone operates on a near-zero-carbon energy budget through mandatory on-site renewable generation, creating a living laboratory for energy technologies while simultaneously demonstrating the commercial viability of zero-carbon industrial operations (Cugurullo, 2016). Masdar's governance model – in which a

sovereign wealth fund (Mubadala) acts as both zone developer and anchor investor – illustrates how state capital can absorb the initial risk of energy technology demonstration at scale.

Peng et al. (2024) provide new empirical insights from ASEAN. The research presents multi-country research utilizing the CS-ARDL (Cross-Sectionally Augmented Autoregressive Distributed Lag) and FMOLS regression models. The article presents an analysis of the performance of industrial SEZs in ASEAN countries (Vietnam, Indonesia, Malaysia, and Thailand) in the context of attracting private investment in energy infrastructure. The study directly measures the impact of World Bank governance metrics - Government Effectiveness, Regulatory Quality, and Corruption Control. The results demonstrate that SEZs provide the maximum contribution to energy security only with high regulatory environment indicators. Transparent governance in the zones reduces risks for long-term energy contracts (PPAs). Modelling reveals a direct long-term correlation between improved public governance within SEZs and private capital inflows into energy supply diversification and security projects (see Table 3). The regression coefficients presented in Table 3 are drawn from the independent empirical study of Peng et al. (2024) and are used here as supporting evidence for the governance-energy investment relationship identified in the comparative analysis. They should not be interpreted as coefficients estimated within the present study or as directly comparable effect sizes across the cases considered below. The underlying studies differ in their dependent variables, geographical coverage, model specifications, samples, and estimation techniques. Therefore, coefficients reported in Tables 3-5 are interpreted within the methodological context of their respective source studies and are used to identify the direction and relative significance of particular governance mechanisms rather than to establish a common statistical scale of effects.

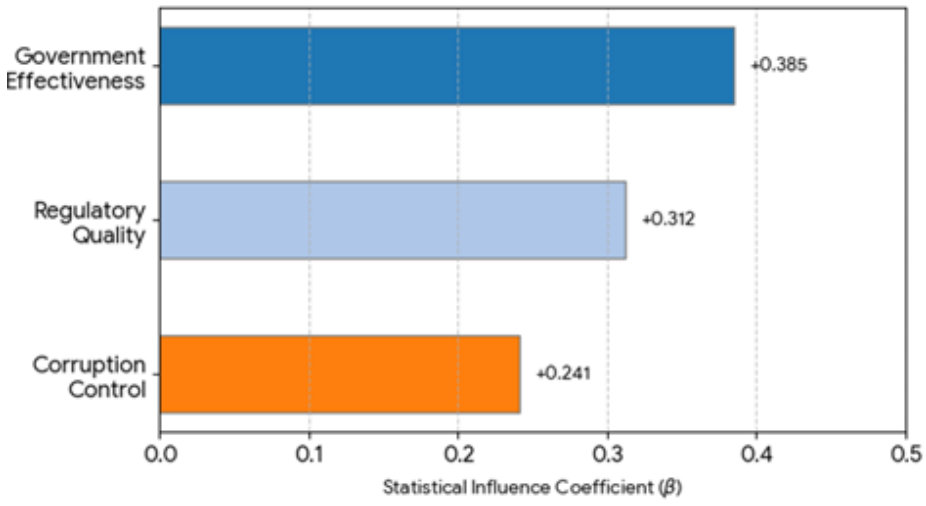

Figure 2. Impact of SEZ Public Governance Metrics on Energy Infrastructure Investment via Long-term Regression Coefficients (β)

Source: developed based on econometric model estimations from Peng et al. (2024)

Using numerical data from the econometric models of this case, we can visualize the strength of influence of various public governance factors in the SEZ on the provision of energy investments, which constitutes an important channel through which energy-system stability and energy security may be strengthened (see Fig. 2).

African context

The African Developmental Model, outlined by Gong and Tiaque, uses FEZs to mitigate energy poverty by anchoring regional grid stability and accelerating decentralized renewable energy deployment (Gong et al., 2026). Econometric modelling indicates that Industrial Zones provide the strongest impact on reducing energy poverty (\(\beta = -0.420\)) when combined with strategic public management of grid infrastructure. The South African Atlantis Special Economic Zone (ASEZ) exemplifies this, focusing on Greentech manufacturing and localized storage to build operational resilience within the Southern African Power Pool (Anyanwu et al., 2026).

The study examines how the creation of SEZs through foreign direct investment (FDI) and clean technology transfer influences energy supply security and the mitigation of energy shortages (components of energy security). The authors emphasize that the key driver of effectiveness is the institutional quality of public administration (policy for providing targeted incentives, monitoring investor compliance with infrastructure obligations, and coordination between agencies). Without effective government regulation, zones become isolated "enclaves" and fail to provide synergies for the national energy system. The study calculates the impact (elasticity coefficients) of different zone types on reducing energy poverty and improving the energy security of the population (see Table 4).

Table 4. Statistical Impact and Elasticity Coefficients of Various SEZ Types on Regional Energy Poverty Reduction (2000–2022).

Type of Economic Zone	Statistical Impact Coefficient (Impact on Reducing Energy Poverty)	Key Governance Channel
Industrial Zones	-0.42 (strongest)	Strategic grid infrastructure planning
Technology Parks	-0.28	Renewable technology diffusion (R&D)
Free Trade Zones	-0.15 (weakest)	Customs facilitation for energy equipment import

Source: adapted from Gong and Tiague (2026)

The coefficients reported in Table 4 originate from the independent empirical analysis of Gong and Tiague (2026). Their inclusion serves to provide complementary evidence concerning the relationship between governance-related arrangements and energy-sector outcomes. As this study employs a different empirical design, dependent variable, geographical coverage, and estimation framework from Peng et al. (2024), its coefficients are not directly comparable with those reported in

Table 2. The values are, thus, interpreted as study-specific empirical evidence supporting institutional mechanisms rather than as observations on a common comparative regression scale.

The North American Market-Oriented Model: Fiscal Architecture and Private Capital Mobilisation

The North American approach diverges fundamentally from the Asian model in its reliance on fiscal incentive design rather than direct state industrial programming. The US Opportunity Zone programme, created under the 2017 Tax Cuts and Jobs Act, designates over 8,700 low-income census tracts as eligible for preferential capital gains treatment on invested capital (Theodos et al., 2020). While the programme was not designed with explicit energy security objectives, empirical analysis reveals that renewable energy projects – particularly utility-scale solar and wind installations – have emerged as the dominant investment category in rural Opportunity Zones, driven by the synergy between capital gains deferral and renewable energy tax credits (NOVOGRADAC, 2022).

This market-driven convergence leads to important theoretical insight: even without explicit energy mandates in FEZ legislation, well-designed fiscal architectures can generate substantial energy security co-benefits when placed in regulatory environments that price externalities appropriately. The limitation of this model, however, is its dependence on mature capital markets and sophisticated tax planning infrastructure – conditions absent in post-conflict contexts. Furthermore, without localisation obligations, the energy security benefits remain primarily in the form of generation capacity addition rather than supply-chain development or technology sovereignty.

Canada's regional development zone approach offers a partial corrective: the Atlantic Canada zones explicitly incorporate technology transfer obligations and skills development requirements as conditions of public investment support, creating a hybrid model closer to the Asian archetype while preserving market price-discovery mechanisms (Atlantic Canada Opportunities Agency (ACOA) ACOA, 2021).

The European Regulated Transformation Model: FEZs as Decarbonisation Pilots

The European model is distinguished by the integration of FEZ policy within supranational regulatory frameworks – specifically, EU state-aid rules, the Emissions Trading System (ETS), and the Green Deal sectoral mandates. This integration simultaneously constrains the scope of permissible FEZ incentives and creates powerful co-incentive structures through carbon pricing and green taxonomy financing advantages.

Recent quantitative assessments of framework inherent in European Regulated Transformation Model, emphasise measurable impact of targeted governance over purely fiscal incentives. A comprehensive panel study conducted by the Centre for European Policy Studies

(CEPS) analysed the restructuring of EU industrial and special economic zones in transitioning coal regions (such as Poland's Katowice SEZ and the Wielkopolska zone) (Kustova et al., 2021). The study measured how public governance mechanisms - specifically the deployment of "flanking measures" (targeted EU-funded technological grants and carbon emission credit shielding) - influenced private capital allocation toward low-carbon technologies and grid stability.

Table 5. Statistical Impact Coefficients of EU FEZ Governance Interventions on Low-Carbon Energy Transition (Fixed-Effects Estimates)

EU Governance Mechanism within FEZ	Estimated Impact Coefficient on Energy Capacity / Decarbonization	Statistical Significance (p-value)	Primary Operational Target
Targeted Technology & R&D Grants	+0.412	<0.01 (highly significant)	Photovoltaic parks & smart grid infrastructure
Carbon Shielding & ETS Flanking Measures	+0.295	<0.01 (highly significant)	Energy storage & heavy industry fuel-switching
Simplified Environmental Permitting	+0.184	<0.05 (significant)	Distributed biomass and localized grid connections

Source: developed by the authors based on: Kustova et al. (2021), Zavarská et al. (2023)

The econometric framework applied fixed-effects models to track investment shifts. The results proved that when zone management coupled infrastructure streamlined-permitting with strict EU taxonomy compliance, the marginal efficiency of clean energy transition investments increased significantly. Specifically, public management interventions designed to subsidize green technology R&D facilities within the zones yielded the highest statistical correlation with long-term regional energy self-sufficiency (Zavarská et al., 2023).

Table 5 summarizes the estimated impact coefficients of these specialized European governance interventions on accelerating regional low-carbon energy security capacity.

The empirical estimates presented in Table 4 are derived from independent studies by Kustova et al. (2021) and Zavarská et al. (2023). These studies examine energy-related outcomes in different geographical and institutional settings and employ distinct empirical specifications and estimation approaches. Consequently, their coefficients should not be interpreted as directly comparable effect sizes with those reported in Tables 2 and 3. Their role in the present analysis is evidentiary: they demonstrate how specific institutional, regulatory, or governance factors have been associated with energy-related outcomes in the respective empirical contexts.

This statistical distribution reveals a critical structural lesson for the European model: within tight supranational regulatory constraints, the state's role pivots from a direct capital provider to a risk-mitigating coordinator. By utilizing EU structural funds to subsidize the technological

"premium" of renewable installations rather than offering raw corporate tax exemptions, FEZ governance effectively aligns local energy security targets with broader continental decarbonization mandates.

Poland's post-2018 SEZ reform is particularly representative for Ukraine's EU accession context. The transformation of 14 separate special economic zones into a unified Polish Investment Zone (PIZ) resolved longstanding fragmentation problems while maintaining differentiated regional investment intensity maps tied to development disparities (PAIH, 2022). Crucially, the reformed PIZ explicitly prioritises investments in renewable energy manufacturing, energy storage, and smart grid technologies through an uplifted incentive coefficient – a mechanism that effectively embeds energy security preferences into the zone's investment incentive architecture without violating EU state-aid constraints.

The Netherlands' Rotterdam Climate Bond illustrates a distinct but complementary mechanism: green bonds issued by the port authority fund decarbonisation infrastructure in the Maasvlakte II industrial zone, creating a financial architecture that channels capital market sustainability preferences into energy security investments without requiring direct public expenditure (Port of Rotterdam, 2021). This model is particularly relevant for Ukraine, where fiscal space for public investment is severely constrained by war financing obligations and reconstruction debt.

Estonia's Ülemiste City zone demonstrates the energy security benefits of data centre-oriented FEZ development: the concentration of digital infrastructure creates significant and predictable electricity demand, justifying dedicated renewable energy generation investments that would not be commercially viable at the individual firm level. This "demand aggregation" mechanism is a distinctive feature of the European model and has direct applicability to Ukraine's significant potential as a data centre hub for EU digital infrastructure resilience.

Comparative Synthesis: The Principle of Dual Asymmetry

Cross-case analysis reveals that the most energy-security-effective FEZs across all three governance models share a structural characteristic that we define as "dual asymmetry." This principle has two complementary dimensions. The first dimension – regulatory asymmetry – refers to deliberate creation of more permissive, simplified, or incentivised regulatory environment within the zone compared to the surrounding territory. This asymmetry is the classical FEZ mechanism, designed to attract investment by lowering transaction costs and improving return expectations.

The second dimension – obligation asymmetry – is less frequently theorised but proves equally essential for energy security outcomes. Obligation asymmetry refers to the imposition of specific performance requirements on zone residents that generate positive externalities for the

national energy system: i) minimum renewable energy generation ratios, ii) local content requirements for energy equipment manufacturing, iii) mandatory technology licensing to domestic firms, iv) grid contribution obligations, or v) energy efficiency performance standards. Without this second dimension, FEZs function purely as fiscal expenditure instruments generating investment without structural energy security transformation. Table 6 presents appropriate comparative analysis.

Table 6. Comparative Analysis of FEZ Governance Models and Energy Security Outcomes

Dimension	Asian Dirigiste	N. American Market	European Regulated
Primary FEZ objective	Industrial policy & tech sovereignty	Investment & employment	Decarbonisation & EU integration
Energy mandate explicitness	High (explicit)	Low (emergent)	Medium (embedded in criteria)
Regulatory asymmetry	Strong tax & permit relief	Tax credit stacking	Reduced compliance costs
Obligation asymmetry	Strong (localisation + grid)	Weak (market-driven)	Medium (ETS + taxonomy aligned)
Technology transfer mechanism	Explicit JV requirements	None / market-driven	Skills and IP licensing clauses
State capital role	Dominant (SWF/SOE)	Marginal (co-investment)	Moderate (de-risking finance)
Dual asymmetry score	High	Low	Medium–High
Energy security outcome quality	Structural / supply chain	Additive / generation	Systemic / transition-aligned

Source: compiled by the authors based on UNCTAD (2019), IEA (2022), KOTRA (2022), PAIH (2022).

The Energy Special Recovery Zone (ESRZ) Model for Ukraine

Ukraine's post-war context exhibits several structural characteristics that collectively define a unique institutional opportunity for FEZ-driven energy security reconstruction. On the demand side, the systematic targeting of energy infrastructure by Russian forces has destroyed estimated 50% of generation capacity, creating an unprecedented reconstruction agenda (World Bank, 2023). On the supply side, Ukraine possesses one of the highest renewable energy potential in Europe – technically exploitable solar capacity of 400 GW and wind capacity of 320 GW – yet this potential remains largely untapped due to grid instability, financing constraints, and regulatory uncertainty (IRENA, 2023).

Drawing on the comparative analysis above, we propose the Energy Special Recovery Zone (ESRZ) as a hybrid institutional model that selectively combines elements of all three governance archetypes while adapting them to Ukraine's specific legal, institutional, and geopolitical constraints. The ESRZ model rests on four structural pillars.

The first pillar is a three-tier governance architecture. At the national level, a dedicated ESRZ Supervisory Authority – operating under dual accountability to the Cabinet of Ministers and the Energy Regulator (NEURC) – establishes performance frameworks and allocates public co-investment. At the zone level, an independent Zone Development Agency (ZDA) manages day-to-day operations with a governance board incorporating municipal authorities, resident firms, civil society representatives, and EU accession monitoring observers. At the resident level, a self-governing Residents' Council participates in collective energy infrastructure management decisions, creating the strategic collaboration mechanism identified by Rodrik (Rodrik as cited in Lee, 2022; Razumei, et al., 2025) as essential for effective industrial policy.

The second pillar is a differentiated incentive architecture structured around technology contribution tiers. Tier 1 residents – producing core renewable energy components (cells, turbine blades, electrolysers) with minimum 40% local content – receive the maximum incentive package: 10-year corporate income tax exemption, VAT exemption on imported capital equipment, and priority grid connection. Tier 2 residents – integrating and deploying renewable energy systems – receive a 5-year tax holiday and expedited permitting. Tier 3 residents – providing ancillary services (logistics, maintenance, digital services) – receive streamlined regulatory processing without fiscal exemptions. This tiered structure ensures that the greatest public subsidy flows toward activities generating the greatest supply-chain and technology sovereignty benefits.

Table 7. ESRZ Institutional Architecture: Key Parameters

Parameter	Specification
Zone type	Energy Special Recovery Zone (ESRZ)
Minimum zone area	500 ha (greenfield) / 200 ha (brownfield industrial)
Governance structure	National Authority → Zone Development Agency → Residents' Council
Resident tiers	3 tiers based on technology localisation depth
Max. incentive duration (Tier 1)	10 years CIT exemption + VAT relief on capital equipment
Energy Obligation Mechanism	Levy of 2–5% of incentive value → local grid modernisation fund
Technology transfer requirement	IP licensing to domestic firms at regulated royalty rates (Tier 1)
EU compliance	Designed within GBER + TCTF boundaries
Monitoring mechanism	Annual KPI review: MW installed, local content %, jobs, grid stability
Target regions (priority)	Kharkiv, Mykolaiv, Zaporizhzhia, Dnipropetrovsk oblasts

Source: developed by the authors.

The third pillar is the Energy Obligation Mechanism (EOM): a mandatory contribution by all ESRZ residents to the local distribution network proportional to their installed generation capacity or energy consumption, funded through a levy on preferential incentive savings. EOM proceeds finance grid modernisation investments within the zone's service area, ensuring that FEZ development

actively strengthens rather than strains local energy infrastructure – a critical concern in post-conflict grid environments characterised by severe distribution network damage.

The fourth pillar is EU accession alignment architecture. All ESRZ incentive mechanisms are designed within the boundaries of EU state-aid block exemption regulations (particularly the General Block Exemption Regulation and the Temporary Crisis and Transition Framework), ensuring that preferential treatment survives the transition to EU membership without requiring renegotiation. This forward compatibility is a critical institutional advantage absent in Ukraine's existing industrial park and special economic zone legislation.

Key parameters of ESRZ institutional architecture are summarized in Table 7.

5. Discussion

Institutional Constraints and Practical Limitations of ESRZ Implementation in Ukraine

The ESRZ model proposed in this article engages with several live tensions in the literature that warrant explicit discussion. The first concerns the fundamental paradox of post-conflict institutional design: the destruction of legacy infrastructure simultaneously creates both an acute energy security emergency and a structural opportunity to bypass the incumbent-resistance dynamics that have slowed energy transitions in states without recent infrastructure shocks. Ukraine's situation – where Goumagias et al. (2022) would predict severe "reconstruction path dependency" toward pre-war infrastructure configurations – instead presents conditions closer to what we term a "forced transition window," in which the absence of functional legacy systems removes the primary political economy obstacle to new technology adoption.

The second tension concerns the compatibility of dual asymmetry with EU state-aid rules. Preliminary legal analysis suggests that the incentive architecture outlined in Table 3 can be structured within existing block exemption frameworks, particularly the Regional Aid Guidelines and the Climate, Environmental Protection and Energy Aid Guidelines (European Commission, 2022). However, the EOM – a novel mechanism in EU FEZ practice – requires careful legal engineering to avoid classification as a parafiscal charge creating market distortions. From a legal-institutional perspective, the principal risks concern the design of tax exemptions, preferential financing, infrastructure support, and other selective advantages provided to ESRZ residents. Their compatibility with the EU State aid acquis will depend on the objective and proportionality of each measure, its geographical and sectoral scope, the conditions attached to the support, and the applicable rules for regional, environmental, and energy-related State aid. The ESRZ framework should incorporate State aid compliance at the design stage, with individual incentive instruments assessed according to the relevant exemption, notification, and monitoring requirements rather than treated as

automatically permissible under the zone's special status. This dimension warrants dedicated legal scholarship beyond the scope of this article.

The third tension involves the political economy of FEZ site selection in a wartime and immediate post-war context. The priority regions identified above – Kharkiv, Mykolaiv, Zaporizhzhia, Dnipropetrovsk – correspond to areas of high reconstruction need and renewable energy potential, but also represent security-risk environments that may deter private investment irrespective of incentive generosity. Resolution of this tension likely requires the participation of multilateral development finance institutions (EBRD, IFC, DFC) as anchor co-investors providing political risk insurance and first-loss capital facilities – an institutional layer not fully elaborated in the ESRZ model as presented but critical for practical implementation.

Finally, the article acknowledges that the evidence base for energy security outcomes attributable specifically to FEZ mechanisms remains thin. The causal identification challenges are substantial: FEZs typically operate in conjunction with other industrial and energy policies, making isolating their contribution methodologically difficult. The comparative analysis presented here is primarily mechanism-tracing rather than impact evaluation. Rigorous quasi-experimental assessment of FEZ-energy security linkages – ideally exploiting the staggered rollout of zone programmes as natural experiments – represents a significant priority for future research.

Meanwhile, although the ESRZ model demonstrates substantial potential as a governance instrument for post-war energy reconstruction, its practical implementation in Ukraine faces several institutional constraints that distinguish the Ukrainian case from the international examples examined above. First, security risks remain the most significant source of uncertainty. Unlike the majority of successful FEZs analysed in this study, Ukraine continues to operate under conditions of ongoing military threats. Potential investors may perceive energy-oriented industrial zones as strategic targets, which increases insurance costs, lengthens investment horizons, and reduces expected returns. Second, governance effectiveness represents a critical determinant of success. Comparative evidence from ASEAN and African cases demonstrates that the positive effects of economic zones on energy development depend heavily on regulatory quality, administrative capacity, and corruption control. Without transparent governance mechanisms, preferential regimes may generate rent-seeking behaviour rather than productive investment. Third, financial constraints may limit the state's ability to provide large-scale incentives comparable to those employed in East Asian developmental models. Given the substantial fiscal burden associated with reconstruction and defence expenditures, the Ukrainian government will likely depend on blended financing mechanisms involving international financial institutions, development banks, and private investors (Petrukha, et al., 2026). Fourth, Ukraine's future integration into the European Union creates additional regulatory constraints. While

EU accession provides access to financial resources and institutional support, it simultaneously restricts the use of certain industrial-policy instruments through state-aid and competition regulations. Consequently, ESRZ incentives must remain compatible with evolving EU regulatory frameworks.

Finally, infrastructure asymmetries between regions may produce uneven implementation outcomes. Regions with greater logistical connectivity, transmission capacity, and industrial traditions are likely to attract investment more rapidly than territories experiencing severe infrastructure damage.

Adaptive ESRZ Framework

The comparative analysis further suggests that the effectiveness of energy-oriented economic zones depends not only on the design of incentives and obligations but also on their capacity to adapt to changing external conditions. International experience demonstrates that geopolitical shocks, market volatility, technological disruptions, and regulatory transformations may significantly alter the performance of zone-based development strategies. To account for these uncertainties, the proposed ESRZ model incorporates an Adaptive Resilience Coefficient (ARC), which reflects the ability of the institutional framework to maintain effectiveness under changing environmental conditions:

$$ARC=\alpha E+\beta G+\gamma F+\delta R \qquad (1)$$

where:

E = energy infrastructure resilience;

G = governance effectiveness;

F = financial sustainability;

R = regulatory compatibility with EU requirements;

subject to: $\alpha+\beta+\gamma+\delta=1$

The components of ARC are defined conceptually rather than treated as empirically calibrated indicators in the present study. Energy resilience (E) refers to the capacity of the zone's energy infrastructure to absorb, withstand, and recover from disruptions and may be operationalised in future empirical research through indicators such as infrastructure redundancy, reserve capacity, diversification of energy sources, and recovery time following disruptions. Governance adaptability (G) captures the capacity of public institutions and zone-management bodies to adjust regulatory and administrative arrangements in response to changing energy, technological, and geopolitical conditions; potential indicators include regulatory response time, institutional coordination capacity,

and the frequency or effectiveness of policy adjustments. Financial sustainability (F) refers to the capacity to maintain energy-related investments and zone incentives without generating unsustainable fiscal exposure and may be assessed through indicators such as investment continuity, fiscal burden, private co-financing, and revenue stability. Regulatory readiness (R) denotes the capacity to comply with and adapt to evolving domestic and EU regulatory requirements, including energy, environmental, investment, and state-aid rules; possible indicators include compliance costs, regulatory adjustment time, and the degree of alignment with applicable EU requirements.

The weights α, β, γ, and δ are not empirically estimated in the present study. They are introduced as adjustable parameters reflecting the relative importance assigned to each dimension in a future empirical application. Accordingly, the ARC should be understood at this stage as an indicative analytical construct rather than as a validated composite index. Future research may calibrate the weights using expert elicitation, statistical techniques, or empirical performance data, depending on the availability and quality of observations.

The overall performance of an Energy Special Recovery Zone may, therefore. be expressed as:

$$ESRZP_{erformance} = DAS \times ARC \qquad (2)$$

where DAS represents the Dual Asymmetry Score reflecting the balance between regulatory incentives and resident obligations.

This formulation introduces a dynamic dimension into the ESRZ framework. While the Dual Asymmetry Score captures the structural quality of institutional design, the Adaptive Resilience Coefficient reflects the capacity of the model to respond to unforeseen shocks, security challenges, financial disruptions, and regulatory changes. Consequently, the framework may be adjusted over time without altering its fundamental governance architecture.

At the present conceptual stage, this expression is not used to generate empirical performance score for ESRZ. Rather, it specifies proposed analytical relationship between structural governance condition represented by DAS and adaptive capacity represented by ARC. Its empirical application would require prior operationalisation and calibration of both components using observed data.

The comparative evidence examined in this study suggests that the effectiveness of energy-oriented free economic zones depends not only on the balance between incentives and obligations but also on the ability of governance arrangements to adapt to changing external conditions. In post-conflict environments, institutional performance may be affected by security threats, regulatory transformations, fiscal constraints, and infrastructure disruptions. Therefore, the ESRZ model should

be understood not as a static institutional design but as an adaptive governance framework capable of maintaining functionality under conditions of uncertainty. Figure 3 illustrates the interaction between the principle of dual asymmetry and the proposed adaptive resilience mechanism that collectively determine long-term energy security outcomes.

The adaptive governance framework presented above demonstrates that the sustainability of energy-oriented economic zones depends on the simultaneous presence of two complementary components. The first component is the institutional architecture of dual asymmetry, which creates incentives for investment while ensuring the generation of broader public benefits through localisation, technology transfer, and infrastructure participation. The second component is institutional resilience, which enables the governance system to absorb external shocks and adjust to changing economic, political, and regulatory conditions. Together, these elements create a flexible policy instrument capable of supporting both post-war reconstruction and long-term energy transformation.

Overall, the findings indicate that the proposed ESRZ model should be viewed as a dynamic governance mechanism rather than a conventional special economic zone. Its effectiveness will ultimately depend on the interaction between regulatory design, governance quality, financial sustainability, and security conditions. While the model requires further empirical validation, it provides a theoretically grounded and policy-relevant framework for aligning investment attraction, industrial development, and energy security objectives within a single institutional architecture.

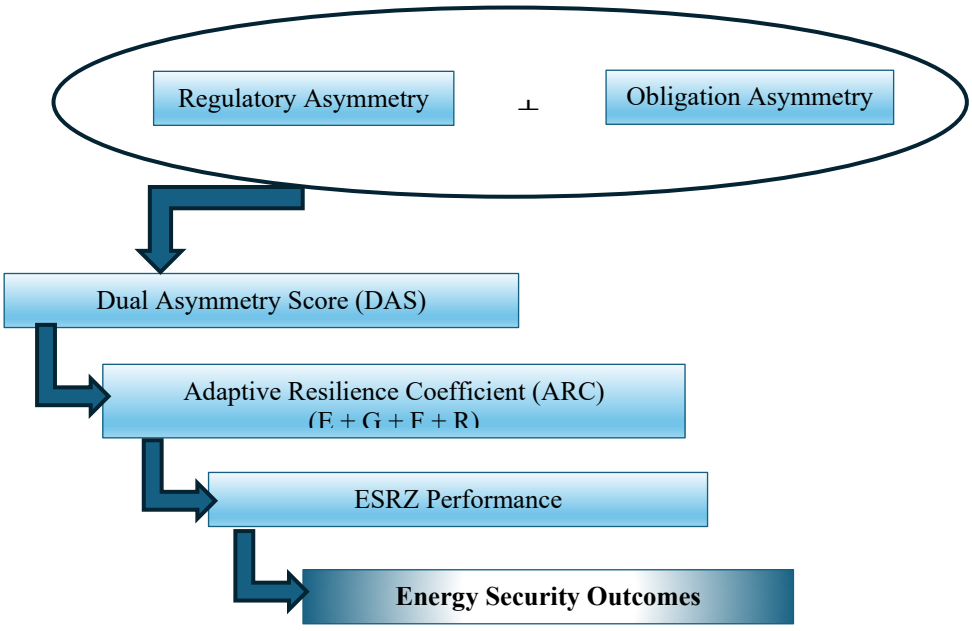

Figure 3. Adaptive ESRZ Governance Model: Interaction Between Dual Asymmetry, Institutional Resilience and Energy Security Outcomes
Source: developed by the authors

6. Conclusion

The presented study examined the role of free economic zones as instruments of state governance in strengthening energy security through a comparative analysis of international experience. The findings demonstrate that FEZs can contribute to energy security not only through investment attraction but also through institutional mechanisms that promote technology transfer, industrial localisation, renewable energy deployment, and infrastructure modernisation. Comparative analysis allowed identification of common governance characteristics shared by the most successful energy-oriented zones across different institutional environments. This characteristic, conceptualised in the article as the principle of dual asymmetry, combines preferential regulatory conditions designed to attract investors with specific obligations that generate positive externalities for the national energy system. Although the intensity and implementation mechanisms vary across governance models, the presence of both dimensions emerges as a recurring institutional pattern in cases associated with stronger and more sustainable energy-security outcomes.

Based on these findings, the article proposed the Energy Special Recovery Zone (ESRZ) model tailored to the specific needs of post-war Ukraine. The proposed framework integrates a three-tier governance structure, differentiated incentive mechanisms, technology-transfer obligations, and an Energy Obligation Mechanism intended to support local grid resilience. In contrast to traditional free economic zones focused primarily on export promotion, the ESRZ model seeks to align investment attraction with broader objectives of energy autonomy, technological sovereignty, and infrastructure recovery.

At the same time, the study acknowledges several limitations. The proposed model remains conceptual and has not yet been tested through empirical implementation. Furthermore, the effectiveness of ESRZs in Ukraine may be influenced by security risks, institutional capacity, fiscal constraints, regional disparities, and evolving European Union regulatory requirements. To address these uncertainties, the article introduced an Adaptive Resilience Coefficient (ARC) as a conceptual mechanism for accommodating changing external conditions and improving the model's long-term flexibility. The broader significance of this research extends beyond the Ukrainian case. As energy security, industrial competitiveness, and geopolitical resilience become increasingly interconnected, governments are likely to seek governance instruments capable of integrating these objectives within a single institutional framework.

These limitations also define the scope of external validity of the findings. The comparative patterns identified in this study should be understood as analytically transferable institutional mechanisms rather than as universally generalisable effects of FEZs on energy security. Their applicability to other countries is likely to depend on the institutional capacity of public authorities,

the degree of regulatory coordination, the fiscal space available for incentives, the structure and resilience of the national energy system, and the applicable international or supranational regulatory framework. The ESRZ model is therefore not intended as a uniform template for post-conflict economies. Rather, its core principles - linking differentiated investment incentives with explicit energy-related obligations and adaptive governance - may be adapted to other contexts where reconstruction, energy resilience, and institutional transformation must be pursued simultaneously. Empirical validation across additional post-conflict and energy-vulnerable settings will be necessary to determine the conditions under which these mechanisms can be effectively transferred.

Future research should focus on the empirical validation of the ESRZ model, the development of quantitative indicators for measuring the Adaptive Resilience Coefficient, and scenario-based modelling of energy-oriented economic zones under different post-conflict reconstruction trajectories. Additional comparative studies could also evaluate the long-term impact of free economic zones on energy-security outcomes using econometric and quasi-experimental methods.

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ЭНЕРГЕТИКАЛЫҚ ҚАУІПСІЗДІКТІ ҚАМТАМАСЫЗ ЕТУДЕГІ МЕМЛЕКЕТТІК БАСҚАРУ ҚҰРАЛЫ РЕТІНДЕГІ ЕРКІН ЭКОНОМИКАЛЫҚ АЙМАҚТАР: ХАЛЫҚАРАЛЫҚ ТӘЖІРИБЕНІ САЛЫСТЫРМАЛЫ ТАЛДАУ ЖӘНЕ УКРАИНА ҮШІН САЛДАРЫ

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Түйін:

Ұлттық энергетикалық жүйелердің геосаяси тұрақсыздыққа, климаттың өзгеруіне және энергетикалық нарықтардың құбылмалылығына осалдығының артуы мемлекеттерді энергетикалық қауіпсіздікті нығайтудың дәстүрлі емес басқару құралдарын іздеуге мәжбүрлеуде. Сонымен қатар, еркін экономикалық аймақтар (ЕЭА) сауда-логистикалық анклавтардан құрылымдық өнеркәсіптік және инфрақұрылымдық саясаттың күрделі құралдарына айналып келеді.

Мақаланың мақсаты – ЕЭА-ның ұлттық энергетикалық қауіпсіздік архитектурасын қалыптастыруға ықпал ететін тетіктерін анықтау және жүйелеу, сондай-ақ халықаралық тәжірибедегі тиімді үлгілерді, әсіресе соғыстан кейінгі қалпына келтіру жағдайында, Украина жағдайына бейімдеудің тұжырымдамалық тәсілдерін әзірлеу.

Зерттеуде мемлекеттік басқаруды салыстырмалы талдау, институционалдық жобалау теориясы, жүйелік талдау және кейс-стади әдістері қолданылды. Қытай, Корея Республикасы және БАӘ-ді қамтитын азиялық дирижистік модель, АҚШ пен Канаданы қамтитын солтүстікамерикалық нарықтық модель, Африка контекстіндегі жағдай, сондай-ақ Польша, Эстония және Нидерланды мысалындағы еуропалық реттелетін трансформация моделі салыстырмалы түрде қарастырылды.

Зерттеу нәтижелері энергетикалық қауіпсіздік саласындағы тиімді шешімдердің негізгі типологиялық ерекшелігі ретінде «қос асимметрия» қағидатын анықтады. Бұл қағидат инвестиция тартуға арналған асимметриялық реттеуші жағдайларды өндірісті жергіліктендіру мен технологиялар трансфертіне қатысты асимметриялық міндеттемелермен ұштастырады. Украина үшін үш деңгейлі басқару құрылымын, сараланған ынталандыру пакеттерін және «энергетикалық міндеттеме» тетігін қамтитын «Арнайы энергетикалық қалпына келтіру аймағы» (ESRZ) моделі ұсынылды.

Қорытындылай келе, соғыстан кейінгі Украина шетелдік инвестицияларды тартуға, технологиялар трансфертіне және энергетикалық дербестікті нығайтуға бағытталған жаңа буын еркін экономикалық аймақтарын құру үшін бірегей мүмкіндікке ие екендігі көрсетілді. ESRZ моделі Еуропалық Одаққа кіру міндеттемелерін ұлттық энергетикалық тұрақтылықты күшейту қажеттілігімен үйлестіруге мүмкіндік береді.

Түйін сөздер: еркін экономикалық аймақтар; энергетикалық қауіпсіздік; жаңартылатын энергия; соғыстан кейінгі қалпына келтіру; институционалдық дизайн; технологиялық егемендік.

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Стэнфорд университеті мен Elsevier аналитикалық компаниясының рейтингісіне сәйкес, Людмила Акимова 2025 жылға арналған әлемдегі ең жоғары дәйексөз келтірілген ғалымдардың ең үздік 2%-ының беделді тізіміне енді. Бұл рейтинг Scopus дерекқорынан алынған ғылымиметриялық көрсеткіштерді егжей-тегжейлі талдауға негізделген және зерттеулердің әлемдік ғылыми қауымдастыққа нақты әсерін бағалайды. Ол ұлттық және халықаралық жинақтар мен журналдардың редакциялық алқаларының мүшесі. ORCID: https://orcid.org/0000-0002-2747-2775. Электрондық пошта: l_akimova@ukr.net.

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СВОБОДНЫЕ ЭКОНОМИЧЕСКИЕ ЗОНЫ КАК ИНСТРУМЕНТ ГОСУДАРСТВЕННОГО УПРАВЛЕНИЯ В ОБЕСПЕЧЕНИИ ЭНЕРГЕТИЧЕСКОЙ БЕЗОПАСНОСТИ: СРАВНИТЕЛЬНЫЙ АНАЛИЗ МЕЖДУНАРОДНОЙ ПРАКТИКИ И ПОСЛЕДСТВИЯ ДЛЯ УКРАИНЫ

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Аннотация:

Растущая уязвимость национальных энергетических систем к геополитической нестабильности, изменению климата и волатильности энергетических рынков побуждает государства искать нетрадиционные инструменты управления для укрепления энергетической безопасности. Одновременно свободные экономические зоны (СЭЗ) претерпевают трансформацию: из торгово-логистических анклавов они превращаются в комплексные инструменты структурной промышленной и инфраструктурной политики.

Целью статьи является выявление и систематизация механизмов, посредством которых СЭЗ способны целенаправленно формировать архитектуру национальной энергетической безопасности, а также разработка концептуальных подходов к адаптации наиболее эффективных международных моделей к условиям Украины, особенно в контексте послевоенного восстановления.

В исследовании использованы методы сравнительного анализа государственного управления, теория институционального проектирования, системный анализ и метод кейс-стади. Рассматриваются три различные модели управления: азиатская дирижистская модель (Китай, Республика Корея, ОАЭ), пример из африканского контекста, североамериканская рыночно-ориентированная модель (США, Канада) и европейская модель регулируемой трансформации (Польша, Эстония, Нидерланды), которые сопоставляются на основе структурированного межстранового анализа.

Результаты исследования показывают, что ключевой типологической особенностью эффективных решений в области энергетической безопасности является принцип «двойной асимметрии», сочетающий асимметричные регуляторные условия (льготные режимы для привлечения инвестиций) с асимметричными обязательствами резидентов в части локализации производства и передачи технологий. Предложена концептуальная модель «Специальной энергетической зоны восстановления» (ESRZ) для Украины, включающая трёхуровневую систему управления, дифференцированные пакеты стимулов и механизм «энергетических обязательств».

Сделан вывод о том, что послевоенная Украина обладает уникальным «окном возможностей» для создания свободных экономических зон нового поколения, ориентированных одновременно на привлечение иностранных инвестиций, трансфер технологий и укрепление энергетической автономии. Модель ESRZ позволяет объединить обязательства по европейской интеграции с насущными задачами повышения национальной энергетической устойчивости.

Ключевые слова: свободные экономические зоны; энергетическая безопасность; возобновляемая энергетика; послевоенное восстановление; институциональное проектирование; технологический суверенитет.

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государственного регулирования рынка финансовых услуг, финансовых рынков, экономической безопасности, государственной политики в области квалификаций, государственного управления и гражданской службы. По результатам рейтингов Стэнфордского университета (Stanford University) и аналитической компании Elsevier, ученая Акимова Людмила вошла в престижный список топ-2% цитируемых ученых мира по итогам 2025 года. Этот рейтинг основан на детальном анализе наукометрических показателей из базы данных Scopus и оценивает реальное влияние исследований на глобальное научное сообщество. Она является членом редакционных коллегий отечественных и международных сборников и журналов. ORCID: https://orcid.org/0000-0002-2747-2775. Email: l_akimova@ukr.net.

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