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Trends in Energy Consumption and their Relationship with Economic Growth in Nepal (2003/04-2023/24)

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Abstract

Energy plays a vital role in economic growth and sustainable development. This study examines the changing patterns of energy consumption in Nepal and their relationship with economic growth during FY 2004/05–2023/24. A quantitative longitudinal research design was employed using secondary data obtained from the Ministry of Finance, Water and Energy Commission Secretariat, Nepal Electricity Authority, National Statistics Office, and other official publications. Descriptive statistics, trend analysis, and correlation analysis were used to assess changes in energy consumption and GDP. The findings show that total energy consumption increased substantially alongside economic growth, although Nepal's energy system remains dominated by traditional biomass and commercial fossil fuels. While electricity consumption and renewable energy have expanded steadily, renewable energy continues to account for a relatively small share of the national energy mix and exhibits a weak, statistically insignificant relationship with GDP growth. The study concludes that expanding renewable energy, promoting clean cooking technologies, improving energy efficiency, and strengthening domestic electricity utilization are essential for accelerating Nepal's energy transition and supporting sustainable economic development.

Keywords: energy consumption, economic growth, energy use patterns, GDP, renewable energy, Nepal

1. Introduction

Access to affordable, reliable, and modern energy services is widely recognized as a prerequisite for achieving inclusive and sustainable development. Energy is a fundamental driver of economic development, social transformation, and human well-being. It supports

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industrial production, agriculture, transportation, communication, and the delivery of essential public services such as health and education (World Bank, 2022). Energy is also explicitly emphasized under Sustainable Development Goal 7 (United Nations, 2015). Countries with higher levels of energy availability and consumption generally exhibit stronger economic performance, higher productivity, and improved living standards (IEA, 2023). Therefore, energy should be viewed not only as a technical input but also as a strategic resource that shapes national development pathways.

The relationship between energy consumption and economic growth has been extensively discussed in development economics and empirical research. Energy enables mechanization, industrialization, and technological innovation, thereby contributing directly to production and productivity (Stern, 2011). In developing economies, rising energy consumption is often associated with structural transformation from agriculture-based economies to industrial and service-oriented systems (Tran et al., 2022; Todaro & Smith, 2020). At the household level, access to modern energy sources reduces dependence on traditional biomass fuels, improves health outcomes by lowering indoor air pollution, and saves time, particularly for women and children, thereby contributing to improved education and labor productivity (World Bank, 2022). In recent decades, growing concerns regarding climate change, environmental degradation, and energy security have further increased the importance of renewable and clean energy sources such as hydropower, solar, wind, and biomass (IEA, 2023; United Nations, 2015).

For countries like Nepal, energy holds strategic importance because of its close linkage with economic development and sustainable growth. Despite possessing substantial renewable energy potential, particularly in hydropower, Nepal continues to face challenges related to energy access, reliability, affordability, and dependence on imported fossil fuels (Water and Energy Commission Secretariat [WECS], 2022). At the same time, expanding energy access in rural and remote areas remains essential for poverty reduction, regional equity, and sustainable livelihoods. Nepal's economy is estimated to have grown by 3.87 percent in FY 2023/24, compared with 2.31 percent in the previous year, while the country is also experiencing rapid changes in its energy structure due to increasing electrification, hydropower expansion, and the growing use of commercial fuels (MoF, 2024/25; WECS, 2024).

Although several studies have examined the energy–GDP relationship in Nepal, most have focused on specific energy sources such as electricity, petroleum, or carbon emissions. Limited attention has been given to the changing composition of traditional, commercial, and renewable energy consumption over a longer time horizon and its association with economic growth. This study therefore seeks to analyze the trends and patterns of energy consumption in Nepal from FY 2004/05 to 2023/24 and examine their relationship with GDP. The study is guided by the following research questions: (i) What are the trends in energy consumption patterns in Nepal during 2004/05–2023/24? (ii) How has the composition of traditional, commercial, and renewable energy changed over time and how it is related with economic growth/GDP in Nepal?

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2. Literature Review

2.1 Energy Consumption and Economic Growth

The relationship between energy consumption and economic growth has been widely examined in both developed and developing economies, making it one of the most extensively studied topics in energy economics. Energy is recognized as a fundamental production input that supports industrialization, technological progress, transportation, and improvements in labour productivity and living standards (Stern, 2011). As economies develop, increasing production, urbanization, and infrastructure expansion generally lead to greater energy demand. However, the nature of the energy–growth relationship differs across countries because of variations in economic structure, energy resource endowment, technological development, institutional quality, and energy policy (Ozturk, 2010).

Empirical evidence on the energy–growth nexus remains inconclusive. Some studies conclude that increased energy consumption stimulates economic growth by enhancing industrial productivity and economic output, whereas others argue that economic growth itself drives higher energy demand. A number of studies report a bidirectional relationship, suggesting mutual reinforcement between energy consumption and economic growth, while others find no statistically significant relationship. Comprehensive reviews by Ozturk (2010) and Shahbaz et al. (2015) demonstrate that these divergent findings are largely explained by differences in countries' development levels, methodological approaches, energy composition, and institutional contexts. Consequently, country-specific studies remain essential for understanding the dynamics of energy consumption and economic growth.

2.2 Theoretical Perspectives and Empirical Evidence

The relationship between energy consumption and economic growth is commonly explained through four competing hypotheses: the growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis. The growth hypothesis argues that energy consumption is an essential driver of economic growth because energy functions as a key production input; consequently, restrictions on energy supply may constrain economic performance. In contrast, the conservation hypothesis suggests that economic growth leads to increased energy demand, implying that energy conservation measures may have limited adverse effects on economic growth. The feedback hypothesis proposes a bidirectional relationship in which energy consumption and economic growth reinforce each other, whereas the neutrality hypothesis argues that no statistically significant relationship exists between the two variables. These hypotheses provide the principal theoretical foundation for empirical studies investigating the energy–GDP nexus.

Empirical findings across countries provide support for each of these hypotheses depending on national circumstances. Evidence from many emerging and developing economies frequently supports the growth or feedback hypotheses, reflecting increasing energy demand associated with industrialization, urbanization, and structural transformation (Shahbaz et al., 2015). Conversely, studies from several developed economies often support the conservation or

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neutrality hypotheses because technological innovation, improvements in energy efficiency, and structural shifts towards service-oriented economies reduce dependence on energy-intensive production (Ozturk, 2010). These contrasting findings indicate that the relationship between energy consumption and economic growth is highly context-specific and cannot be generalized across countries.

2.3 Nepalese Context and Research Gap

In Nepal, research on the energy–growth nexus has primarily focused on electricity consumption, hydropower development, petroleum imports, or the contribution of individual energy sources to economic growth. Most existing studies report a positive association between energy consumption and GDP; however, they are generally limited to specific energy sources, shorter study periods, or particular sectors of the economy. Comparatively fewer studies have examined the long-term evolution of Nepal's overall energy mix by simultaneously considering traditional, commercial, and renewable energy consumption alongside economic growth. Furthermore, Nepal's energy sector has undergone significant structural transformation during the past two decades through rapid electrification, expansion of hydropower generation, increasing commercial energy use, and gradual adoption of renewable energy technologies. These developments warrant a comprehensive reassessment of changing energy consumption patterns and their implications for economic development.

Despite the growing body of literature, several important research gaps remain. First, limited attention has been given to analysing long-term changes in Nepal's overall energy composition rather than individual energy sources. Second, few studies have examined how the transition from traditional biomass towards commercial and renewable energy has evolved over time. Third, existing studies provide limited evidence on how these structural changes in energy consumption relate to economic growth during Nepal's recent period of energy sector transformation. Addressing these gaps, the present study examines long-term trends in Nepal's energy consumption during FY 2004/05–2023/24 and analyses their relationship with gross domestic product (GDP). By integrating traditional, commercial, and renewable energy consumption within a single analytical framework, the study contributes to a more comprehensive understanding of Nepal's evolving energy transition and provides evidence to inform sustainable energy policy and long-term economic planning.

3. Methodology

This study employed a quantitative longitudinal research design using secondary time-series data to examine changes in energy consumption and their relationship with Nepal's economic growth during FY 2004/05–2023/24. The selected period captures important developments in Nepal's energy sector, including rapid electrification, expansion of hydropower generation, increasing commercial energy consumption, and the gradual emergence of renewable energy. A longitudinal approach was considered appropriate because it enables the analysis of long-term trends and structural changes in both energy consumption and economic performance.

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The study relied exclusively on secondary data obtained from official government publications and national statistical agencies. Data on gross domestic product (GDP) and macroeconomic indicators were obtained from the Economic Survey published by the Ministry of Finance (various years). Information on energy consumption by source was compiled from the Energy Sector Synopsis Reports of the Water and Energy Commission Secretariat (WECS), publications of the Nepal Electricity Authority (NEA), Nepal Rastra Bank (NRB), the National Statistics Office (NSO), and other relevant government reports. GDP was measured at constant prices to ensure comparability across years, while energy consumption was classified into traditional, commercial, and renewable sources following the WECS classification. Depending on the source, energy consumption is presented in thousand tonnes of oil equivalent (TOE), petajoules (PJ), or gigajoules (GJ), as reported in the original publications.

The analysis considered GDP as the principal indicator of economic performance, while different categories of energy consumption served as the explanatory variables. Descriptive statistics, percentage change analysis, trend analysis, graphical presentation, and comparative analysis were employed to examine changes in the composition and consumption of traditional, commercial, and renewable energy over time. Pearson's correlation analysis was further applied to assess the degree of association between GDP and renewable energy consumption. Compound annual growth rates (CAGR) were calculated for the period FY 2004/05–2023/24 to examine the long-term growth of different energy categories. These analytical techniques were selected because they are appropriate for identifying long-term trends, comparing changes in the energy mix, and examining statistical associations without attempting to establish causal relationships.

The collected data were compiled, verified, and organized using Microsoft Excel before analysis. Tables and figures were used to illustrate temporal trends and facilitate comparison across different energy sources. As the study is based entirely on secondary aggregate data, the findings should be interpreted as indicating associations rather than causal relationships. Furthermore, the analysis is constrained by the availability and consistency of published national statistics and does not capture sector-specific or household-level behavioural variations. Since the study used publicly available secondary data and did not involve human participants, ethical approval was not required.

4. Findings and Discussion

4.1 Changing Structure of Nepal's Energy Consumption

Nepal's energy consumption pattern has experienced a gradual structural transformation over the past two decades, although traditional energy sources continue to dominate the national energy mix. As presented in Table 1 and Figure 1, the overall composition of energy consumption has shifted slowly from traditional biomass towards commercial and renewable energy sources rather than undergoing a rapid energy transition. According to the Nepal Energy Synopsis Report, total energy consumption reached 401 PJ in 2008/09, of which fuel wood accounted for 77.7 percent, followed by agricultural residue (4%), animal dung (6%),

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petroleum products (8%), and coal and electricity (4%). Consequently, traditional energy sources represented 87 percent of total energy consumption, while commercial and renewable energy contributed only 12 percent and 1 percent, respectively (WECS, 2024).

Table 1

Annual Growth Rate of Energy Consumption (in percent) in Different Periods

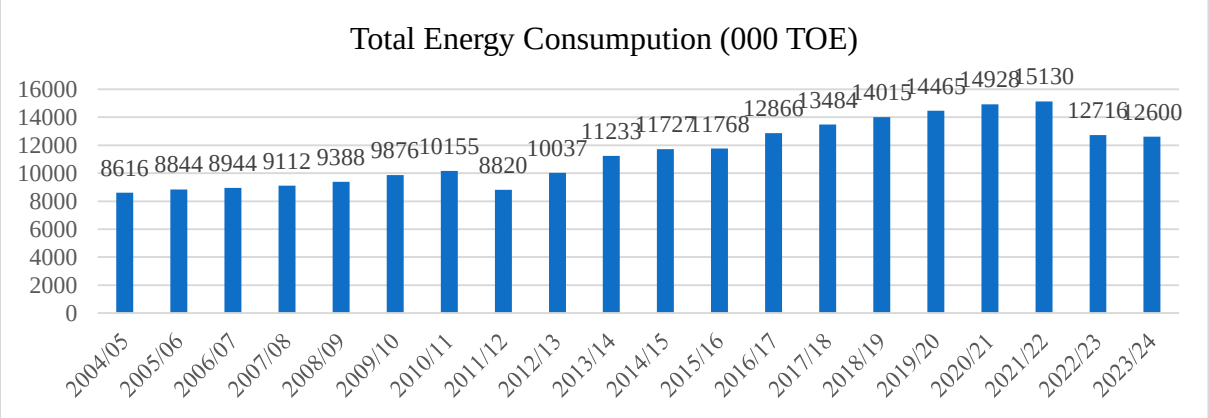
Energy Sources	2004/05-2009/10	2010/11-2014/15	2016/17-2019/20	2020/21-2023/24
Fuel Wood	10.92	10.67	6.03	-24.56
Agriculture Waste	-0.92	25.93	6.86	26.61
Animal Dung	10.87	-21.60	-1.16	-48.24
Coal	88.16	62.59	124.95	-8.22
Petroleum	36.88	52.23	97.07	-5.53
Electricity	35.67	86.38	37.78	99.27
Renewable	52.17	317.14	20.55	22.73
Total	14.62	15.8	18.9	-12.90

Source: Economic Survey, MOF, 2024/25

Table 1 further demonstrates that the annual growth rates of different energy sources varied considerably across the study period. Fuel wood recorded positive growth during the earlier periods (10.92%, 10.67%, and 6.03%) before declining sharply by 24.56 percent during 2020/21–2023/24. In contrast, electricity exhibited sustained and substantial growth throughout the study period, reaching its highest annual growth rate of 99.27 percent in the most recent period. Renewable energy also expanded steadily despite its relatively small contribution to total energy consumption. Commercial energy sources, particularly petroleum and coal, experienced rapid growth during the earlier years before moderating in the latest period. These variations indicate that Nepal's energy transition has been uneven across different energy sources, reflecting changing consumption behaviour, infrastructure development, and policy priorities rather than a uniform shift towards modern energy systems.

Figure 1

Nepal's Total Energy Consumption from FY 2004/05 to 2023/24



Source: Economic Surveys in different years, MOF

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Figure 1 further illustrates the long-term changes in Nepal's total energy consumption. While total energy demand generally increased over the study period, the composition of energy use changed gradually. Fuel wood remained the largest energy source despite a declining share, whereas commercial energy—including petroleum products, coal, LPG, and electricity—expanded steadily. The increasing share of commercial energy reflects growing urbanization, improvements in road transport, industrial expansion, and wider access to electricity. At the same time, renewable energy maintained a positive but modest growth trajectory, suggesting that Nepal's transition towards cleaner energy is progressing incrementally rather than rapidly. These findings indicate that Nepal is currently experiencing a gradual energy transition characterized by coexistence of traditional and modern energy sources. Rather than replacing biomass completely, commercial and renewable energy have progressively supplemented traditional fuels. This pattern is consistent with the energy transition process commonly observed in developing economies, where improvements in income, infrastructure, and electrification gradually diversify energy consumption while traditional biomass continues to play an important role, particularly in rural households. The findings therefore indicate that Nepal's energy transition remains incomplete and continues to face structural constraints related to accessibility, affordability, and regional disparities in modern energy use.

4.2 Dominance and Decline of Traditional Energy Sources

The findings presented in Tables 2 and 3 demonstrate that traditional biomass continues to constitute the foundation of Nepal's energy system despite its declining relative importance. Throughout the study period, fuel wood remained the dominant energy source, accounting for 78.13 percent of total energy consumption in 2004/05 before declining to 52.46 percent in 2023/24. Similarly, animal dung declined from 5.77 percent to 1.75 percent during the same period, whereas agricultural residues remained relatively stable with only modest fluctuations. Although traditional energy still represented the largest share of Nepal's total energy consumption, its gradual decline indicates an ongoing transition towards more diversified energy sources.

Table 2

Energy Consumption (in thousand Tons of Oil Equivalent; TOE)

	2004/05		2009/10		2014/15		2019/20		2023/24	
Energy Sources	Energy Consumption	%	Energy Consumption	%	Energy Consumption	%	Energy Consumption	%	Energy Consumption	%
Fuel Wood	6732	78.13	7467	75.61	8264	70.47	8762	60.57	6610	52.46
Agriculture Waste	327	3.80	324	3.28	408	3.48	436	3.01	552	4.38
Animal Dung	497	5.77	551	5.58	432	3.68	427	2.95	221	1.75

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Coal	152	1.76	286	2.90	465	3.97	1046	7.23	960	7.62
Petroleum	705	8.18	965	9.77	1469	12.53	2895	20.01	2735	21.71
Electricity	157	1.82	213	2.16	397	3.39	547	3.78	1090	8.65
Renewable	46	0.53	70	0.71	292	2.49	352	2.43	432	3.43
Total	8616	100	9876	100	11727	100	14465	100	12600	100

Source: Economic Survey, MOF 2024/25

The long-term trend presented in Table 3 further illustrates that fuel wood consumption increased steadily from 6,732 thousand TOE in 2004/05 to 8,762 thousand TOE in 2019/20 before declining to 6,610 thousand TOE in 2023/24. Agricultural waste exhibited moderate fluctuations but remained relatively stable, whereas animal dung showed a continuous decline during the latter years of the study period. The annual growth rates presented in Table 1 reinforce these trends by indicating that fuel wood experienced positive growth during the first three observation periods but recorded a substantial negative growth rate of 24.56 percent during 2020/21–2023/24. These changes suggest that the decline in traditional biomass is not the result of a sudden transformation but rather reflects gradual shifts in household energy choices over time.

Table 3

Energy Consumption Details (000 TOE) (2004/5-2023-24)

Year	Fuel Wood	Agriculture Waste	Animal Dung	Coal	Petroleum	Electricity	Renewable	Total
2004/5	6732	327	497	152	705	157	46	8616
2005/6	6862	329	507	243	686	164	53	8844
2006/7	6999	337	518	144	709	178	59	8944
2007/8	7149	337	529	193	655	190	59	9112
2008/9	7301	344	540	182	775	182	64	9388
2009/10	7467	324	551	286	965	213	70	9876
2010/11	7606	331	563	293	1058	229	75	10155
2011/12	6274	310	448	348	1083	248	109	8820
2012/13	7153	353	511	415	1182	257	166	10037

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2013/14	8154	403	426	320	1264	375	291	11233
2014/15	8264	408	432	465	1469	397	292	11727
2015/16	8376	414	438	536	1275	437	292	11768
2016/17	8459	418	442	664	2088	501	294	12866
2017/18	8604	425	444	762	2388	565	296	13484
2018/19	8720	431	450	970	2633	512	299	14015
2019/20	8762	436	427	1046	2895	547	352	14465
2020/21	9023	449	429	1436	2658	626	307	14928
2021/22	8905	762	262	1111	2839	892	359	15130
2022/23	7276	612	234	812	2469	919	394	12716
2023/24	6610	552	221	960	2735	1090	432	12600

Several factors may explain this gradual decline in traditional energy consumption. Increasing access to electricity, expansion of LPG distribution networks, improvements in rural electrification, urbanization, rising household incomes, and greater public awareness regarding the health and environmental consequences of biomass use have encouraged many households to adopt cleaner energy alternatives. Nevertheless, the continued predominance of fuel wood indicates that modern energy sources have not yet become universally accessible or affordable. In many rural and mountainous areas, biomass remains readily available, culturally accepted, and economically attractive, making it an important component of household energy security. This uneven transition reflects disparities in infrastructure, income, and energy access across geographical regions. Consequently, Nepal's energy transition should not be interpreted simply as a replacement of traditional energy with modern energy but rather as a gradual diversification of the national energy mix.

4.3 Changes in Commercial Energy and Electricity Consumption

The findings presented in Table 1 and Figure 2 demonstrate a substantial increase in the consumption of commercial energy sources over the study period, reflecting Nepal's gradual transition towards a more diversified energy system. Among the commercial energy sources, electricity exhibited the most remarkable growth, followed by petroleum products and coal. Electricity recorded consistently high growth rates throughout the study period, reaching 99.27

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percent during 2020/21–2023/24, while petroleum products experienced sustained expansion before recording a modest decline in the most recent period. Coal consumption also increased rapidly during the earlier years, although its growth slowed in the later period. These trends indicate that commercial energy has become increasingly important in meeting Nepal's growing energy demand, particularly in urban areas and productive sectors of the economy.

The increasing consumption of commercial energy reflects Nepal's ongoing socio-economic transformation. Rapid urbanization, industrial expansion, improved transportation networks, rising household incomes, and increased access to electricity have collectively contributed to greater demand for petroleum products, electricity, LPG, and coal. The expansion of electricity generation, particularly through hydropower development and increased investment by Independent Power Producers (IPPs), has strengthened domestic electricity supply and improved access across many parts of the country. Similarly, the continued growth of petroleum consumption reflects increasing mobility, expanding economic activities, and continued dependence on imported fossil fuels to meet transportation and industrial energy needs. These developments suggest that commercial energy consumption has become an important driver of economic modernization while simultaneously exposing Nepal to challenges associated with energy imports and price volatility.

Figure 2 further illustrates the changing composition of Nepal's energy consumption by comparing traditional, commercial, and renewable energy sources over time. While traditional biomass continues to account for the largest share of total energy consumption, the share of commercial energy has increased steadily throughout the study period. This structural shift reflects gradual improvements in infrastructure, electrification, and energy accessibility rather than a complete substitution of traditional fuels. Instead, Nepal's energy transition is characterized by the coexistence of traditional and modern energy sources, with households and industries increasingly diversifying their energy choices according to accessibility, affordability, and functional requirements.

Figure 2

Energy Consumption Patterns (Traditional, commercial and Renewable)

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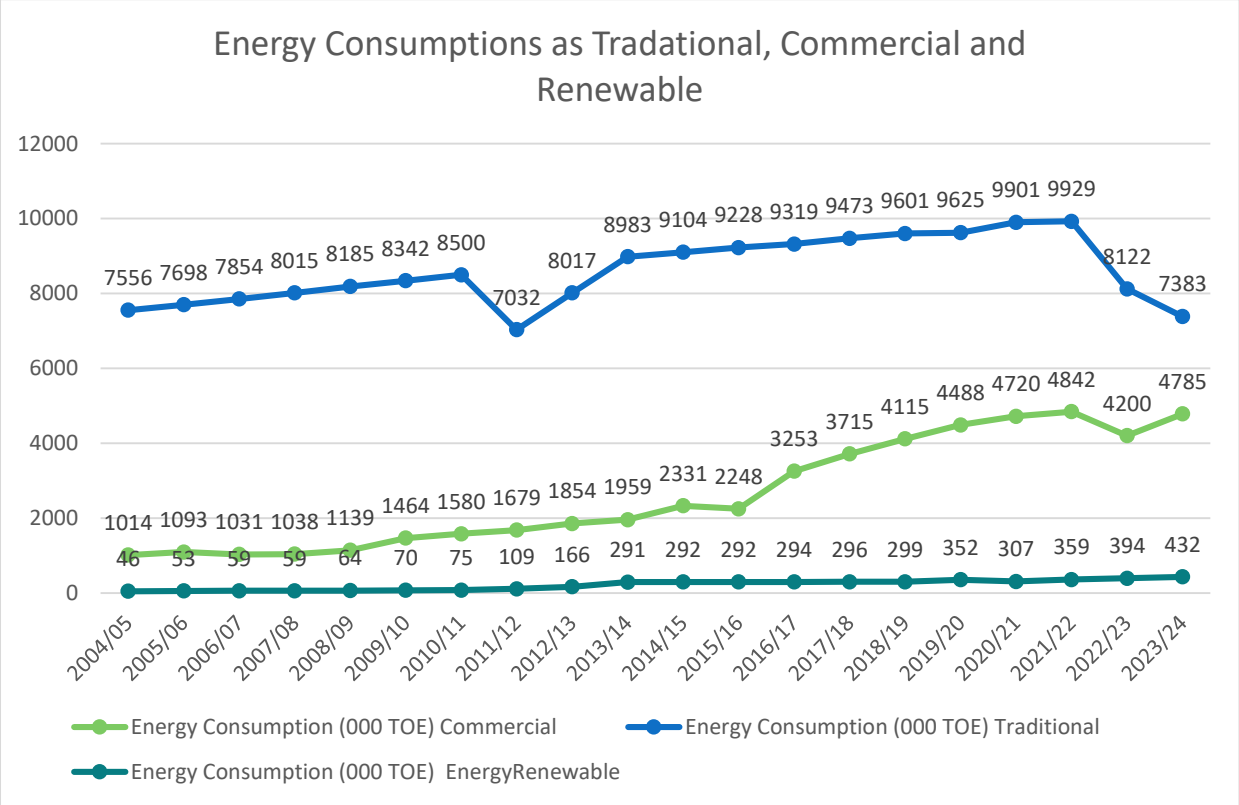

Despite these positive developments, the findings also reveal that Nepal's transition towards commercial energy remains uneven across sectors. Electricity consumption has expanded rapidly, yet petroleum products continue to dominate transportation, while coal remains an important fuel for brick industries and other manufacturing activities. Consequently, increasing commercial energy consumption should not be interpreted solely as evidence of successful energy transition but also as an indication of growing dependence on imported fossil fuels. These findings reveal an importance of strengthening domestic electricity utilization, promoting industrial electrification, and improving energy efficiency. It would ensure that increasing commercial energy consumption contributes to sustainable economic development rather than greater external energy dependence.

4.4 New Emerging Role of Renewable Energy

The findings indicate a gradual but meaningful expansion of renewable energy within Nepal's overall energy mix. As presented in Figure 3, the share of renewable energy increased from only 0.53 percent of total energy consumption in FY 2004/05 to 3.43 percent in FY 2023/24. Although renewable energy continues to represent a relatively small proportion of national energy consumption, the upward trend reflects a gradual diversification of Nepal's energy portfolio and the country's increasing commitment to cleaner and more sustainable energy sources. This pattern confirms that renewable energy is emerging as a complementary component of the national energy system rather than a substitute for traditional and commercial energy sources.

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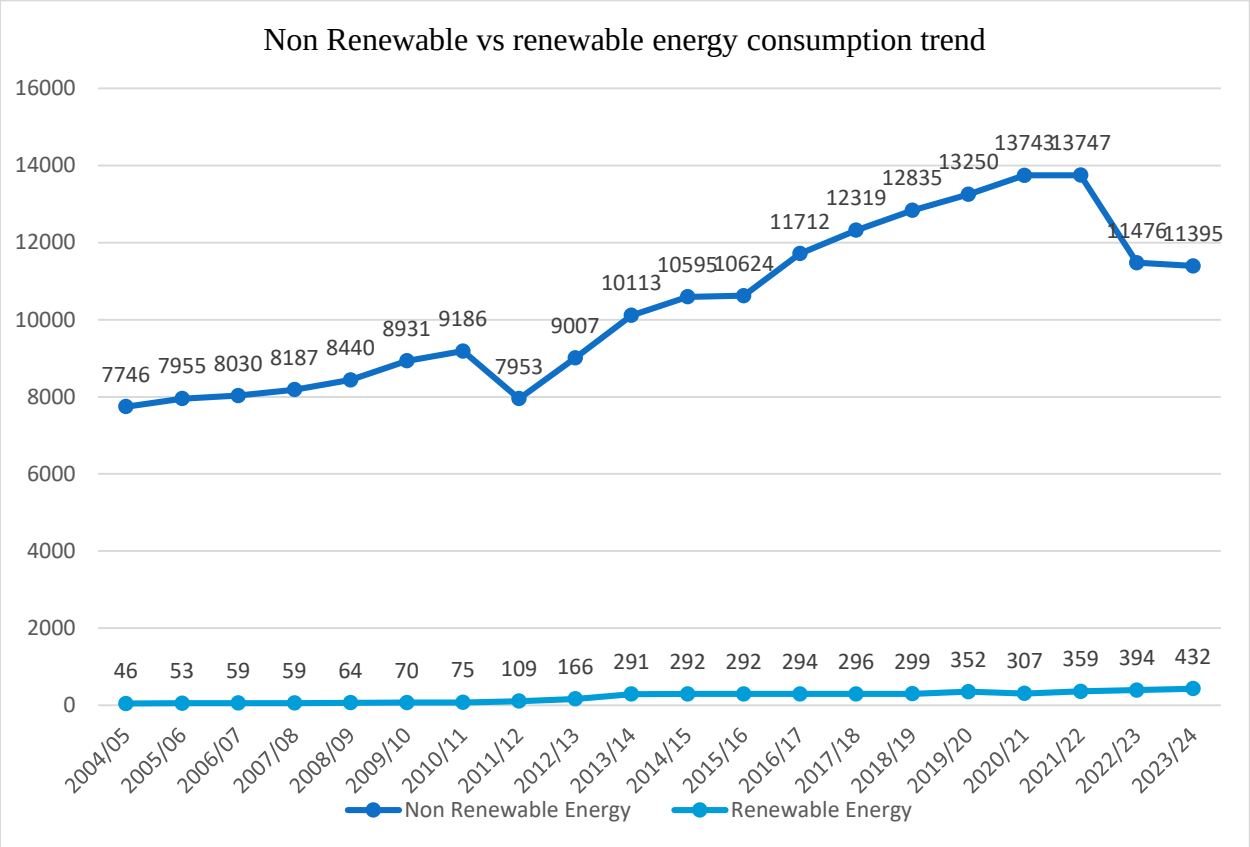
Figure 3

Nonrenewable vs. Renewable Energy Consumption Trends



The increasing share of renewable energy can largely be attributed to government policies promoting renewable technologies, expansion of decentralized energy systems, and growing investment in hydropower, solar photovoltaic systems, biogas, and micro-hydropower projects. Nevertheless, the relatively modest contribution of renewable energy indicates that Nepal's energy transition remains at an early stage. Structural constraints, including inadequate infrastructure, limited investment, technological barriers, and unequal access to modern energy services, continue to restrict the large-scale adoption of renewable energy. Consequently, while the observed trend is encouraging, substantial policy support and long-term investment are required to accelerate the transition towards a more sustainable energy system.

Household energy-use patterns further illustrate the current stage of Nepal's energy transition. According to the 2021 National Population and Housing Census, Nepal had 6,666,937 households with an average household size of 4.37 persons. Fuelwood remained the dominant cooking fuel, followed by LPG, cow dung, biogas, electricity, and kerosene, whereas electricity accounted for 92.2 percent of household lighting, followed by solar energy (6.6%). These findings demonstrate that the transition towards renewable and modern energy has progressed more rapidly in electricity access than in household cooking practices. The continued dependence on biomass for cooking indicates that improvements in energy access alone are

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insufficient to transform household energy behaviour, which is also influenced by affordability, availability, cultural practices, and the reliability of alternative energy sources.

4.5 Energy Use at Home for Cooking and Lighting

Household energy consumption reflects the uneven nature of Nepal's ongoing energy transition. Table 4 and Figure 4 show considerable differences between energy use for cooking and lighting, indicating that improvements in electricity access have not translated into equivalent changes in household cooking practices.

The data further illustrates the long-term changes in household energy consumption between FY 2004/05 and FY 2023/24. Throughout the study period, commercial energy consumption increased substantially alongside overall energy demand, while traditional energy remained an important component of household consumption. The increasing use of electricity reflects improvements in national electricity generation, transmission, and distribution, whereas continued reliance on fuelwood demonstrates that access to electricity does not automatically lead to the adoption of electric cooking technologies.

Table 4

Energy Consumptions in Gj for HH Activities Different Years

Year	Traditional	Fuel Wood	Agriculture Waste	Animal Dung	Commercial	Coal	Petroleum	Electricity	Renewable	Total
2004/05	48189.41	13690.18	13690.8	20808.4	42454.152	6363.936	29516.94	6573.276	1925.928	92569.49
2005/06	48775.56	13773.91	13774.6	21227.1	45761.724	10173.92	28721.45	6866.352	2219.004	96756.29
2006/07	49905.98	14108.84	14109.5	21687.6	43165.908	6028.992	29684.41	7452.504	2470.212	95542.1
2007/08	50366.53	14108.84	14109.5	22148.2	43458.984	8080.524	27423.54	7954.92	2470.212	96295.73
2008/09	51413.22	14401.9	14402.6	22608.7	47687.652	7619.976	32447.7	7619.976	2679.552	101780.4
2009/10	50199.08	13564.58	13565.2	23069.3	61294.752	11974.25	40402.62	8917.884	2930.76	114411.24
2010/11	51287.64	13857.65	13858.3	23571.7	66151.44	12267.32	44296.34	9587.772	3140.1	120579.2
2011/12	44714.4	12978.46	12979.1	24187	70296.372	14570.06	45343.04	10383.26	4563.612	119574.4
2012/13	50952.65	14778.7	14779.4	24694.5	77623.272	17375.22	49487.98	10760.08	6950.088	135526
2013/14	51580.57	16872	16872.8	17835.8	82019.412	13397.76	52921.15	15700.5	12183.588	145783.6

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2014 /15	52250 .45	17081 .33	17082. 1	180 87.0	97594. 308	1946 8.62	61504 .09	16621 .6	12225 .456	1620 70.2
2015 /16	53004 .06	17332 .52	17333. 4	183 38.2	94119. 264	2244 1.25	53381 .7	18296 .32	12225 .456	1593 48.8
2016 /17	53506 .47	17499 .99	17500. 8	185 05.7	136196 .6	2780 0.35	87420 .38	20975 .87	12309 .192	2020 12.3
2017 /18	54176 .34	17793 .05	17793. 9	185 89.4	155539 .62	3190 3.42	99980 .78	23655 .42	12392 .928	2221 08.9
2018 /19	54929 .95	18044 .25	18045. 1	188 40.6	172286 .82	4061 1.96	11023 8.4	21436 .42	12518 .532	2397 35.3
2019 /20	54385 .66	18253 .58	18254. 4	178 77.6	187903 .58	4379 3.93	12120 7.9	22901 .8	14737 .536	2570 26.8
2020 /21	55557 .94	18797 .83	18798. 7	179 61.4	197616 .96	6012 2.45	11128 5.1	26209 .37	12853 .476	2660 28.4
2021 /22	74774 .72	31901 .89	31903. 4	109 69.4	202724 .86	4651 5.35	11886 3.3	37346 .26	15030 .612	2925 30.2
2022 /23	61042 .32	25621 .99	25623. 2	979 7.1	175845 .6	3399 6.82	10337 2.1	38476 .69	16495 .992	2533 83.9
2023 /24	55474	23110 .03	23111. 1	925 2.8	200338 .38	4019 3.28	11450 9	45636 .12	18086 .976	2738 99.4

Several factors may explain this disparity. Household decisions regarding cooking energy depend not only on electricity availability but also on appliance affordability, cooking habits, fuel prices, supply reliability, and cultural preferences. Consequently, electrification has been considerably more successful in replacing traditional lighting technologies than in replacing biomass-based cooking practices. These findings suggest that achieving universal electricity access alone is insufficient for promoting clean household energy transitions. Complementary policies supporting affordable electric cooking technologies, improved energy infrastructure, behavioural change, and reliable electricity supply are equally important.

4.6 Emerging Issues in Nepal's Energy Transition

To further examine the relationship between energy consumption and economic growth, Pearson's correlation (r) analysis was performed between GDP growth and renewable energy consumption. As presented in Table 5 and Figure 5, the correlation coefficient between GDP growth and renewable energy consumption is −0.073 (N = 20), with a significance value of 0.759. The correlation is extremely weak and statistically insignificant, which indicates that changes in GDP during the study period were not systematically associated with changes in renewable energy consumption. Therefore, the findings should be interpreted as evidence of statistical association rather than causation.

Figure 5

Increasing Trend of Energy Consumption and GDP

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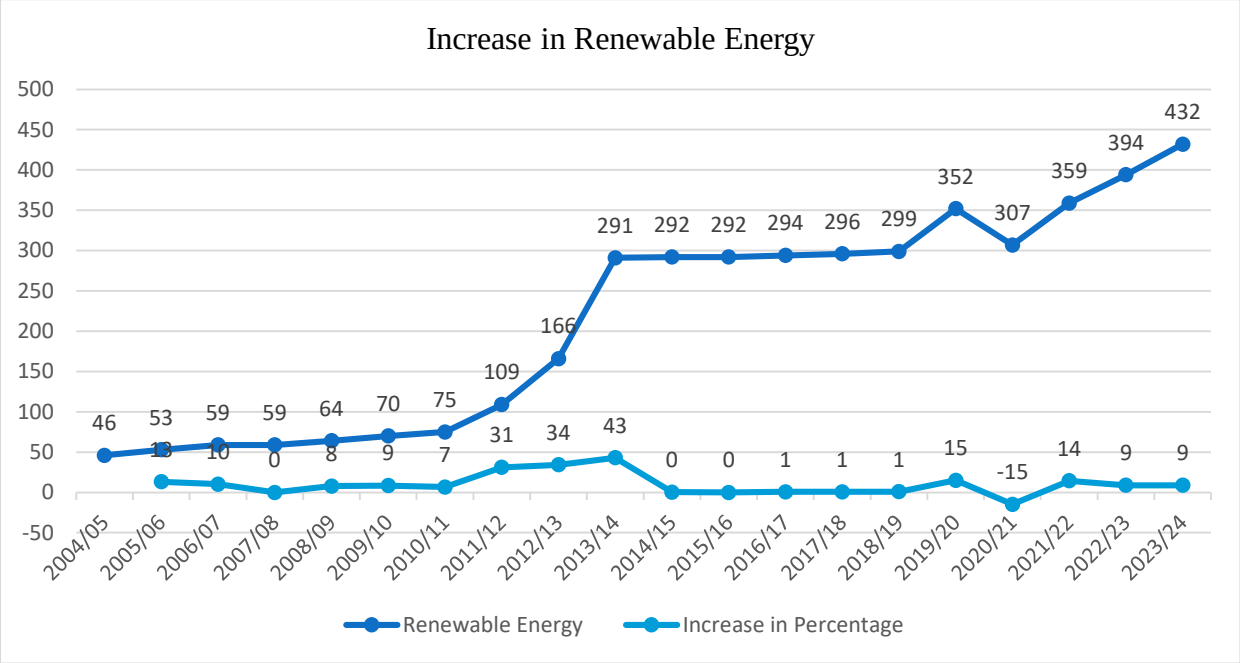

Table 5

Correlations Between in GDP Growth Rate (%) and Energy Use

		Increased in GDP	Renewable Energy
Increased in GDP	Pearson Correlation	1	-.073
	Sig. (2-tailed)		.759
	N	20	20
Renewable Energy	Pearson Correlation	-.073	1
	Sig. (2-tailed)	.759	
	N	20	20

The absence of a statistically significant relationship suggests that Nepal's renewable energy transition has been influenced more by policy interventions, institutional initiatives, technological advancement, and infrastructure development than by economic growth alone. Although GDP has generally increased over the study period, renewable energy has expanded gradually rather than proportionally, indicating that macroeconomic growth has not automatically translated into greater renewable energy adoption. These findings imply that targeted public policies and investment strategies remain more important than economic expansion in driving the country's transition towards cleaner energy systems.

5. Discussion

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The findings demonstrate that Nepal's energy system is undergoing a gradual but uneven structural transformation. Although traditional biomass remains the dominant source of energy, its relative contribution has steadily declined as commercial and renewable energy sources have expanded. Total energy consumption increased from 8,616 thousand TOE in FY 2004/05 to a peak of 15,130 thousand TOE in FY 2021/22, which reflects creasing energy demand associated with population growth, urbanization, industrialization, infrastructure expansion, and rising household consumption. While total energy use declined during FY 2022/23 and FY 2023/24, this short-term decline does not alter the broader long-term trend of increasing national energy demand.

To examine the long-term growth of different energy categories, compound annual growth rates (CAGR) were calculated for the period FY 2004/05–2023/24 (Table 6). The results presented in table 6 show that renewable energy recorded the highest annual growth rate at 12.53 percent, followed by commercial energy at 8.42 percent, while total energy consumption increased at an average annual rate of 5.86 percent. In contrast, traditional energy grew very slowly, with a CAGR of only 0.74 percent. These findings indicate that Nepal's energy system is gradually diversifying away from traditional biomass towards commercial and renewable energy sources.

Table 6

CAGR Analysis of Energy Use (2004/05-2023/24)

Energy Category	2004/05	2023/24	CAGR (%)
Traditional Energy	48,189.41	55,474.00	0.74%
Commercial Energy	42,454.15	200,338.38	8.42%
Renewable Energy	1,925.93	18,086.98	12.53%
Total Energy Consumption	92,569.49	273,899.40	5.86%

Note: Beginning value = FY 2004/05; Ending value = FY 2023/24; and n = 19 years (from 2004/05 to 2023/24)

The findings further reveal that Nepal's energy transition is characterized by diversification rather than complete substitution. Commercial energy, particularly electricity and petroleum products, has expanded rapidly, yet traditional biomass continues to dominate household cooking. Similarly, renewable energy has grown steadily from 46 thousand TOE in FY 2004/05 to 432 thousand TOE in FY 2023/24, although its contribution to the national energy mix remains relatively limited. These results suggest that Nepal is progressing towards a cleaner energy system, but the transition remains constrained by infrastructural limitations, technological capacity, investment requirements, and disparities in energy access between urban and rural areas.

Another important finding is that renewable energy consumption exhibits no statistically significant relationship with GDP growth during the study period. This indicates that the expansion of renewable energy is not driven solely by economic growth but is strongly influenced by policy priorities, institutional commitment, public investment, and technological development. Consequently, sustained economic growth alone is unlikely to accelerate the

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renewable energy transition unless accompanied by effective policy implementation and long-term investment in clean energy infrastructure.

Overall, the findings indicate that Nepal has entered an important stage in its energy transition. Future progress will depend on reducing dependence on traditional biomass and imported fossil fuels, strengthening domestic renewable energy production, promoting clean household energy technologies, improving energy efficiency, and ensuring equitable access to modern energy services. These measures will not only strengthen national energy security but also contribute to sustainable economic development and long-term environmental sustainability.

6. Conclusion

This study examined the changing patterns of energy consumption in Nepal and their relationship with economic growth during FY 2004/05–2023/24. The findings indicate that Nepal's total energy demand has increased considerably over the past two decades, driven by urbanization, economic expansion, infrastructure development, and rising household energy needs. Although traditional biomass and commercial fossil fuels continue to dominate the national energy mix, their composition has gradually shifted with increasing electricity consumption and a modest but steady expansion of renewable energy. The analysis also reveals that Nepal's energy transition remains uneven across sectors. While electricity has become the principal source of household lighting, fuelwood continues to dominate cooking energy, reflecting persistent structural, economic, and accessibility constraints. Furthermore, the weak and statistically insignificant relationship between GDP growth and renewable energy consumption suggests that economic growth alone has not been sufficient to accelerate the country's transition towards cleaner energy sources.

The study concludes that Nepal's energy transition is progressing but remains incomplete, requiring stronger policy interventions to promote sustainable and diversified energy development. Expanding renewable energy, encouraging clean cooking technologies, improving energy efficiency, strengthening domestic electricity utilization, and reducing dependence on imported fossil fuels should remain central priorities of national energy policy. In addition, the recent decline in total energy consumption observed during the final years of the study warrants further investigation to determine whether it reflects structural changes in the economy, improvements in energy efficiency, policy interventions, or data-related factors. Future studies employing advanced econometric techniques and sector-specific analyses would further strengthen the understanding of the causal relationship between different forms of energy consumption and economic growth in Nepal.

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