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Impact of Electricity Distribution Loss on Energy Intensity in the SAARC Countries

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Abstract: ***Abstract****: Electricity is necessary for modern life, industries, households, healthcare, and overall economic activities. It drives economic growth, creates technological development, and improves living standards by access to education, essential services, and clean water, but distribution losses are the grave issue, especially in developing countries such as SAARC economies. For this purpose, the study aims to examine the influence of electricity distribution losses on energy intensity in SAARC countries for the data period consisting of 2000 to 2023, employing robust econometric techniques and panel data analysis. The outcomes show a significant positive association between electricity distribution losses and energy intensity, enhancing the need for targeted reforms to increase energy efficiency. Renewable energy integration depicts an adverse relationship with energy intensity, highlighting its key role in promoting sustainable energy usage and diminishing per capita energy use. Industrial growth illustrates a favorable correlation with energy intensity, highlighting the issues of balancing economic expansion with energy efficiency. Technical cooperation and CPIA quality depict a negative influence on energy intensity. Granger causality study further depicts a bidirectional association between energy consumption and industrial growth, as well as renewable energy, while energy consumption unidirectionally impacts electricity distribution loss, renewable energy, and technical assistance. The study provides some recommendations, consisting of reducing electricity distribution losses, enhancing renewable energy integration, strengthening regional cooperation, and implementing energy-efficient industrial policies.*

Keywords: Energy Intensity (EI), Country Policy and Institutional Assessment (CPIA), Gross Domestic Product (GDP), Renewable Energy (RE), World Development Indicators (WDI).

Introduction

Electricity is a foundation stone of modern society; now it's an integral part of human life and economic activity. Access to consistent electricity promotes industrialization, wires innovation, and improves productivity, contributing to a nation's economic growth. In the context of sustainable development, electricity is central to advancing clean energy solutions, lessening dependence on fossil fuels, and diminishing climate change impact. Strielkowski, W et al., 2021). But on the other hand, distribution loss is a significant issue for the energy sector; it refers to the energy missing during the process of distributing and transmitting electricity from power production plants to end consumers. These losses can be classified into two main kinds: technical and non-technical victims Kim, H et al., 2021. Technical losses take place naturally due to the confrontation in electrical mechanisms, such as transformers, distribution lines, cables, and electricity transmission. Non-technical losses, on the other hand, are due to human nature, such as meter tampering, electricity theft, wrong billing, and illegal consumption.

These losses severely affect the energy intensity level in the world, especially in the SAARC countries. According to a report in 2022, shows that India' distribution losses are 19%, while Pakistan's losses exceed 20%, among the maximum in the region. These losses result in enlarged energy intensity as more energy is necessary to meet the same economic output, leading to higher costs and environmental deprivation due to increased dependence on fossil fuels.

Indeed, SAARC countries are especially vulnerable to these issues due to various causes. These causes include their rising energy demand, low infrastructure, and insufficient investment in grid advancement. As economies in the area try for industrialization and urbanization processes, the demand for energy is estimated to increase at a rate of 5% to 6% till 2030. This increasing demand, joined with high distribution losses, exacerbates energy consumption and reduces the competitiveness of these countries. Undeniably, electricity distribution losses are vital for increasing energy efficiency in countriesHassan, Q., Viktor, P et al., 2024). The region's dependence on outdated grid mechanisms results in huge technical losses, while fragile governance and insufficient enforcement result in non-technical losses. For instance, Bangladesh, in spite of high improvements in the energy sector, still shows distribution losses of more than 11%. These inefficiencies not only decline energy affordability for consumers but also induce governments to boost energy subsidies, inserting significant burdens on the public exchequer. Advancement of grid systems and the assumption of advanced technologies such as smart grids and real-time monitoring could considerably decrease these losses and recover overall energy efficiency.

Moreover, the environmental effects of high electricity distribution losses are profound. Increased energy intensity due to distribution inefficiencies leads to greater greenhouse gas (GHG) emissions as fossil fuels govern the energy mix in SAARC countries. India, for instance, is the third-largest emitter of greenhouse gases globally, and falling distribution losses could play a critical role in achieving its pledge to net-zero emissions by 2070. Similarly, Pakistan and Sri Lanka face rising pressures to line up their energy policy with global climate objectives while running their economic constraints. Undertaking distribution losses can thus add to both economic and environmental sustainability in the said countries.

Put into brief, this analysis aims to bridge the gap by investigating the direct influence of electricity distribution losses on energy intensity in SAARC nations by using various robust econometric methods and comprehensive panel data assessment from 2000 to 2023. It explores how diminishing distribution losses could better energy intensity levels, enhance economic progress, and support climate risk efforts. The finding provides actionable suggestions for authorities and policymakers, enhancing the significance of regulatory reforms, technological development, and regional assistance in addressing these issues. By highlighting the relationship between energy efficiency and electricity distribution, this study aims to seek and provide meaningfully to sustainable energy transitions in SAARC economies.

Literature Reviews

In fact, electricity distribution losses considerably affect energy intensity, mainly in the SAARC countries, leading to greater energy costs and environmental issues. Addressing these inefficiencies is vital for enhancing energy efficiency and sustainable expansion. This review observes key studies on the subject and recognizes gaps for further investigation. By Pandey, A., Brauer, M., Cropper, M. L. et al., 2021) examine the association between electricity distribution losses and energy consumption in developing economies. It emphasizes that how inefficient power distribution mechanisms lead to higher energy intensity, increasing energy consumption. The study highlights that enhancement of grid resilience and technological advancement can significantly decline these losses. Their outcomes suggest that targeted interventions to decline electricity losses can better overall energy efficiency and grid resilience. The study recommends strategic investments and work for advancement in grid infrastructure to lessen energy intensity. In contrast, Bhattarai et al., 2024) investigates the crucial role of power systems, particularly electricity distribution losses, in shaping energy consumption in the South Asian countries. The outcome shows that electricity losses lead to greater energy consumption for the same level of output, thereby increasing energy consumption. The study highlights the need for regional cooperation among SAARC countries to tackle common challenges in the power distribution. The study underscores the need for comprehensive policies and technological solutions to better grid efficiency and resilience. It concludes that addressing these losses could foster sustainable economic growth in the region.

Indeed, Hoque et al., 2024) assess the influence of grid efficiency and electricity distribution losses on power intensity in Asian countries, in the case of SAARC countries. The study reveals that poor grid reliability and substantial losses exacerbate energy ineffectiveness, increasing energy intensity scale. The outcome highlights the role of government policies in civilizing grid performance through authoritarian reforms and investment in higher technologies. The authors argue that a mutual effort of technical innovation and vigorous policy measures can improve energy effectiveness. Their result underlines the significance of prioritizing grid flexibility in energy development. Similarly, Rehman, F. U et al., 2024) examines the structural factors of energy intensity in SAARC economies and recognizes electricity distribution losses as a vital contributor to inefficiency. The study shows how aging infrastructure and low investment direct to important power losses in the area. The authors advocate adopting modern grid resilience and improving energy systems to address these issues. They highlight that low distribution losses can have a vital influence on decreasing energy consumption and supporting sustainable development. The study offers a roadmap for policymakers to cope with this grave issue effectively.

Additionally, Gandhi, O et al 2020) conducts a detailed examination of electricity distribution losses and their impact on energy systems, especially energy intensity. The authors emphasize that high losses lead to more energy consumption, thereby increasing the energy intensity. They highlight the significance of civilizing grid infrastructure to address inefficiencies in electricity distribution. The study also argues the economic implication of lofty energy intensity, including increased production costs and environmental deprivation. To put it briefly, the study suggests that reducing electricity distribution losses is very important for achieving energy efficiency objectives. Similarly, Kim, H et al., 2021) examine the influence of renewable energy integration in lessening electricity distribution losses and its impact on energy consumption. The study discovers that incorporating renewable energy into the grid not only increases energy efficiency but also lessens distribution losses. The authors argue that renewable energy, coupled with modern grid systems, can significantly lessen energy intensity in developing countries. They recommend that targeted investment in clean technologies and grid advancement can address inefficiencies in the power system. The research highlights the dual benefits of declining energy intensity and promoting sustainable energy transition.

Undeniably, Chen, H et al., 2021) comprehensively, assess the economic implications of electricity distribution losses on energy intensity in the selected developing economies. The authors underscore the financial burden of these losses imposed on utility suppliers and consumers, leading to bigger energy utilization. They highlight that addressing these inefficiencies through the latest technologies, such as effective grid resilience, can increase energy efficiency. The study offers empirical evidence indicating a direct association between reduced distribution losses and lessened energy intensity. The authors suggest that reducing power losses is important for achieving economic, social, and environmental sustainability in the said countries. In contrast, Kumar, A., & Shrestha, B. (2021) assess the policy implications to reduce electricity distribution losses in South Asia and their influence on energy intensity. The study highlights the role of policy frameworks in grid resilience and encouraging energy-efficient work. They uncover that countries with severe energy policies have significantly lessened energy intensity scale. The study also examines the role of regional collaboration in allocating best practices to tackle power distribution ineffectiveness. The outcome underscores the importance of a synchronized policy approach to decrease energy intensity across SAARC nations.

Similarly, Raza, M. H et al., 2023) explore the impact of technological advancement, such as smart meters and real-time monitoring mechanisms, in lessening power distribution losses in the case of South Asian countries. The authors emphasize that these innovations can integrate power distribution systems, increasing efficiency and lessening energy intensity. The study underscores that investment in technology advancement is a cost-effective plan for tackling distribution inefficiencies. The authors suggest that adopting technological advancement is vital for achieving long-term energy efficiency and sustainability. In contrast, Ali, M., & Kha T. (2019) comprehensively examine regional energy efficiency policies in SAARC countries, especially focusing on electricity distribution losses. The study recognizes common issues, including obsolete infrastructure and inadequate regulatory frameworks, that exacerbate these losses. They emphasize cross-border cooperation to tackle these shared challenges effectively. The study underscores the potential for regional energy trade to optimize resource use and reduce energy consumption. The authors suggest that mutual efforts can significantly improve energy efficiency in the said area.

Put into brief, the existing literature highlights the serious role of electricity distribution losses in determining energy intensity, enhancing the need for technological progress, policy implementation, and regional cooperation to address inefficiencies. However, existing studies lack a region-specific emphasis, a comprehensive assessment of recent data, and insights into the economic and policy drivers impacting this association. Moreover, the association between electricity losses and energy intensity is underexplored. Addressing these issues will provide a deeper insight into the issue and compose effective strategies for reducing energy intensity in the SAARC countries.

Materials and Techniques

This chapter consists of an estimation strategy, variables, data sources, and the formulation of an appropriate statistical method to examine the impact of electricity distribution loss on energy intensity in the SAARC countries.

3.1. Variables and data sources

The present study aims to analyze the empirical investigation of electricity distribution loss on energy intensity in the selected SAARC countries for the data period 2000 to 2023. For this purpose, various variables are taken into account, which include electricity distribution loss, energy intensity, CPIA, industrial growth, renewable energy, and technical cooperation. The dependent variable **e**lectricity distribution loss is sourced from EIA. It shows efficiencies of grid percentage of total electricity production, while energy intensity is sourced from EIA; it shows energy efficiency of a country, measured in energy per unit of GDP. The data for CPIA is taken from WDI; it evaluates governance and policy quality of a country and indicates scores from 1 to 6. The data for **i**ndustrial growth is sourced from WDI and captures the boost of economic activities of energy demand, measured as an annual percentage growth rate. Renewable energy production is sourced from EIA, which shows the percentage of total energy production Chen, H et al., 2021. Finally, technical cooperation from WDI emphasizes investment and capacity-building initiatives in technological innovation measured by (USD). Put into brief, all these variables provide a strong framework for understanding the dynamics of sustainable energy transition.

3.2. Econometrics Methodology

To examine the determinants of grid resilience, the study initially established an econometric model to estimate the impact of electricity distribution loss on the energy intensity of the selected SAARC countries. The concise econometric model is as follows, as in Eq. (1).

$$EI_{it} = \beta_0 + \beta_1 EDL_{it} + \beta_2 CPIA_{it} + \beta_3 TC_{it} + \beta_4 Ind\ G_{it} + \beta_5 RE_{it} + \varepsilon_{it}$$

The above equation indicates EI is energy intensity a dependent variable in the model, while the others are independent variables, such as EDL shows electricity distribution loss, CPIA indicates policy and governance of sustainable energy transition, TC shows technical cooperation, Ind G indicates industrial growth, and lastly the RE shows renewable energy consumption of the said countries. Moreover, ε shows error term or unobserved factors effects in the model.

3.3. Foundation of Model

In panel data analysis, the foundation of an appropriate model is a critical issue. But still it is possible, though econometric rules. Before choosing any statistical estimation methods, we check various necessary stages Khan, A. W., Khan, et al 2023). Initially, the study conducts descriptive statistics to check for outliers and divergence in the data set. Secondly, the CD (Breusch & Pagan, 1980; Pesaran, 2004) tests cross-sectioned to check cross-sectioned section dependency among the entities. Furthermore, to analyze the long-run association among the variables, the study conducts a Kao cointegration test. Hence the outcomes of the Kao test confirm a long-run association among variables; the next critical step is to determine which econometric method would be better. For this purpose, various econometric tests are conducted, such as the Durbin-Wu-Hausman test of Durbin and Hausman (1990) to check endogeneity. Outcomes of these tests suggested that the FMOLS estimation method is appropriate for the said objectives. FMOLS measures serial correlation and endogeneity in the model. Moreover, FMOLS can't capture causal association between variables; therefore, in the next step, the study applied the causality test (Dumitrescu & Hurlin, 2012) to detect the direction of causality among variables. Put into brief the assumptions, limitations, and interpretations of all the cited techniques discussed below.

3.4. Diagnostic Test

3.4.1. Cross Section Dependency Test (CD).

CD means when observations in a dataset are not independent of each other, diagonally different cross-sections. Hence, to check cross-sectional interdependence, the analysis used the (Breusch & Pagan, 1980; Pesaran, 2004) CD test. The null hypothesis of this test is no cross-sectional interdependence.

$$CD = \frac{\sqrt{T(T-1)}}{2} . \frac{1}{N} \sum_{i \neq j} \rho_{ij}$$

T shows, time, N indicate cross sectional dimensions and ρ shows to the correlation coefficient between residuals of cross sectional unit i and j. Furthermore, $\sum i \neq j$ indicates summation of overall unique pairs of cross sectional unit.

3.4.2. Kao Cointegration Test

The **Kao Cointegration Test** is performed to capture the long-term equilibrium links between variables in the model. When residuals are stationary, it suggests a cointegrating association among variables.

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$$Y_{it} = \alpha_i + \beta X_{it} + \gamma Y_{it-1} + \delta X_{it-1} + \mu_{it}$$

Where Y is dependent variable, X is independent variable, $\propto$ is intercept and β shows to coefficient of variables. Moreover, γ indicates coefficient of the lagged dependent variable.

3.4.3. Variance Inflation Factor (VIF)

The VIF is a statistical tool to measure multicollinearity in the regression model. A situation when two or more independent variables are highly correlated with each other.

$$VIF_j = \frac{1}{1-R_j^2}$$

This formula examines the multicollinearity, while R^2 indicates the proportion of variance.

3.4.4. Dumitrescu-Hurlin panel causality test (DHPCT)

This test is used to estimate the direction and nature of associations among variables in the model. With **the FMOLS model**, the **DHPCT** is a vital choice for investigating causality.

Long run Estimation Techniques

The study broadly conducted the above-mentioned estimation technique; hence it concludes that **the** most appropriate method is FMOLS. Indeed, FMOLS is an econometric technique used to measure long-run associations between variables Liddle, B. (2012). It is crucial to adjust issues like endogeneity and serial correlation and give efficient and consistent investigation of the long-term equilibrium**.** The equation is **given below.**

$$\boldsymbol{Y_{it}} = \propto_i + \boldsymbol{\beta x_{it}} + \boldsymbol{\mu_{it}}$$

The above equation shows, Y_{it} is dependent variable, while X_{it} is dependent variable, $\propto_i$ individual constant effects, β indicates long run parameter and $\mu_{it}$is error term in the model.

Put into brief, this section of methodology gives a planned approach to investigating the electricity distribution loss on energy intensity backed by emerging diagnostic tests, allowing for an accurate assessment of long-run associations and providing insight into how to entirely develop grid resilience in the selected SAARC countries.

RESULT & DISCUSSION

This part of the study shows comprehensive outcomes of each diagnostic test and statistical model to indicate the objective of the study, which is given below separately.

Table 1: Descriptive Statistic

	ENERGY CON PC	LN CPIA	GR DIS LOS	RENEWABLE ENERGY	INDSTRL GROWT	TECHNICAL COPRATION
Mean	2.140070	1.171858	2.033422	3.910542	1.486034	18.91487
Median	2.323823	1.252763	1.630968	3.856508	1.852122	19.06114
Maximum	3.219276	1.386294	5.693732	4.514151	2.844216	20.09774
Minimum	0.444686	0.916291	-0.916291	3.218876	-3.752671	17.71829
Std. Dev.	0.717204	0.128651	2.018726	0.334187	1.049003	0.618863
Jarque-Bera	18.69208	3.310907	10.93200	2.512861	244.8638	3.646789
Probability	0.000087	0.191005	0.004228	0.284668	0.000000	0.161477
Sum Sq. Dev.	61.21136	1.969588	484.9553	13.29001	130.9486	45.57601

The results of descriptive statistics provide an overview of the variables used in the study. The mean value of ENERGY CON with a standard deviation indicating moderate variability. Similarly, **LN CPIA** has a mean of 1.172 and a lower standard deviation, showing relatively consistent values. On the other hand, **GR DIS LOS** exhibits the highest variability. The Jarque-Bera test verifies that **LN** ENERGY CON**,** LN GR DIS, and INDSTRL GROWT significantly deviate from the level of significance < 0.05. In contrast, CPIA**,** RENEWABLE ENERGY, and TECHNICAL COPRATION have Jarque-Bera greater than 0.05, suggesting they follow a normal distribution. This variability across variables highlights the need for robust econometric methods to account for differences and scale.

Table 2: Correlation Matrix

LN_ENERGY_CON_PC	1					
LN_CPIA	-0.1990	1				
LN_GR_DIS_LOS_	0.6958	0.4308	1			
LN_RENEWABLE_ENERGY	-0.7564	-0.02187	-0.6928	1		
LN_INDSTRL___GROWT	0.1169	-0.1043	0.1424	-0.2874	1	
LN_TECHNICAL_COPRATION	-0.3063	0.2923	0.8170	-0.5611	0.1745	1

The correlation matrix represents diverse relationships between variables. Energy consumption per capita is positively correlated with electricity distribution losses. In contrast, renewable energy and technical cooperation have negatively affected the energy intensity. Moreover, industrial growth is weakly correlated with energy usage, and CPIA negatively affects energy intensity. These relationships suggest trade-offs between energy intensity and renewable energy, with stronger links between technical cooperation and distribution losses.

Table 3: Results of VIF

Variable	**Variance**	**VIF**
CPIA	0.093693	1.305297
DIS LOS	0.015869	3.310073
URBAN POP GRWTH	0.014584	1.427980
RENEWABLE_ENERGY	0.081563	2.604134
INDSTRL GROWT	0.000738	1.023076
TECHNICAL COPRATION	0.019274	1.207040

The table presents the variance inflation factor (VIF) of each variable. Most variables show low multicollinearity, with **CPIA**, **URBAN POP**, **INDSTRL GROWT**, and **TECHNICAL COPRATION** showing VIF values below 2.5, representing minimal multicollinearity. While **GR DIS LOS** and **RENEWABLE ENERGY** have moderate VIFs (3.31 and 2.60, respectively), signifying some multicollinearity, but nothing that increases significant concerns. Overall, none of the variables show high multicollinearity, as VIFs above 5 are typically measured as problematic.

Table 4: Results of the Cross-Sectional Dependency Test

Results of CD test

Test	Statistic	Prob.
Breusch-Pagan LM	0.754275	0.4507
Pesaran scaled LM	-1.282996	0.1995
Pesaran CD	0.641061	0.5215

The results of the cross-sectional dependence tests show no significant cross-sectional dependence among the variables of various entities in the data. The p-value of the Breusch-Pagan LM test, the Pesaran-scaled LM test, and the Pesaran CD test is greater than the level of significance, which fails to reject the null hypothesis of no cross-sectional dependence. Therefore, the data do not show significant cross-sectional dependence.

Table 5: Results of Kao Co-integration test

Metric	**Value**
Null Hypothesis	No co-integration
ADF t-Statistics	-2.3520
Residual Variance	0.0206
HAC Variance	0.0105
Prob.	0.0116

The results indicate evidence of co-integration between the variables. The null hypothesis of no co-integration is evaluated, which in the critical value, proposes that the variables may be co-integrated. The residual variance is 0.0206, and the HAC variance is somewhat higher at 0.0105, accounting for potential heteroskedasticity or autocorrelation in the model. The p-value of 0.0116 is less than 0.05, given that there is strong evidence against the null hypothesis, thus representing the presence of co-integration between the variables at the 5% level of significance.

Table 6: Results of Long-run Estimates (FMOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_CPIA	-0.923733	0.149169	-6.192515	0.0000
LN_GR_DIS_LOS_	0.244046	0.117403	2.078709	0.0401
LN_RENEWABLE_ENERGY	-1.101321	0.276097	-3.988887	0.0001
LN_INDSTRL___GROWT	0.251190	0.074398	3.376277	0.0010
LN_TECHNICAL_COPRATION	-0.177125	0.048685	-3.638178	0.0004

The above table shows results of FMOLS. Initially the **CPIA** has a negative coefficient of -0.9237, with a p-value of 0.0000, representing a significant negative relationship with the energy intensity. Indeed, it shows that an increase in CPIA quality decreases energy intensity in the SAARC countries. **TDIS_LOS has** OS has a positive coefficient of 0.2440, a p-value of 0.0401, indicating a significant positive association. It shows that an increase in electricity distribution loss also increases energy intensity in the said region. **RENEWABLE_ENERGY** depicted a negative coefficient of -1.1013, a p-value of 0.0001, indicating a significant negative association with the dependent variable. An obvious increase in renewable energy decreases energy consumption per capita. Moreover, **INDSTRL**

GROWT indicates a positive coefficient of 0.2512, a p-value of 0.0010, representing a positive association with energy intensity. Finally, **TECHNICAL COPRATION** has an adverse coefficient of -0.1771, with a p-value of 0.0004, indicating a significant negative impact. Overall, the results have shown a significant association with energy intensity with various coefficient notations and p-values.

Table 7: Results of Dumitrescu Hurlin Panel Causality Tests

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
LN_CPIA does not homogeneously cause LN_ENERGY_CON_PC	2.39433	0.11013	0.9123
LN_ENERGY_CON_PC does not homogeneously cause LN_CPIA	2.20355	-0.05445	0.9566
LN_GR_DIS_LOS_ does not homogeneously cause LN_ENERGY_CON_PC	1.52131	-0.64300	0.5202
LN_ENERGY_CON_PC does not homogeneously cause LN_GR_DIS_LOS_	8.53470	5.40724	6.E-08
LN_RENEWABLE_ENERGY does not homogeneously cause ENERGY_CON_PC	8.76156	5.60294	2.E-08
LN_ENERGY_CON_PC does not homogeneously cause RENEWABLE ENERGY	9.71753	6.42764	1.E-10
LN_INDSTRL___GROWT does not homogeneously cause LN_ENERGY_CON_PC	4.52829	1.95103	0.0511
LN_ENERGY_CON_PC does not homogeneously cause LN_INDSTRL___GROWT	4.86629	2.24261	0.0249
LN_TECHNICAL_COPRATION does not homogeneously cause ENERGY_CON_PC	1.72154	-0.47026	0.6382
LN_ENERGY_CON_PC does not homogeneously cause TECHNICAL_COPRATION	5.07025	2.41857	0.0156
LN_GR_DIS_LOS_ does not homogeneously cause LN_CPIA	2.22498	-0.03596	0.9713
LN_CPIA does not homogeneously cause LN_GR_DIS_LOS_	2.42716	0.13845	0.8899
LN_RENEWABLE_ENERGY does not homogeneously cause LN_CPIA	2.37843	0.09642	0.9232
LN_CPIA does not homogeneously cause LN_RENEWABLE_ENERGY	2.35478	0.07601	0.9394
LN_INDSTRL___GROWT does not homogeneously cause LN_CPIA	0.47819	-1.54286	0.1229
LN_CPIA does not homogeneously cause LN_INDSTRL___GROWT	1.22593	-0.89782	0.3693
LN_TECHNICAL_COPRATION does not homogeneously cause LN_CPIA	1.64319	-0.53786	0.5907
LN_CPIA does not homogeneously cause LN_TECHNICAL_COPRATION	2.71084	0.38317	0.7016
LN_RENEWABLE_ENERGY does not homogeneously cause	6.44389	3.60356	0.0003

LN_GR_DIS_LOS_			
LN_GR_DIS_LOS_ does not homogeneously cause LN_RENEWABLE_ENERGY	3.40630	0.98313	0.3255
LN_INDSTRL___GROWT does not homogeneously cause LN_GR_DIS_LOS_	2.57870	0.26918	0.7878
LN_GR_DIS_LOS_ does not homogeneously cause LN_INDSTRL___GROWT	1.77843	-0.42119	0.6736
LN_TECHNICAL_COPRATION does not homogeneously cause LN_GR_DIS_LOS_	1.23856	-0.88692	0.3751
LN_GR_DIS_LOS_ does not homogeneously cause LN_TECHNICAL_COPRATION	2.71314	0.38516	0.7001
LN_INDSTRL GROWT does not homogeneously cause LN_RENEWABLE_ENERGY	5.96814	3.19315	0.0014
LN_RENEWABLE_ENERGY does not homogeneously cause LN_INDSTRL GROWT	6.15434	3.35377	0.0008
LN_TECHNICAL_COPRATION does not homogeneously cause RE	4.64842	2.05467	0.0399
LN_RENEWABLE_ENERGY does not homogeneously cause TECH Cooperation	2.77079	0.43489	0.6636
LN_TECHNICAL_COPRATION does not homogeneously cause INDSTRL GROWT	2.00346	-0.22706	0.8204
INDSTRL GROWT does not homogeneously cause LN_TECHNICAL_COPRATION	1.11072	-0.99720	0.3187

The above test shows the results of pairwise Granger causality: **energy consumption per capita** causes **electricity distribution loss, renewable energy**, and **technical cooperation**, whereas **renewable energy** causes **distribution loss** and **industrial growth**. Moreover, bidirectional causality is established between **renewable energy** and **energy consumption** and between **industrial growth** and **renewable energy**. In contrast, there is no significant causality found between **CPIA** and other variables, including **technical cooperation** and **industrial growth.**

Conclusion

The aim of this study is to investigate the influence of electricity distribution losses on energy intensity in SAARC countries for the period from 2000 to 2023. This analysis uses robust econometric techniques and panel data estimation. The results of the Kao co-integration test show strong evidence of long-run co-integration between the variables, which endorse the substantial association between electricity distribution losses, industrial growth, renewable energy adaptation, nd technical cooperation in impact energy intensity. Findings of the study depict key insights. Electricity Distribution Losses: significant positive association between electricity distribution losses and energy intensity. It means reducing these losses can play a crucial role in enhancing energy efficiency and affordability in the said region. Renewable energy and energy intensity are negatively correlated, as an increase in renewable energy adaptation leads to lower electricity distribution losses and thus lower energy intensity per capita. Additionally, industrial growth and energy intensity are significant and have a favorable relationship. It means that as an increase in industrial growth increases, per capita energy consumption also increases. Moreover, technical cooperation and CPIA show a negative and significant association with energy intensity, as an increase in the level of technical cooperation and CPIA quality ratio diminishes per-unit energy consumption. Finally, the causality outcome illustrates a bidirectional association between energy consumption and renewable energy, as well as among industrial growth and renewable energy. Furthermore, unidirectional causality is shown where energy consumption impacts electricity distribution loss, renewable energy, and technical assistance.

In conclusion, this analysis bridges a crucial research gap by showing the direct influence of electricity distribution losses on energy intensity and their wide implications for economic and environmental sustainability.

Policy Implications

The study highlights some key recommendations for stakeholders

- **Reducing Distribution Losses:** On the basis of empirical relations, the study recommends the implementation of targeted reform mechanisms to decline electricity distribution losses that considerably enhance energy effectiveness to the people of this region.
- **Promoting Renewable Energy:** Enhancing renewable energy in the total energy mix may increase energy affordability and lead to diminished per capita energy consumption in the SAARC economies. Accelerating the adoption of renewable energy through subsidies, investments, and policy support can contribute to sustainable energy transitions in SAARC economies.

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