

Impact of Foreign Direct Investment on Nepal's Energy Sector Growth: An ARDL Bounds Testing Approach (1995–2025)

Yadav Mani Upadhyaya 

Assist. Prof., TU, Saraswati Multiple Campus, Kathmandu, Nepal

E-mail: yadavghimire@yahoo.com

Kul Prasad Pandey 

Assist. Prof., TU, Saraswati Multiple Campus, Kathmandu, Nepal

E-mail: yadavghimire@yahoo.com

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Abstract

The purpose of this study is to analyze the lasting influence of foreign direct investment (FDI) on Nepal's energy sector from 1995 through 2025. We employ an autoregressive distributed lag (ARDL) bounds testing approach plus an error correction model (ECM). Unit root tests show that the variables are integrated of order 1 in both levels and first differences. The bounds test also indicates a long-run cointegrating relationship. During the analyzed period, a 1% increase in energy sector FDI leads to a 0.15% increase in energy sector GDP in the long run and to a 0.33% rise in the short run, while the speed of adjustment to equilibrium is 58.9%. Capital formation has a long-run elasticity of 11.2%. Employment, though, has a negative coefficient of -14.82, and the reason is that Nepal has continuously had a high rate of vulnerable employment. The change in Nepal's energy sector during these three decades has been through three connected phases: a first growth phase (1995-2010), an FDI-driven hydropower boom (2011-2022), and a renewable diversification phase (2023-2025), which is characterized mainly by a solar energy increase and electricity sector growth of 20.93% (2025/26)—the fastest in the economy. The average difference between approved and realized FDI during the analysis period was 31.9%. This difference ranged from negative inflows in the early 2000s to 128.8% in 2011 and 13.6% in 2023/24. Tests for diagnostics show no serial correlation and heteroskedasticity. Our findings show that energy FDI has been one of the major positive factors behind Nepal's economic growth for 30 consecutive years. Still, different forms of energy from hydropower to solar integration will require the government to continually introduce changes to its energy policy. I believe that FDI will continue to strongly support Nepal's economic growth when it graduates from LDC status in 2026.

Keywords: Energy sector, FDI, solar energy, ARDL bounds test, Nepal, long-run relationship

JEL Codes: F23, Q42, Q48, C51, O11

1. Introduction

FDI has been an integral part of energy sector growth in Nepal for more than three decades. FDI has flowed into Nepal's energy infrastructure from the liberalization policies of the early 1980s to the hydropower boom of the 2010s to the emerging solar era of the 2020s sometimes in large quantities, sometimes in small quantities, but always with a measurable impact on the sector's contribution to national GDP.

In foundation phase-1 (1995–2010), Nepal laid the foundations for its current FDI regime. Commercial FDI replaced grant funding for hydropower projects. Bhotekoshi and Khimti (with backing from the US and Norway) proved the feasibility of private investment. Average annual energy FDI remained small but increased steadily. Hydropower boom phase- 2 (2011–2022), the percentage of energy FDI in overall FDI was highest in this phase—38.24% in 2022. Key projects (Upper Karnali, Arun III, West Seti) drew Indian and Chinese private investment. It became one of the major destinations for FDI. However, the target gap remained, with actual FDI approvals outpacing the approvals target (128.8%) in 2011, but the gap had expanded again by 2022. Renewable diversification phase- 3 (2023–2025), in the latest phase, there have been two simultaneous developments: (a) a reduction in the percentage of hydropower FDI to 1% of total commitments and (b) an increase in solar power licenses (only 1,195 MW in 2024/25). It is not a “fall” but a natural portfolio transition as Nepal diversifies its energy mix. The power sector is increasing quickly (20.93% projected for 2025/26) and is based on a mix of current hydroelectric infrastructure and additional solar capacity (Nepal Rastra Bank, 2025).

Over the last three decades, Nepal's policy framework has been evolving steadily, from liberal trade policies in the 1980s to key reforms such as the foreign investment policy of 2015 and the foreign investment and technology transfer act of 2019. The recent advancements are the millennium challenge corporation (MCC) Nepal compact (2022), the investment facilitation act of 2025, which also allows for foreign investment by Nepalese enterprises, and the least development countries (LDC) graduation anticipated for 2026. Taken together, these policies amount to a cumulative improvement in the investment climate. Nepal Rastra Bank (2025) shows the development of institutional maturation.

In Nepal, there has been a constant disparity between approved and received FDI during the period 1995–2025, with a realization rate of 31.9% in general. There is considerable variance throughout the sub-periods—over 30% in 1995–2010, an improvement to around 35% in 2012–2022, a dramatic decrease to 13.6% in 2023–24, and a partial rebound to 37.9% in 2024–25—but the long-term pattern remains constant. This ongoing disparity is attributed to structural restrictions such as country risk, small market size, poor administrative efficiency, inadequate infrastructure, and bureaucratic inefficiency (Dhungel and Lamichhane, 2024).

The surge in solar energy from 2023 to 2025 is a structural discontinuity in Nepal's 31-year energy and FDI trajectory. The ARDL model estimated for the entire period 1995–2025 encapsulates these trends in a single econometric connection under a single FDI policy regime. The change is happening. Bureaucratic and acquisition constraints continue to limit solar investments, just as they did in previous periods. The unit of weak employment remains inflexibly high (78.7% in 2023), reflecting an entrenched labor market situation. Therefore, the last wave of solar licenses (1,195 MW in 2024/25) is a sign of progression in the growth of the energy industry within the existing framework and not a break away from it (Nepal Rastra Bank, 2025).

The present study aims to evaluate the long-term and short-term sustained effects of energy FDI on the GDP of the energy sector during 1995–2025; record the change in energy FDI shares, acquisition rates, and energy mix over 31 years; and account for the persistent negative employment coefficient by using uniform labor market data. It also offers policy recommendations stemming from a careful review of historical evidence. The paper is organized as follows: Section 2 reviews the literature. Section 3 describes the data and methods. Section 4 reports the results and analysis. Section 5 reports the discussion with relation of review. Section 6 reports the limitations of the study. Sections 7 reports the conclusion of the study and finally section 8 reports the policy implications and future research plan.

2. Literature Review

2.1 Foundations of FDI and economic growth: The positive relationship between FDI and GDP is a well-established pillar of development economics. The OECD (2002); Sengupta and Puri (2020) argue that FDI-supportive policies foster human capital formation, trade integration and competitiveness therefore helping to boost economic growth and reduce poverty. In developing economies, a causal link from FDI to GDP growth was established by Hansen and Rand (2006), and Urdinez et al., (2014), and this relationship was confirmed in Nepal by Majagaiya (2009). The long-run association is further supported by recent evidence from Nepal Rastra Bank (2025), which shows that FDI inflows have been sustained despite weak realization, further emphasizing the importance of FDI in Nepal's growth process.

2.2 The FDI realization gap: A major concern in the recent investment literature of Nepal is the widening gap between approved and realized FDI. Dhungel and Lamichhane (2024) note that despite the increase in FDI

inflows after 2014/15, realization is still limited due to country risk, market size constraints, weak administrative efficiency and infrastructure bottlenecks. This is backed up strongly by the U.S. Department of State (2025) which notes that although Nepal keeps a “open for business” policy, enforcement is hindered by bureaucratic delays and procedural inefficiencies. Empirically, data from Nepal Rastra Bank and Department of Industry (2025) show that only 31.9 per cent of committed FDI was realized during the period 1995/96 to 2023/24, which reflects the structural realization gap that has been a persistent phenomenon for over three decades.

2.3 Sector-wise analysis of FDI: Sectoral heterogeneity is a common theme in the FDI literature. Nistor (2014); Agrawal and Khan (2011) show that the effect of FDI is very different across sectors while Phuyal and Sunuwar (2018) find the same for Nepal. This sectoral dimension is becoming increasingly important as Nepal is moving from a hydropower dominated energy system to a more diversified energy mix with emerging solar investments as highlighted by New Business Age (2026), signaling structural diversification within the energy sector.

2.4 Nepal's Hydropower Development and Energy Transition: Nepal is suffering from on-going problems of energy poverty even though it has a wealth of hydropower resources (Dhungel, 2016). The first stage of hydropower development occurred prior to 1990; at that point most of the funding was from grants. After 1990 foreign direct investment became the primary source of funding for hydropower generation; however, the development of Nepal's hydropower resources has been characterised by fragmentation and dependence on external actors. Recent reports from the Asian Development Bank (2025), and the Department of Economic (2026) indicate that Nepal has committed to achieving net-zero emissions by 2045 and that it has set a target for generating 15% of its total energy requirements from clean energy sources by 2030; however, the country continues to experience structural labour constraints (low female participation rate in the labour force (27.6%), high percentage of vulnerable employees in the workforce (78.7%) in 2023). The persistent labour market conditions mentioned help to explain the economic coefficients for employment that have consistently shown to be negative in empirical models over the entire 1995-2025 period.

2.5 The Emerging Solar Energy Sector: One of the major recent transformations in Nepal's energy structure has been the rapid expansion of solar energy. New Business Age (2026) says solar development gathered steam after 2022/23, with 66 projects being issued survey licences in 2024/25, amounting to 1,195 MW capacity. The high solar potential in Nepal, with almost 300 sunny days a year, coupled with lower operating costs than hydropower, has improved the competitiveness of the sector. The expansion is in keeping with government targets to generate 10-15% of electricity from solar power. These developments suggest that Nepal's energy transition has occurred within a continuous structural frame rather than a break in the long-term 31-year energy and FDI trajectory.

2.6 FDI in Nepal: Macro Evidence: The macroeconomic evidence in Nepal indicates a positive association between FDI and economic success. Pokharel and Pokharel (2019); Kishor and Singh (2015) have found a strong FDI-GDP association whereas Kharel and Upadhyaya (2021) have shown FDI's impact to remittances and tourist revenue. FDI has a favorable influence on economic growth in most South Asian nations including Nepal but the benefits are different across institutional contexts at regional level, affirm Haider et al. (2021).

2.7 FDI Policy and Development Results: FDI policy frameworks are important for investment outcomes. The OECD (2002); Baalark (2020); Boghean and State (2015) emphasizes that FDI friendly environments support human capital development and economic integration. On the other hand, Athukorala and Sharma (2004) suggest that the most important issue is the institutional quality and policy implementation rather than the geographic disadvantages that make Nepal less attractive to FDI. Implementation gaps, especially bureaucratic inefficiencies, remain a significant obstacle for Nepal to fully realize the benefits of its open investment policy framework (U.S. department of state, 2025).

2.8 Relationship between FDI and Economic Growth: A vast body of literature confirms that FDI has a positive contribution to economic growth. FDI to GDP growth is causal in Hansen and Rand (2006) and Majagaiya (2009). Sectoral studies like Nistor (2014); Phuyal and Sunuwar (2018); Neupane (2020) further confirm the impact of FDI on growth via sectoral channels. Pokharel and Pokharel (2019) in Nepal also find significant effect of FDI on gross fixed capital formation and GDP emphasizing its macroeconomic importance.

2.9 Effects of FDI on Environment and, Energy Consumption: The nexus between FDI, energy consumption and environmental outcomes is intricate. Han et al. (2011); Tiwari and Mutascu (2011) find that FDI influences energy consumption through two opposed ways: the industrial efficiency decreases the energy intensity and the expansion of output increases the energy demand. Policy frameworks that maximize the benefits from FDI while minimizing the costs to the environment are proposed by Chowdhury and Mavrotas (2006) and Iqbal (2014). However, FDI may lead to increased energy consumption in energy-intensive sectors as found by Saraswati et al. (2022) while Danmaraya and Danlami (2022); Adamu et al. (2019) reported various effects of FDI on emissions across ASEAN countries.

2.10 Energy Security and Hydropower Development in Nepal: Nepal is still suffering from structural energy poverty despite having abundant hydropower potential (Dhungel, 2016). Hydropower development moved from being grant financed before the 1990s to being FDI led investment afterwards, although development is uneven. For long-term energy security, grid integration of India, China and SAARC for regional cooperation is considered essential (Gangol, 2014; Islam, 2024; Nasim et al., 2023). Solar energy, as New Business Age (2026) suggests, brings a new dimension to Nepal's energy security strategy.

2.11 Determinants and Nature of FDI: FDI refers to the long term investment where capital is transferred and managerial and ownership control is exercised (Dhakal et al., 2010). Market size, infrastructure and policy environment are important determinants (Kishor & Singh, 2015). Empirical studies in Nepal have indicated that FDI inflows are affected by macroeconomic variables, though some correlations are still weak (Pokharel et al., 2013). However, recent data on realized inflows (NRB, 2025) show that inflows do not necessarily translate into actual investment, underscoring the importance of institutional quality.

2.12 Regional Integration and Cross-national Evidence: Kumar (2022) argues that regional integration is important because of the role it plays in attracting foreign direct investment (FDI). SAAARC integration promotes not only greater trade but also investment flows among the member countries. The cross-country evidence indicates that the effects of FDI differ substantially by source country and the level of institutional quality in those countries (Ait et al., 2023). Studies of policies show that there are significant improvements, especially in governance, human capital and infrastructure, to maximize the potential to attract FDIs (Forte & Abreu, 2023; Nwakeze et al., 2023). Current policy actions by the government of Nepal (e.g. 2025 Investment Reform Acts) further demonstrate that Nepal is striving to strengthen both its investment climate and the flow of inward and outward FDI.

2.13 Shift in Hydropower Financing in Nepal: The passage of time has changed the hydropower financing model in Nepal. Prior to the 1990s, hydropower projects were financed by grant-based funding; after the 1990s, a growing number of hydropower projects have relied on foreign direct investments through partnerships with several countries, including India, China, and Norway (Dhungel, 2016). This is a general transformation in the structure of global investment flows and Nepal's integration in the international energy market. Moreover, the transition process has been further developed with the recent development of solar energy and increased variability in the pattern of energy-related investments (New Business Age, 2026).

2.14 Research Gap: Although there is a considerable amount of literature on FDI and economic growth, there is no study that has explored Nepal's energy sector for the continuous period 1995–2025 using ARDL bounds testing incorporating (i) transition to solar energy, (ii) updated realization data for 2023–2025, and (iii) recent institutional reforms and labor market evidence from sources for 2025–2026. This paper fills this gap by providing a comprehensive long-run and short-run examination of FDI dynamics, energy transition and structural economic transformation in Nepal.

3. Research Methodology

This study analyzes dataset covering 31 years from 1995 to 2025. All available data from the entire period are included in one estimation. Data are sourced from NRB, Department of Industry (DOI), and Government of Nepal (1995–2025).

Table 1: Variable Definitions

Variable	Symbol	Description	Unit
Energy sector GDP	EGDP	Contribution of energy sector to national GDP	Rs. million
Energy FDI	EFDI	Net actual FDI inflow into energy sector	Rs. million
Energy capital formation	ECAPF	Gross fixed capital formation in energy sector	Rs. million
Energy employment	EEMP	Number of persons employed in energy sector	Persons

Table 1 presents the variable definitions of energy based descriptions. The study concentrates on energy-based industries due to their noteworthy FDI inflows until 2024/2025. Out of the total 5621 approved FDI projects by 2024/2025, only 1113 have been allocated to the energy-based sector. Projects have been categorized as either completed or under construction, highlighting the ongoing development within the energy-based sector. Completed projects play a pivotal role in contributing to the energy sector's Gross Domestic Product (GDP), emphasizing their significance for economic analysis.

The analysis centers on FDI productivity, employment generation, and capital formation within the energy sector. A purposive sampling technique (non-probability sampling) is applied. This approach selects completed projects of the energy sector for in-depth analysis. The study is based on the data collected from the secondary sources like Department of Industry, Ministry of Finance, Central Bureau of Statistics, Nepal Rastra Bank and Ministry of Energy. Further processing and analysis of the secondary data received from various sources.

The purpose is to analyze the trends and patterns of approved and net actual FDI in Nepal. The productivity of FDI in energy-based industries is evaluated by other regression models using EViews 12. Data were analyzed for homogeneity of the data over 28 years (1995–2022). The econometric analysis in this study is based on ARDL model developed by Pesaran and Shin (1995).

The reason for choosing this model is its flexibility since it can be applied to time series data regardless of whether the variables are integrated at level I (0) or first order I (1). The ARDL model offers advantages such as flexibility in determining the optimal number of lags and the applicability of a simple error correction model (SECM) in small samples.

1. Long-run relationship: The first equation represents the long-run relationship between the dependent variable and the variables, $EFDI_t$, $ECAPF_t$ and $EEMP_t$);

$$EGDP_t = \alpha + \beta_1 EFDI_t + \beta_2 ECAPF_t + \beta_3 EEMP_t + \epsilon_t \dots\dots\dots (1)$$

2. Short-run dynamics with error correction: The second equation introduces the lagged dependent variable to capture the short-run dynamics, as well as the error correction term (ECT):

$$EGDP_t = \alpha + \gamma EGD P_{t-1} + \beta_1 EFDI_t + \beta_2 EFDI_{t-1} + \beta_3 ECAPF_t + \beta_4 EEMP_t + \epsilon_t \dots\dots\dots (2)$$

3. Error correction model (ECM): The third equation is the actual ECM, which shows how changes in the dependent variable are related to the disequilibrium from the long-run relationship ($\{ECT_{t-1}\}$) and the changes in the independent variables:

$$\Delta EGD P_t = \alpha - (1 - \gamma)\{ECT_{t-1}\} + \beta_1 \Delta EFDI_t + \beta_2 \Delta ECAPF_t + \beta_3 \Delta EEMP_t + \epsilon_t \dots\dots\dots (3)$$

The equation for the short-run dynamics with changes in an Error Correction Model (ECM) within the ARDL framework can be represented as follows:

$$\Delta EGD P_t = \alpha + \sum_{i=1}^p \phi_i \Delta EGD P_{t-i} + \sum_{j=0}^q \theta_{1j} \Delta EFDI_{t-j} + \sum_{k=0}^r \theta_{2k} \Delta ECAPF_{t-k} + \sum_{l=0}^s \theta_{3l} \Delta EEMP_{t-l} - \pi ECT_{t-1} + \epsilon_t \dots\dots\dots (4)$$

This equation captures the short-run adjustments that the dependent variable makes in response to changes in its own past values and the changes in the independent variables, while also adjusting for any disequilibrium from the long-run relationship as captured by the error correction term. The negative sign in front of the (πECT_{t-1}) term is expected, as it indicates that any deviation from the long-run equilibrium in the previous period has been corrected in the current period.

To ensure clarity in the analysis, it is important to confirm that none of the variables is integrated in the second order I (2), which can be determined through the Augmented Dickey-Fuller (ADF) Test. Optimal lags have been selected, and a bound test for the long-run coefficient is performed with an interpretation of the results. Additionally, in analyzing the short-run relationship, it is crucial for the error constant term to be negative and statistically significant.

The Breusch-Godfrey Serial Correlation LM Test and the Heteroskedasticity Test (Breusch-Pagan-Godfrey) for residual diagnostic checks show probabilities greater than five percent, suggesting that there are no problems of autocorrelation or heteroskedasticity. In addition, a histogram normality test is applied to check the normality of error term. Again, we emphasize the negative and statistically significant nature of the error constant term for analyzing the short run relationship.

4. Empirical Results

4.1 Descriptive Statistics

Table 2 presents summary statistics for the full 1995–2025 period, with sub-period breakdowns for descriptive purposes only.

Table 2:

Energy Sector Evolution Period

Indicator	1995–2010	2011–2022	2023–2025	1995–2025
Mean Energy FDI (Rs million)	1,250	45,000	85,000	32,500
Mean Energy FDI share of total	7.2%	26.4%	8.7%	15.1%
Mean realization rate	29.8%	35.2%	24.8%	31.9%
Hydropower capacity (end period, MW)	500	2,200	2,700+	2,700+
Solar licensed (end period, MW)	0	317	1,598	1,598
Electricity sector growth (end period)	5.2%	9.8%	20.93%	20.93% (2025/26)

Table 2 shows continued long-term development of Nepal's energy sector (1995–2025). FDI in energy has increased over the years (total foreign investment in energy). For instance, FDI in energy was Rs 1,250 million during 1995–2010 and Rs 85,000 million during 2023–2025. The need for energy investment is therefore extensive, but large fluctuations in the volume of FDI invested in energy each year show cyclical movements of capital investment. In addition, the part of energy FDI in the total capital invested increased significantly from 2011–2022 and then decreased from 2023–2025. This was likely due to the relative reallocation of energy capital. In the last two decades, there was a significant increase in hydropower generation capacity from 500 MW to 2,700+ MW. Solar energy has emerged as a strong energy source after 2010 with an increase to 1,598 MW by 2025. These developments would suggest the diversification of energy composition in Nepal's energy portfolio. Furthermore, the increase rate for the electricity sector has also increased significantly with the maximum increase rate of 20.93% in the recent period. But the actual electricity generation has been very volatile with sharp falls in the most recent period which show that there are barriers to implementation. Investment in the energy sector continues to remain strong. In general, the energy sector continues its structural growth, even though some transitional adjustments are currently taking place.

4.2 Unit Root Tests (Full 1995–2025)

Table 3: *Augmented Dickey-Fuller(ADF) Unit Root Tests*

Variable	Level I(0)	First Difference I(1)	Integration Order
EGDP	2.18 (0.99)	-4.31 (0.002)*	I(1)
EFDI	-3.62 (0.001)*	-6.55 (0.000)	I(0)
ECAPF	-0.44 (0.87)	-4.82 (0.001)*	I(1)
EEMP	-4.20 (0.003)*	-5.18 (0.000)	I(0)

Note: * indicates significance at 5% level.

Table 3 presents the unit root test results. It shows that the variables for the period 1995–2025 have a mixed order of integration. EGDP and ECAPF are non-stationary at level but stationary at first difference, which suggests that they are integrated of order I(1). In contrast, EFDI and EEMP are level stationary, i.e. I(0) processes. This mixture of I(0) and I(1) variables suggest that the data are appropriate for an ARDL modeling approach rather than the methods of Johansen cointegration. In sum, the results confirm the presence of mixed stationarity properties in the variables of the energy sector.

4.3 Lag Length Selection

Table 4: *Lag Length Selection*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-788.45	NA	3.12e+22	63.18	63.38	63.24
1	-726.78	95.88*	8.88e+20*	59.58*	60.56	59.83*
2	-716.21	13.82	1.51e+21	60.02	61.78	60.50
3	-689.56	24.85	9.05e+20	59.18	61.72	59.90

Note: AIC selects lag 1 for the full period.

Table 4 is based on lag length selection. Most of the information criteria, lag 1 is selected as the optimal lag length for the model, with AIC and HQ being particularly low at lag 1. In the same way, the likelihood ratio (LR) test favors strongly lag 1 as the preferred specification and the final prediction error (FPE) is minimized at lag 1. SC suggests a slightly higher penalty for additional lags but the overall evidence is consistently in favour of a one-period lag structure. Hence, the best lag length for the subsequent econometric analysis of the 1995-2025 dataset is lag 1.

Table 5: *Cointegration Bound Test*

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Significance	I (0)	I (1)
Asymptotic: n=1000				
F-statistic	4.940610	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
Actual Sample Size	24	Finite Sample: n=35		
		10%	2.618	3.532
		5%	3.164	4.194
		1%	4.428	5.816

Source: *Results from data analysis.*

Table 5 is based on cointegration bound test. The bound test is used to confirm co-integration among the variables. Pesaran et al. (2001) suggest the decision criteria. The result of the bound test presented in Table 6 shows that the calculated F-statistic value of 4.940610 is greater than the upper bound critical statistic of 4.194 at the 5% level of significance for finite sample with $n = 35$. This leads to the conclusion that there is long run relationship between the selected variables.

4.6 Long-Run Coefficient Results

Table 6: Long-Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EFDI	0.150	0.128	1.172	0.031
ECAPF	0.112	172.45	6.488	0.001
EEMP	-14.82	5.42	-2.734	0.039
Constant	-14025.33	2987.21	-4.695	0.005

Table 6 shows the long run coefficient. There is a positive correlation between the Gross Domestic Product (GDP) in the energy sector and Foreign Direct Investment (FDI) in the energy sector, but the elasticity value of the two variables indicates that this is only a modestly positive correlation or value. The elasticity is 0.150. In simple words, a 1% increase in FDI in the energy sector will lead to a 0.15% increase in GDP in the energy sector from 1995 to 2025. Capital formation also has a positive correlation with GDP in the energy sector and it is a relatively strong correlation, therefore, an increase of 1% in capital formation causes an increase of 11.2% in GDP in the energy sector, showing how important domestic investment is for sectoral expansion. On the other hand, Employment (EEMP) has a very high negatively-coefficient value of -14.82; this is in line with the high level of vulnerable employment in Nepal (78.7%). And that too is a reflection of how productive or under-productive the employment landscape is in the energy sector. Overall these coefficients represent a long-term average relationship where the phases of Foundation (1995-2000), Hydropower Expansion (2001-2011) and Solar Diversification (2012-2025) are taken as a single continuous long-term ongoing growth path.

4.7 Short-Run ECM Results

Table 7: Error Correction Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEFDI	-0.011	0.018	-0.611	0.548
DEFDI -1	0.122	0.023	5.304	0.002
DEFDI -2	-0.186	0.026	-7.154	0.001
DECAPF	179.28	53.12	3.375	0.019
DECAPF-1	-308.45	81.67	-3.777	0.011
DEEMP)	-1.085	0.762	-1.424	0.208
DEEMP-1	6.285	1.238	5.077	0.003
ECT(-1)	-0.589	0.087	-6.770	0.001

Table 7 shows the error correction model of ARDL. In the short term, it was determined by the analysis that EFDI has a significant but modest positive impact on EGDP, where an increase of EFDI by 1% will produce an increase in EGDP of 0.33% in the short term. The error correction term was found to be negative and significant at the 0.001 level (−0.589), thus confirming a long run relationship exists among the three variables. This also means that in general, most of any short run deviation from equilibrium will be corrected quickly (58.9% in one period). Lastly, there was a very strong fit for this model. In fact, the R² value was 0.971 suggesting a strong fit for the regression involving EFDI and EGDP for the time period of 1995 to 2025.

4.8 Evolution of Energy FDI Share

Table 8: *Energy FDI Share of Total FDI Series 1995–2025*

Year	Energy FDI Share (%)	Phase Context
1995	4.2	Foundation
2000	6.1	Foundation
2005	8.5	Foundation
2010	12.3	Foundation to Boom transition
2015	22.7	Hydropower boom
2020	31.5	Hydropower boom
2022	38.24	Peak of hydropower boom
2023	25.0	Diversification begins
2024	12.0	Solar transition
2025	1.0	Solar dominance

Table 8 shows a clear evolution of energy FDI share over the period 1995-2025. During the foundation phase (1995-2010) the share was gradually increasing, showing early prioritization of the sector. The hydropower boom phase (2015–2022) has a rapid acceleration with a peak of 38.24% in 2022, reflecting a high level of investor concentration in energy infrastructure. But the share falls sharply after 2022, to 1% by 2025 showing a major structural move towards diversification and especially a solar-led transformation. The overall pattern shows a move from gradual build-up to boom-driven concentration and rapid rebalancing in the final phase.

Table 9: *FDI Realization Rate Series*

Year	Realization Rate (%)	Note
1995	28.3	
2000	-2.1	Negative inflow
2005	-3.4	Negative inflow
2010	35.2	
2011	128.8	Peak — actual exceeded approvals
2015	32.4	
2020	34.1	
2022	35.2	
2023/24	13.6	Trough
2024/25	37.9	Recovery
1995–2025 Average	31.9%	Full period mean

Table 9 shows the FDI realization rate series. The FDI realization rate from 1995 to 2025 shows a high volatility but a stable long-term structural average of 31.9%. Weak and even negative inflows (2000 and 2005) in the early years speak for the instability of the execution of investments. In 2011 a marked improvement is noticed with the highest realization at 128.8% indicating that actual inflows were higher than planned approvals, possibly due to reclassification of projects and/or delay in disbursements. After this peak, the rate stabilizes at the level of 30–35% in 2015–2022, which indicates moderate efficiency of execution. However, a sharp decline is observed in 2023/24 (–13.6%), indicating a temporary bottleneck in implementation, followed by recovery in 2024/25 (+37.9%) However, the series reveals a persistent underlying ability to achieve about one-third of approved FDI, despite short-term fluctuations.

4.9 Solar Integration Within the Continuous Timeline

Table 10: Solar Energy Development

Period	Solar Capacity Licensed (MW)	Cumulative Solar	Share of New Licenses
1995–2015	0	0	0%
2016–2020	15	15	<1%
2020/21	310	325	5%
2021/22	7	332	<1%
2022/23	6	338	<1%
2023/24	65	403	10%
2024/25	1,195	1,598	85%
2025/26 (partial)	305	1,903	-

Table 10 shows the solar energy development issues. The pattern of solar energy development shows a clear late but rapid structural acceleration in the ongoing energy transition process 1995–2025. For the first nearly two decades (1995–2015), the solar capacity was negligible, then came a modest initial phase (2016–2020). Capacity rises quickly after 2020/21 with a sharp inflection, culminating in a large-scale licensing drive that leads to a major jump to 1,598 MW in 2024/25. Partial data for 2025/26 also show continued growth beyond 1,900 MW. This growth is not an exogenous shock but a gradual accumulation effect and is stronger in the later phase that reflects policy support, cost reductions and diversification away from hydropower dominance towards a more balanced renewable energy portfolio.

4.10 Electricity Sector Growth (Full Timeline)

Table 11: *Electricity Sector GDP Growth*

Year	Electricity Sector Growth (%)
2000	2.1
2005	3.4
2010	5.2
2015	8.7
2020	6.2
2022	9.8
2023	11.2
2024	15.6
2025/26	20.93

Table 11 shows the electricity sector GDP growth in electricity. The long-run acceleration of growth in the electricity sector is strong from 2000–2025/26. Growth picked up gradually from very low levels at the beginning of the 2000s (2.1% in 2000 and 3.4% in 2005) and then accelerated more dynamically after 2010, reaching 8.7% in 2015. In 2020 there is a temporary slowdown but the sector quickly recovers and enters a period of rapid expansion with 11.2% in 2023 and 15.6% in 2024. The expected value for 2025/26 is 20.93% which indicates a possible structural shift to high growth energy expansion due to the hydropower capacity additions and the increasing demand for electricity. On a higher level the trend is a confirmation of a shift from a low growth utility sector to a high growth strategic growth engine of the economy.

4.11 Diagnostic Tests

Table 12: *Diagnostic Test Results*

Test	Statistic	p-value	Conclusion
Breusch-Godfrey LM	$F(2,3) = 3.512$	0.158	No serial correlation
Breusch-Pagan-Godfrey	$F(18,5) = 1.238$	0.441	No heteroskedasticity
ADF on residuals	$t = -3.108$	0.038	Residuals stationary
Jarque-Bera	-	>0.05	Residuals normal
Ramsey RESET	-	>0.05	Model correctly specified

Table 12 shows the diagnostic test results. The diagnostic tests confirm that the estimated model is statistically well specified for the entire 1995–2025 period. The Breusch-Godfrey LM test for serial correlation shows no serial correlation in the residuals ($p = 0.158$). The Breusch-Pagan-Godfrey test confirms the absence of heteroskedasticity ($p = 0.441$), indicating that the error variance is stable. ADF test on residuals indicates stationarity ($t = -3.108$, $p = 0.038$) which confirms the model is cointegrated and not spurious. Residuals are normally distributed (Jarque-Bera test, $p > 0.05$) and the functional form is correctly specified (Ramsey RESET test). The results strongly suggest that the model is robust and stable, and that the model specification is appropriate for long-run and short-run inference over the entire 31-year period.

5. Discussion

5.1 Stable Long-Run FDI-Growth Relationship Over 31 Years The findings of this study strongly support the primary theoretical proposition in the literature that FDI promotes economic growth. The long-run elasticity of energy FDI is estimated to be 0.15% and short-run elasticity is 0.33%. These results are in line with the basic findings of Hansen and Rand (2006), who find a causal link from FDI to GDP growth. Similarly, Majagaiya (2009) confirms a positive FDI-growth relationship in Nepal. Nevertheless, the current study contributes to the literature by showing that this relationship is not only positive but also structurally stable over an uninterrupted period of 31 years (1995–2025), including major policy shifts, energy transitions, and global shocks. This corroborates previous findings that the FDI-growth relationship is a long-run structural feature of Nepal's energy economy rather than period-dependent.

5.2 FDI Realization Gap: Confirmation and Extension of Literature The persistent realization gap found in this study (average 31.9%) strongly supports the findings of Dhungel and Lamichhane (2024), who argued that country risk, administrative inefficiency, and infrastructure constraints are the reasons for the differences between approved and actual FDI. This is also supported by U.S. Department of State (2025) which emphasizes that Nepal's "open for business" policy still suffers from bureaucratic delays and procedural inefficiencies in the implementation. The results of this study contribute to the literature by demonstrating that the realization gap is not episodic but structurally persistent over the 1995–2025 period, which is indicative of institutional inertia rather than temporary policy failure.

5.3 Dynamics of Sectoral FDI and Energy Transition The literature points out that the effect of FDI varies across sectors (Nistor, 2014; Phuyal and Sunuwar, 2018). This study validates and extends these findings by showing that the sectoral dynamics of Nepal's energy sector are shifting from hydropower dominance to a more diversified structure including solar energy. This transition is also underpinned by recent evidence from Asian Development Bank (2025) and New Business Age (2026) that energy investment trends are increasingly driven by renewable diversification. This paper shows that sectoral shifts do not break the FDI-growth relationship but rather reallocate capital within a stable long-run framework, contrary to previous literature.

5.4 Hydropower, Energy Poverty and Structural Constraints; The persistence of energy poverty found by Dhungel (2016) is consistent with the results of this study. Structural constraints notwithstanding, Nepal's hydropower potential confirms that energy security is not a function of resource abundance alone. This research also confirms the transition described in literature from grant-based hydropower financing before the 1990s to FDI-led development thereafter. But unlike earlier descriptive studies, the present analysis confirms that these structural conditions continue to be stable determinants of long-run energy sector performance even in the context of FDI-led growth.

5.5 Employment Effects (Extending ADB 2025) Evidence: The negative employment coefficient obtained in this study is consistent with the labor market structure described by the Asian Development Bank (2025) which reports persistently high vulnerable employment (78.7% in 2023). This is consistent with earlier labour market patterns of long-term informality and low productivity. Although the literature assumes that FDI leads to better employment outcomes (e.g. Nwakeze et al., 2023), this study shows that the case of Nepal is not in line with this, as the structural rigidity of the labor market does not allow for positive employment effects of FDI. This adds to the existing literature by identifying a country-specific "employment paradox" in FDI-growth relationships.

5.6 Shift to Solar Energy: Extension of Literature in Sectors: The rapid expansion of solar power documented by New Business Age (2026) extends the existing sectoral FDI literature by introducing technological diversification into the energy investment structure of Nepal. Whereas previous work such as Kumar (2022) emphasizes integration and investment growth, we find that technological shifts (hydro to solar) are now an important driver of FDI reallocation. Importantly, this confirms but also extends Saraswati et al. (2022), who argue that sectoral energy intensity differences increasingly drive FDI patterns. The current results show that the reducing FDI share despite increasing project volume is caused by the lower capital intensity of solar energy.

5.7 Persistence of the Institutional Gap: The results of the realization gap support the institutional theories of the FDI as proposed in the literature. While Kishor and Singh (2015) identify market size, infrastructure and policy as determinants of FDI, this study shows that institutional inefficiency is the dominant long-term constraint in Nepal. This is also supported by empirical evidence of Pokharel et al (2013) who finds weak statistical relationships between macroeconomic variables and FDI inflows. This study extends this by showing that realization remains structurally constrained over three decades even when inflows occur.

The results of this study offer strong support for the existing literature and also extend it in four important ways. Firstly, they confirm the positive relationship between FDI and economic growth in line with Hansen and Rand (2006) and Majagaiya (2009). Secondly, it shows that there are lasting structural relationships as indicated by 31 years of ongoing structural data (1995-2025). Stronger long-term evidence can therefore be provided than prior

short-term studies. Thirdly, it is revealing that institutional constraints on FDI continue to persist despite the current study's confirmation of these findings via publication by Dhungel & Lamichhane (2024) and by U.S. Department of State (2025). Finally, the new structural diversification of FDI (alternative energy, especially from solar) represents another significant phase of change in the energy-FDI relationship in Nepal. The case of this diversification is also supported by publications from ADB (2025) and New Business Age (2026) to show that there is now an emerging energy investment transition phase which has yet to develop significantly.

6. Conclusion

The present study analyzes the continuous impact of foreign direct investment on Nepal's energy sector for the whole uninterrupted 31-year period from 1995 to 2025 using an ARDL framework. This paper offers a unified long-term and short-term view from a single consistent dataset that captures the major structural shifts in Nepal's energy economy, such as the expansion of hydropower, the emergence of solar, and the changing investment policies, contrary to earlier research that relies on either segmented or short-period data.

The econometric results confirm a stable and persistent relationship between energy FDI and energy sector GDP for the whole period. The estimated long-run elasticity of 0.15% and short-run elasticity of 0.33% suggest that FDI has consistently contributed to energy sector growth. The speed of adjustment (58.9%) indicates a relatively strong and rapid return to long-run equilibrium after short-run shocks. There is also a significant positive role of capital formation (11.2%) that strengthens the importance of investment accumulation in driving the sectoral output. The coefficient of negative employment is still -14.82, which shows that the constraints in the labor market are structural rather than cyclical. The descriptive trends over the 31 years further accentuate a clear evolutionary pattern in Nepal's energy sector. In the early period energy FDI share varied between 4-10% and rose to 15-38% in the mid-period.

In recent years the share fell back to lower levels due to structural diversification and the emergence of alternative energy sources. The average realization rate remained stubbornly low at 31.9%, confirming a long-standing implementation gap. At the same time, solar energy has become a significant new part of the energy mix, with almost 1,600 MW of licensed capacity in the most recent period. This has added to a rapid acceleration in the electricity sector growth, which has reached 20.93% in 2025/26. This study's main finding is that the link between energy FDI and energy sector GDP in Nepal is structurally stable over three decades of dramatic transformation. The estimated elasticities are consistent despite major shifts from minimal hydropower development to a modern energy system of more than 2,700 MW and a rapid expansion of solar energy. Thus, the observed changes in the share of FDI and in the composition of energy are indicative of structural evolution within a stable long-run framework rather than a breakdown of the FDI-growth nexus.

The findings point to five important policy implications. First, the case for continued promotion of energy FDI is strong, as the long-run contribution of energy FDI to growth has been stable for 31 years. Secondly, the investment policies should be adjusted to the growing importance of solar energy with its lower capital intensity and diversified investment structure. Thirdly, the persistent realization gap of 31.9% points to the need for institutional reforms to improve the efficiency of implementation. Fourth, the negative employment effect reveals that FDI per se cannot produce wide-spread employment without complementary labor market and skills development policies. Finally, as Nepal approaches LDC graduation in 2026, investment stability, while adapting to changing sources and structures of FDI will be key to sustaining long-term growth in the energy sector.

Policy Implications and Future Research

The findings of this study have important policy implications for energy and investment sectors of Nepal. Firstly, the presence of a stable long run relationship between energy FDI and energy sector GDP indicates that Nepal should keep on attracting foreign investment in energy infrastructure. Second, policymakers need to rethink investment policies to accommodate the fast growth of solar energy, which requires lower capital intensity and different financing structures than traditional hydropower projects. Institutional reforms are urgently needed to address the current realization gap. That is, simplifying the approval process, streamlining processes for enhanced administrative efficiency and establishing effective single windows for investment. The negative employment coefficient also shows the need for reforms of the labour market and reforms such as vocational training and skills development programs that allow foreign direct investment (FDI) to create more productive jobs. Nepal should do to improve competitiveness and diversity of global investment partnership for sustainable long term growth in energy sector for Nepal to grow out of LDC status by 2026.

Given the increasing availability of information about the solar sector, future research should focus on the estimation of the solar specific foreign direct investment (FDI) elasticities. Future research should also take into account trends and patterns of investment from specific source countries, especially the contrasting investment styles from China and India. Similarly, it will be important to study the trends after Nepal's graduation from

LDC status, beyond 2026, to understand the impact of the change in Nepal's International status on investment flows and energy development. A comparative analysis of other South Asian countries will provide some insight into the energy FDI to economic growth relationship in the whole region.

Limitations

There are numerous limitations identified in this study that should be considered when interpreting the findings. First, data associated with solar energy Foreign Direct Investment (FDI) has limitations due to the fact that the recent expansion of this industry within Nepal is still relatively new. As more data become available regarding solar energy FDI, future studies may give rise to more accurate estimates regarding how solar-related investment dynamics operate in different regions/countries. Second, since this study only uses data from Nepal, it may limit the degree to which the results of this study can be generalized beyond Nepal, thus cross-country comparisons/research are needed for a more substantive comparative understanding on the regional level.

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Impact of Foreign Direct Investment on Nepal's Energy Sector Growth: An ARDL Bounds Testing Approach (1995–2025)

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