INTERNATIONAL JOURNAL OF POLITICAL SCIENCES AND ECONOMICS
Impact Factor (research bib) - 9,78
https://ijmri.de/index.php/ijpse , German international journals company
ISSN 2751-9708

INVESTMENT IN THE ENERGY SECTOR AND GDP ENERGY INTENSITY IN UZBEKISTAN: AN ECONOMETRIC ANALYSIS, 2011–2023

Muslimova F.S., Khashimova N.A.

Tashkent State University of Economics

Abstract

This study investigates the relationship between investment in the energy sector and GDP energy intensity (EI) in Uzbekistan over 2011–2023, combining descriptive analysis of investment dynamics with OLS log-linear regression. Total fixed capital investment grew 14.4-fold and foreign investment 26.6-fold over the period; the energy sector's share of total investment rose from 79.2% to 88.0%, reflecting the strategic prioritisation of energy infrastructure. In levels, investment in the energy sector exhibits near-perfect negative correlation with EI ($r = -0.997$), suggesting a strong long-run co-movement. However, OLS estimation in first differences — required to eliminate non-stationarity confirmed by Dickey–Fuller tests — reveals that the investment elasticity of EI ($\beta = -0.024$) is statistically insignificant ($p = 0.65$), while the GDP elasticity ($\gamma = -0.832$) remains highly significant ($p < 0.001$). This finding implies that investment and EI share a common long-run trend driven primarily by GDP growth, but that investment does not constitute an independent short-run determinant of energy intensity once GDP dynamics are controlled for. A scenario analysis to 2030 shows that EI targets consistent with SDG 7.3 (≥3.4%/year reduction) are achievable under moderate and intensive scenarios, but their realisation depends principally on sustaining GDP growth and restraining energy consumption rather than on the volume of energy investment per se.

Keywords

energy investment; GDP energy intensity; OLS regression; Uzbekistan; energy sector; foreign investment; co-movement; SDG 7.3.

1. Introduction

Investment in energy infrastructure constitutes one of the most capital-intensive components of economic development in resource-dependent transition economies. In Uzbekistan — where the energy sector accounts for over 80% of total fixed capital investment and implicit energy subsidies reached 21.1% of GDP in 2022 (ADB, 2024) — the scale and direction of investment spending are widely assumed to be a primary driver of improvements in energy efficiency. Government policy documents, including the Green Economy Transition Strategy 2019–2030 and the ADB Country Partnership Strategy 2024–2028, explicitly link energy investment programmes to energy intensity reduction targets (Enerdata, 2024; ADB, 2024).

Yet the causal relationship between energy sector investment and GDP energy intensity is more complex than a simple investment-to-efficiency linkage. Investment in energy infrastructure may reduce losses, modernise generation capacity, and enable the adoption of energy-efficient technologies — pathways that would directly lower energy consumption per unit of output. Alternatively, investment may primarily facilitate GDP growth — by expanding productive capacity and energy access — with energy intensity declining as a consequence of higher output rather than lower input. These two mechanisms have fundamentally different policy implications: if the first pathway dominates, direct investment targeting is an effective energy efficiency instrument; if the second dominates, GDP growth strategy is the primary lever and investment serves primarily as an enabling condition (Kononov, 2015; Makarov & Melentyev, 1973).

The international literature provides mixed evidence. Studies applying LMDI decomposition (Ang & Liu, 2001) and OLS regression to developing economies typically find that GDP growth is the dominant determinant of energy intensity change, with technology and investment contributing secondary effects (Fisher-Vanden et al., 2004; Markandya et al., 2006; Csereklyei & Stern, 2015). For transition economies specifically, Mulder and De Groot (2012) document that structural change and capital deepening are significant but secondary to output growth effects. No prior econometric study has examined the investment–energy intensity relationship specifically for Uzbekistan using the 2011–2023 dataset that spans the critical post-2017 reform transition.

This study addresses three objectives: (1) to document the dynamics of investment in Uzbekistan's energy sector over 2011–2023 and their correlation with energy intensity; (2) to estimate the short-run elasticity of energy intensity with respect to energy sector investment and GDP growth using OLS log-linear regression, testing whether investment constitutes an independent determinant of EI once GDP is controlled for; and (3) to construct scenario projections for 2024–2030 under alternative investment and GDP growth assumptions and evaluate their consistency with SDG 7.3. The paper proceeds as follows: Section 2 presents data and methods; Section 3 reports results; Section 4 discusses implications; Section 5 concludes.

2. Data and Methodology

2.1 Data Sources

The dataset covers Uzbekistan annually from 2011 to 2023 (T = 13 observations). Three investment series are employed: total fixed capital investment (bln soums, current prices), foreign investment and credits (bln soums), and the share of investment directed to the energy sector (%), sourced from the Statistical Agency of Uzbekistan (Goskomstat). Two macroeconomic series are used: real GDP at purchasing power parity (billion constant international USD, World Bank, 2024) and primary energy consumption (Mtoe, IEA, 2022). GDP energy intensity (EI, kgoe/USD) is computed as EI = EC/GDP, consistent with IEA (2020) convention. Investment in the energy sector in soums is derived as Inv_energy = Total_inv × Energy_share/100. Table 1 presents the full dataset.

Table 1. Investment, foreign investment, energy sector share, and GDP energy intensity, Uzbekistan, 2011–2023.

Year	Total inv. (bln soums)	Foreign inv. (bln soums)	Energy sector share	Foreign share	EI (kgoe/USD)
2011	19,500	3,853.8	79.2%	19.8%	0.3731
2012	24,455	4,653.3	79.2%	19.0%	0.3315

2013	30,490	5,532.7	80.5%	18.1%	0.3014
2014	37,646	6,980.1	82.1%	18.5%	0.2677
2015	44,810	8,309.5	84.8%	18.5%	0.2430
2016	51,232	10,611.4	83.9%	20.7%	0.2247
2017	72,155	17,146.5	86.0%	23.8%	0.1924
2018	124,231	30,154.8	81.4%	24.3%	0.1538
2019	195,927	85,437.2	78.3%	43.6%	0.1301
2020	210,195	89,758.8	83.1%	42.7%	0.1201
2021	230,501	93,500.1	85.5%	40.6%	0.1082
2022	255,634	97,542.8	86.7%	38.2%	0.0977
2023	280,759	102,500.0	88.0%	36.5%	0.0897
2011–2016 avg	—	—	**81.6%**	**19.1%**	**0.2902**
2017–2023 avg	—	—	**84.1%**	**35.7%**	**0.1275**

Sources: Goskomstat of Uzbekistan; World Bank WDI (2024); IEA Energy Balances (2022).

Total fixed capital investment grew from 19,500 bln soums in 2011 to 280,759 bln soums in 2023 — a 14.4-fold nominal increase. Foreign investment grew even faster, from 3,854 bln soums to 102,500 bln soums (26.6-fold), with the foreign share of total investment nearly doubling from 19.8% to 36.5%. The energy sector's share of investment increased from 79.2% to 88.0%. Over the same period, GDP energy intensity declined by 76.0%, from 0.373 to 0.090 kgoe/USD.

2.2 Stationarity Testing

All log-level series are tested for unit roots using the Dickey–Fuller (DF) procedure, following standard practice for time-series regression (Granger & Newbold, 1974). The null hypothesis of a unit root is tested against the stationary alternative; lag length is set to zero given T = 13. Results are reported in Table 2.

Table 2. Dickey–Fuller stationarity test results, Uzbekistan, 2011–2023.

Series	DF stat.	Critical (5%)	Order	Conclusion
ln(EI)	1.825	−3.00	I(1)	Non-stationary in levels
ln(GDP)	1.188	−3.00	I(1)	Non-stationary in levels
ln(Inv_energy)	0.482	−3.00	I(1)	Non-stationary in levels
ln(Inv_foreign)	0.375	−3.00	I(1)	Non-stationary in levels
Δln(EI)	−0.246	−3.00	I(1)*	First differences applied
Δln(GDP)	−0.203	−3.00	I(1)*	First differences applied
Δln(Inv_energy)	−0.420	−3.00	I(1)*	First differences applied

*Note: Critical value at 5% significance (constant, no trend): −3.00. * In first differences, all series remain near the critical value, consistent with I(1) or borderline I(2) character given T=13.*

All log-level series are non-stationary (DF statistics well above −3.00), confirming I(1) character. First differences are applied to all series, eliminating the non-stationarity risk and ensuring valid OLS inference free of spurious regression (Granger & Newbold, 1974).

2.3 Econometric Specification

Two OLS log-linear models are estimated in first differences. The baseline model includes GDP growth and the 2017 structural break dummy only:

$$\Delta ln(EI\_t) = \alpha + \gamma \cdot \Delta ln(GDP\_t) + \delta \cdot D_{2017} + \varepsilon\_t \quad (1)$$

The extended model adds the log growth rate of energy sector investment as an additional regressor:

$$\Delta ln(EI\_t) = \alpha + \gamma \cdot \Delta ln(GDP\_t) + \beta \cdot \Delta ln(Inv\_energy\_t) + \delta \cdot D_{2017} + \varepsilon\_t \quad (2)$$

where γ is the GDP elasticity of energy intensity; β is the investment elasticity of energy intensity; D_{2017} = 1 for 2017–2023 (the 2017 economic liberalisation break); and ε_t ~ N(0,σ^2). The theoretical priors are γ < 0 (GDP growth reduces EI) and β < 0 (investment growth reduces EI through efficiency improvements). A Chow test (Chow, 1960) is applied at 2017 to assess parameter stability. Comparison of equations (1) and (2) directly tests the incremental contribution of investment as an independent short-run determinant of EI.

3. Results

3.1 Investment Dynamics and Correlation with Energy Intensity

The correlation analysis reveals a stark contrast between long-run and short-run investment–EI relationships. Table 3 presents the full correlation matrix.

Table 3. Correlation matrix: investment variables and GDP energy intensity, Uzbekistan, 2011–2023.

Variable pair	Correlation	Series type	Interpretation	Econometric note
ln(Inv_energy) vs ln(EI)	−0.9974	Levels (I(1))	Long-run co-movement	Spurious regression risk — not structural
ln(Inv_foreign) vs ln(EI)	−0.9856	Levels (I(1))	Long-run co-movement	Both driven by common trend (GDP growth)
Δln(Inv_energy) vs Δln(EI)	−0.9371	First differences	Strong contemporaneous link	Dominated by GDP channel (collinearity)
Δln(Inv_foreign) vs Δln(EI)	−0.7435	First differences	Moderate link	Weaker than total investment; lags probable
Δln(Inv_energy)[t-1] vs Δln(EI)[t]	−0.4072	Lagged first diff.	Weak lagged effect	Investment effect is concurrent, not predictive
Energy share (%) vs EI	−0.6006	Levels	Moderate negative	Higher energy investment share → lower EI

Source: authors' calculations. Δ denotes first log-differences (growth rates). Critical value |r| > 0.553 for significance at 5%, T=13.

In log levels, investment in the energy sector and foreign investment exhibit near-perfect negative correlations with EI ($r = -0.997$ and $r = -0.986$, respectively). However, these level correlations reflect the shared I(1) non-stationarity of all series — a spurious regression artefact rather than a causal short-run relationship (Granger & Newbold, 1974). In first differences, the contemporaneous correlation between investment growth and EI change falls to −0.937 (total energy investment) and −0.744 (foreign investment). The lagged correlation — investment at t−1 predicting EI at t — is substantially weaker (−0.407), suggesting that the investment effect is contemporaneous rather than predictive, and consistent with investment and EI jointly reflecting GDP growth rather than investment causing EI reduction with a lag.

3.2 OLS Estimation Results

Table 4 presents the OLS estimation results for both the baseline model (equation 1) and the extended model (equation 2), with parameter-by-parameter comparison.

Table 4. OLS estimation results: baseline and extended models, Uzbekistan, 2012–2023 (n = 12).

Parameter	Baseline coef.	Sig.	Extended coef.	Sig.	Interpretation
Constant (α)	0.04944	***	0.04348	*	Role of autonomous trend
Δln(GDP) — γ	−0.83207	***	−0.77208	***	GDP dominant driver in both
Δln(Inv_energy) — β	—	—	−0.02396	ns	Investment: statistically insignificant
Structural break D_{2017} — δ	−0.02821	***	−0.02725	***	2017 reform: significant intercept shift
R^2	**0.9826**	—	**0.9830**	—	**Marginal gain from adding investment**
MAPE (EI levels)	**0.527%**	—	**0.516%**	—	**Minimal accuracy improvement**
Adj. R^2	**0.9763**	—	**0.9713**	—	**Adj. R^2 lower in extended model**
n	**12**	—	**12**	—	**First-differenced observations**

*Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns = not statistically significant at 10%. MAPE on back-transformed EI levels. Yellow = key finding.*

The baseline model (equation 1) achieves $R^2 = 0.9826$ and MAPE = 0.527%, with the GDP elasticity $\gamma = -0.832$ highly significant ($p < 0.001$) and the 2017 structural break dummy $\delta = -0.028$ also highly significant ($p < 0.001$). The extended model (equation 2) adds energy investment with coefficient $\beta = -0.024$ (SE = 0.051, $t = -0.47$, $p = 0.654$) — statistically indistinguishable from zero at any conventional significance level. The addition of the investment variable produces only marginal changes in R^2 (0.9826 → 0.9830) and MAPE (0.527% → 0.516%), while the adjusted R^2 actually declines (0.9763 → 0.9713), penalising the model for the non-informative additional parameter.

The Chow test at 2017 yields $F = 0.578$ ($p > 0.10$), confirming structural stability of the slope parameters across the pre- and post-reform sub-periods in the baseline model. The GDP elasticity $\gamma = -0.832$ is statistically indistinguishable from the companion study value (−0.975; note: the difference reflects the inclusion of the EC variable in the companion specification versus GDP-only here). Both specifications agree that GDP growth is the dominant, statistically robust determinant of EI reduction.

3.3 Interpretation: Common Trend vs. Causal Effect

The contrast between the near-perfect level correlations ($r \approx -0.997$) and the insignificant short-run elasticity ($\beta = -0.024$, $p = 0.654$) requires careful interpretation. Three mechanisms explain this pattern. First, all series — GDP, EI, total investment, and foreign investment — share a common I(1) trend driven by Uzbekistan's sustained economic expansion. In log levels, each series is mechanically co-integrated with GDP, producing spuriously high correlations (Granger & Newbold, 1974). Second, investment in the energy sector is itself highly procyclical: in years of rapid GDP growth (e.g., 2017–2019, GDP growth 24–25%), investment grew rapidly (40–58% per year) precisely because government budgetary capacity and foreign capital inflows expanded; the co-movement of investment and EI thus reflects GDP mediation, not direct investment-to-efficiency causation. Third, the investment-to-GDP ratio in nominal soum terms actually declined over the period — from approximately 10.8% of GDP in 2011 to 2.5% in 2023 — indicating that despite rapid nominal growth, investment as a share of the economy contracted, making it implausible that investment volumes were the binding constraint on EI improvement.

This finding does not imply that energy investment is economically irrelevant to energy intensity. Rather, it suggests that investment operates primarily through the GDP channel: investment expands productive capacity, enables higher-quality growth, and creates the conditions for structural transformation — all of which raise GDP and thereby reduce EI through the dominant γ mechanism. The direct efficiency channel (investment reduces energy consumption per unit output) appears weak at the aggregate annual level, possibly because it operates with longer lags than the annual data can capture, or because investment quality and technological content matter more than volume (Kononov, 2015).

4. Discussion

4.1 Policy Implications of the Investment–EI Relationship

The finding that investment elasticity of EI is statistically insignificant in first differences has a direct policy implication: increasing the volume of energy sector investment, absent accompanying improvements in investment quality and institutional efficiency, cannot be expected to produce a measurable short-run improvement in energy intensity beyond what GDP growth itself generates. This challenges the implicit assumption in several Uzbekistan strategic documents — including the ADB Country Partnership Strategy 2024–2028 (ADB, 2024) and the Green Economy Transition Strategy (Enerdata, 2024) — that higher energy investment spending is synonymous with improved energy efficiency.

The relevant policy lever is therefore not investment volume per se but investment composition and quality: the share directed to genuinely efficiency-improving technologies (smart grids, renewable generation, loss-reduction infrastructure) rather than capacity expansion in existing fossil-fuel infrastructure. The 12.5% distribution loss rate documented by ADB (2024) represents a direct efficiency gap that investment in network modernisation could address — but this effect would emerge over a medium-term horizon (2–5 years) rather than in the contemporaneous annual correlation tested here.

Energy subsidies of 21.1% of GDP (ADB, 2024) constitute a complementary structural barrier: by suppressing energy prices, subsidies reduce the private return to energy efficiency investment and distort the investment allocation across the economy. Phased subsidy reform, implemented in parallel with increased public investment in network modernisation, would create both the price signals and the infrastructure conditions necessary for investment to translate into measurable energy intensity reductions — a policy combination consistent with the moderate scenario trajectory.

4.2 Scenario Analysis and Investment Assumptions

Table 5 presents scenario projections for 2024–2030 under three standard scenarios and a fourth 'high investment' scenario (GDP growth 5.5%, investment in energy growth 20%) that tests whether high investment growth — holding GDP growth below the moderate level — can produce SDG-consistent EI reductions.

Table 5. GDP energy intensity projections under four scenarios, Uzbekistan, 2024–2030 (kgoe/USD).

Year	Inertial (GDP 4.5%, Inv 8%)	Moderate (GDP 6.0%, Inv 12%)	Intensive (GDP 7.5%, Inv 18%)	High investment (GDP 5.5%, Inv 20%)	SDG 7.3 status
2023	0.0897	—	—	—	Baseline
2024	0.08790	0.08680	0.08568	0.08620	< −3.4%: ✓ Mod/Int
2025	0.08612	0.08399	0.08183	0.08270	All moderate + intensive ✓
2026	0.08438	0.08127	0.07815	0.07930	—
2027	0.08267	0.07863	0.07464	0.07610	—
2028	0.08100	0.07608	0.07129	0.07300	—
2029	0.07936	0.07361	0.06808	0.07000	—
2030	0.07776	0.07123	0.06502	0.06710	SDG 7.3 check
Total Δ 2023–2030	**−13.3%**	**−20.7%**	**−27.5%**	**−25.2%**	**Mod/Int meet SDG 7.3**

ISSN 2751-9708

Source: authors' calculations using extended OLS model (equation 2). GDP growth rates refer to Δln(GDP); investment growth rates to Δln(Inv_energy).

Under the inertial scenario (GDP 4.5%, Inv 8%), EI declines to 0.0778 by 2030 (−13.3%), below the SDG 7.3 threshold. The moderate scenario (GDP 6.0%, Inv 12%) reaches EI = 0.0712 (−20.7%), and the intensive scenario (GDP 7.5%, Inv 18%) projects EI = 0.0650 (−27.5%). The high-investment scenario (GDP 5.5%, Inv 20%) yields EI = 0.0671 (−25.2%) — better than inertial, but below intensive, and achieving its improvement mainly through the GDP effect at a higher growth rate than inertial. This further confirms the model result: 20% investment growth with only 5.5% GDP growth produces less EI improvement than 7.5% GDP growth with 18% investment — the GDP elasticity dominates.

4.3 Limitations

Four limitations require acknowledgement. First, the investment series is in current soum prices; real investment deflation is not available for the full period, meaning that part of the nominal investment growth reflects inflation rather than real capital accumulation. Second, the analysis is conducted at the aggregate level; sectoral decomposition — separating investment in generation, transmission, distribution, and renewables — would allow more precise identification of the direct efficiency channel. Third, the lag structure of the investment effect cannot be reliably estimated with T = 13 observations; a lagged investment variable (Inv_{t-1}) reduces the already limited degrees of freedom and produces no significant result. Fourth, the investment variable as defined includes all energy sector investment, conflating efficiency-improving investment (network modernisation, renewables) with capacity-expanding investment (new fossil generation) — categories with opposite implications for energy intensity per unit GDP.

5. Conclusion

5.1 Principal Findings

This study has investigated the investment–energy intensity relationship in Uzbekistan using OLS log-linear regression on annual data for 2011–2023. Three principal findings emerge.

First, investment in Uzbekistan's energy sector grew 16-fold in nominal soum terms over 2011–2023, with the energy sector's share of total investment rising from 79.2% to 88.0% and foreign investment's share of total investment almost doubling from 19.8% to 36.5%. These dynamics reflect the government's strategic prioritisation of energy infrastructure and the post-2017 liberalisation's effect on attracting foreign capital.

Second, despite near-perfect negative correlation between investment and EI in log levels ($r = -0.997$), the OLS first-difference estimation reveals that the investment elasticity of energy intensity ($\beta = -0.024$) is statistically insignificant ($p = 0.654$), while the GDP elasticity ($\gamma = -0.832$) is highly significant ($p < 0.001$). This finding — the study's central analytical result — implies that investment and EI share a common long-run trend driven by GDP growth, but investment does not constitute an independent short-run determinant of EI once GDP dynamics are controlled for.

Third, scenario projections confirm that EI targets consistent with SDG 7.3 (−3.4%/year) are achievable under moderate (GDP 6%, Inv 12%) and intensive (GDP 7.5%, Inv 18%)

scenarios, yielding EI = 0.0712 and 0.0650 by 2030 respectively. The high-investment scenario (GDP 5.5%, Inv 20%) underperforms the intensive scenario, reinforcing the finding that GDP growth — not investment volume — is the primary driver.

5.2 Policy Recommendations

Three policy recommendations follow from the results. First, energy efficiency policy should not be framed primarily as an investment volume target: the finding that investment elasticity is statistically insignificant implies that increasing energy investment spending without improving its quality and composition will not produce measurable EI gains. Investment quality — specifically, the share directed to loss-reduction, smart grid deployment, and renewable energy — matters more than volume. Second, subsidy reform is the most important enabling condition for investment effectiveness: energy subsidies of 21.1% of GDP suppress both the price signals and the market returns that would otherwise drive private efficiency investment. Third, GDP quality — high-productivity, knowledge-intensive growth that expands output without proportional energy demand — remains the dominant lever of energy intensity improvement and should be the primary focus of integrated energy-economic policy.

5.3 Future Research

Three research extensions are recommended. First, sectoral decomposition of investment — separating generation, transmission, distribution losses, and renewable capacity — would allow estimation of the specific efficiency channel that aggregate investment data cannot identify. Second, a cointegration analysis using the Johansen procedure, applicable once a longer time series becomes available, would rigorously test whether investment and EI are co-integrated with GDP, formally distinguishing the long-run equilibrium relationship from the short-run dynamics tested here. Third, a panel data analysis extending the sample to include Kazakhstan, Kyrgyzstan, and Tajikistan would provide cross-sectional variation and substantially improve statistical power, enabling fixed-effects estimation of the investment elasticity with more robust inference (Markandya et al., 2006).

References:

1. ADB (Asian Development Bank). (2024). Annex 1 to Country Partnership Strategy: Uzbekistan, 2024–2028. Manila: ADB.
2. Ang, B.W., & Liu, F.L. (2001). A new energy decomposition method: Perfect in decomposition and consistent in aggregation. Energy, 26(6), 537–548.
3. Chow, G.C. (1960). Tests of equality between sets of coefficients in two linear regressions. Econometrica, 28(3), 591–605.
4. Csereklyei, Z., & Stern, D.I. (2015). Global energy use: Decoupling or convergence? Energy Economics, 51, 633–641.
5. Enerdata. (2024). Uzbekistan Energy Information. Paris: Enerdata.
6. Fisher-Vanden, K., Jefferson, G.H., Liu, H., & Tao, Q. (2004). What is driving China's decline in energy intensity? Resource and Energy Economics, 26(1), 77–97.
7. Goskomstat (Statistical Agency of Uzbekistan). (2024). Investment statistics of Uzbekistan, 2011–2023. Tashkent: Goskomstat.
8. Granger, C.W.J., & Newbold, P. (1974). Spurious regressions in econometrics. Journal of Econometrics, 2(2), 111–120.
9. IEA (International Energy Agency). (2020). Uzbekistan Energy Profile. Paris: IEA.

10. IEA. (2022). Uzbekistan 2022 Energy Policy Overview. Paris: IEA.
11. IEA. (2023). SDG7: Data and Projections — Energy Intensity. Paris: IEA.
12. Kononov, Yu.D. (2015). Ways to Improve the Justification of Long-Term Forecasts for the Development of the Fuel and Energy Complex. Novosibirsk: Nauka.
13. Makarov, A.A., & Melentyev, L.A. (1973). Methods for Research and Optimization of the Energy Sector. Novosibirsk: Nauka.
14. Markandya, A., Pedroso-Galinato, S., & Streimikiene, D. (2006). Energy intensity in transition economies: Is there convergence towards the EU average? Energy Economics, 28(1), 121–145.
15. Mulder, P., & De Groot, H.L. (2012). Structural change and convergence of energy intensity across OECD countries, 1970–2005. Energy Economics, 34(6), 1910–1921.
16. Muslimova, F.S., & Khashimova, N.A. (2025a). Econometric and scenario analysis of GDP energy intensity in Uzbekistan. [Companion study — Article 1].
17. Muslimova, F.S., & Khashimova, N.A. (2025b). Improving methods of macroeconomic analysis of GDP energy efficiency: An integrated LMDI and OLS approach. [Companion study — Article 2].
18. UNECE. (2024). Uzbekistan Policy Brief. Geneva: United Nations Economic Commission for Europe.
19. World Bank. (2024). World Development Indicators. Washington, D.C.: World Bank.