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Research Article

From Import Dependency to Energy Self-Reliance: Nepal's Policy Push Towards Renewable Energy Solutions

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ABSTRACT

Nepal's energy transition highlights the challenges of shifting from fossil fuel dependence to renewables despite generating over 90% of its electricity from hydropower. Heavy reliance on imported petroleum for transport (52%) and industry (28%) exposes the country to economic and geopolitical risks, as seen during the 2015 fuel blockade. While policies like the National Renewable Energy Policy (2011) improved rural electrification, barriers such as high costs, weak infrastructure, and limited solar/wind adoption hinder progress. This study applies Dependency Theory and Energy Transition Theory to analyze Nepal's energy landscape, emphasizing the socio-political dimensions of the shift. It proposes the Integrated Renewable Transition Model (IRTM), combining policy reforms, financial mechanisms (e.g., green bonds), hybrid energy systems, and community engagement. Strategies include renewable quotas for industries, promoting electric vehicles, and leveraging international climate funds. Achieving energy self-reliance requires holistic reforms across transport, industry, and households, aligning with global sustainability goals. Nepal's experience offers lessons for developing nations, demonstrating that strategic planning and collective action can foster a resilient, low-carbon future.

Keywords: Renewable Energy, Fossil Fuels, Energy Policies, Sustainable Development Goals

INTRODUCTION

Nepal, a landlocked country in South Asia, has long been dependent on imported fossil fuels to meet its energy needs. Despite its large potential for renewable energy, particularly hydropower, solar and wind, the country has struggled to transition away from fossil fuels due to infrastructural, financial and policy-related challenges. The reliance on imported energy not only strains Nepal's economy but also exposes it to geopolitical vulnerabilities, particularly in light of fluctuating global oil prices and supply chain disruptions. In recent years, Nepal has made significant effort in increasing its renewable energy capacity, particularly in hydropower, which now accounts for over 90% of its electricity generation (Raihan et al., 2024). However, the country still faces challenges in achieving energy self-reliance, as a significant portion of its energy consumption, particularly in the transportation and industrial sectors, remains dependent on imported fossil fuels.

The global energy landscape is undergoing a significant transformation, driven by the urgent need to mitigate climate change and reduce dependence on fossil fuels. The European Union's plan, for instance, aims to accelerate the transition to renewable energy and reduce dependence on Russian gas and oil imports (Balode & Blumberga, 2023). Similarly, Nepal's push for renewable energy solutions aligns with global efforts to achieve energy security and independence. However, the path to energy self-reliance is troubled with challenges, including high initial costs, technological barriers and the need for robust policy frameworks to support the transition.

To understand Nepal's transition from import dependency to energy self-reliance, it is essential to examine the theoretical underpinnings of this shift. Two key theories provide a framework for analyzing this transition: Dependency Theory and Energy Transition Theory. Dependency Theory posits that developing countries often remain economically and politically dependent on more developed nations due to their reliance on imported goods, including energy resources (Frank, 1967). In the context of Nepal, this theory highlights the country's historical dependence on imported fossil fuels, which has hindered its economic development and exposed it to external shocks. The theory suggests that breaking free from this dependency requires a shift towards self-sufficiency, particularly in energy production. Nepal's push for renewable energy solutions can be seen as an attempt to reduce its dependency on foreign energy imports and achieve greater economic and political autonomy.

Energy Transition Theory, on the other hand, focuses on the shift from fossil fuel-based energy systems to renewable energy sources. This theory emphasizes the role of policy, technology,

and societal change in driving the transition (Geels, 2002). In Nepal's case, the transition to renewable energy is not just a technological challenge but also a socio-political one. The country must navigate complex policy landscapes, secure financing for renewable energy projects, and build the necessary infrastructure to support the transition. The theory also highlights the importance of aligning national energy policies with global sustainability goals, such as those outlined in the United Nations' Sustainable Development Goals (SDGs).

Despite the growing body of literature on Nepal's renewable energy transition, there is a lack of comprehensive studies that examine the interplay between policy, technology, and socio-economic factors in driving the transition. Most studies focus on specific aspects of the transition, such as hydropower development or solar energy adoption, without providing a holistic view of the challenges and opportunities. Additionally, there is limited research on the role of international cooperation and financing in supporting Nepal's energy transition, particularly in light of the country's limited financial resources. Thus, it can be said that Nepal's transition from import dependency to energy self-reliance is hindered by a lack of comprehensive policy frameworks, financial constraints and infrastructural challenges. While the country has made significant progress in increasing its renewable energy capacity, there was a need for a more holistic approach that addresses the socio-economic, technological, and policy-related barriers to achieving energy security and independence.

In regards to these backgrounds, this study aimed to prepare a unified development strategy on reducing the fossil fuel consumption through renewable energy for sustainable development framework for Nepal. For this, this study firstly, analyzed the current state of Nepal's energy sector, with a focus on its dependence on imported fossil fuels and the potential for renewable energy. Secondly, examined the policy and regulatory frameworks related to Nepal's transition to renewable energy and lastly, recommended the strategy for reducing the fossil fuel through transition to renewable energy.

Literature Review

Several studies have examined the challenges and opportunities associated with Nepal's renewable energy transition. Raihan et al. (2024) provide a comprehensive review of Nepal's current energy mix and the potential for renewable energy, emphasizing the need for proactive policies to support clean energy adoption. Similarly, Agupugo et al. (2024) discuss the role of policy and regulatory frameworks in facilitating the deployment of renewable energy microgrids and energy storage systems, which were critical for ensuring energy security

and resilience. These studies underscored the importance of financial incentives, technical standards and regulatory mandates in driving the transition to renewable energy.

The literature reveals that while Nepal has made significant progress in increasing its renewable energy capacity, several barriers remain. High initial costs, lack of infrastructure, and policy inconsistencies were among the key challenges that need to be addressed. Moreover, the country's reliance on imported fossil fuels for non-electricity energy needs, such as transportation and industry, highlights the need for a more comprehensive approach to energy transition. The European Union's plan offers valuable lessons for Nepal, particularly in terms of diversifying energy supply and accelerating the adoption of renewable energy technologies (Balode & Blumberga, 2023). However, Nepal's unique geographical and socio-economic context requires tailored solutions that address its specific challenges.

Moreover, Nepal has made notable efforts in policy formulation to support renewable energy development. The government has established the Alternative Energy Promotion Centre (AEPC) to promote, develop and facilitate alternative energy technologies in Nepal (AEPC, 2022). The AEPC has been instrumental in implementing various renewable energy projects, including solar, wind and micro-hydro projects, particularly in rural areas. Additionally, the Nepal Electricity Authority (NEA) has been established for generating, transmitting and distributing electrical energy with sufficient quantity, high reliability and at affordable costs (NEA, 2022). These institutional frameworks are vital for the successful implementation of renewable energy policies.

The government has introduced several policies to encourage renewable energy adoption. The National Renewable Energy Policy (2011) aims to increase the share of renewable energy in the national energy mix and reduce dependency on fossil fuels (Adhikari et al., 2024). Furthermore, the Renewable Energy Subsidy Policy (2016) provides financial incentives for households and businesses to adopt renewable energy technologies, such as solar panels and biogas plants (Acharya, 2018). These policies have played a significant role in increasing the adoption of renewable energy, particularly in rural and off-grid areas.

After 2000, Nepal introduced several key energy policies to promote renewable energy and address energy security challenges. The Renewable Energy Policy (2006) was a landmark policy aimed at increasing the use of renewable energy technologies like solar, wind, micro-hydro, and biomass, particularly in rural areas (Government of Nepal, 2006). The National Rural and Renewable Energy Program (NRREP, 2012) further expanded these efforts, focusing on decentralized renewable energy solutions to improve rural energy access (Government

of Nepal, 2012). The Energy Crisis Mitigation and Electricity Development Decade (2016) was launched to address energy shortages and accelerate hydropower and renewable energy development (Government of Nepal, 2016). Additionally, the National Energy Efficiency Strategy (2018) emphasized improving energy efficiency across sectors, while the Nepal Electricity Regulatory Commission Act (2017) established a regulatory framework to oversee the electricity sector (Government of Nepal, 2017; Government of Nepal, 2018). These policies collectively aim to enhance energy security, promote sustainable energy, and reduce reliance on fossil fuels.

Similarly, Nepal implemented policies to regulate and manage fossil fuel imports, primarily focusing on petroleum products, to ensure energy security and efficient distribution. The Petroleum and Gas Regulations (1994), though enacted earlier, continued to play a significant role in governing the import, storage, and distribution of petroleum and LPG (Government of Nepal, 1994). Additionally, the Petroleum Act (1983) remained the foundational legal framework for the petroleum sector, ensuring proper licensing and safety standards for fossil fuel operations (Government of Nepal, 1983). While Nepal has not introduced major new policies specifically targeting fossil fuel imports after 2000, the government has periodically revised regulations and adopted measures to stabilize supply, such as diversifying import sources and improving storage infrastructure. These efforts aim to reduce dependency on fossil fuels and align with broader energy transition goals.

Despite these efforts, challenges persist in developing the renewable energy to replace fossil fuel. The high initial costs of renewable energy projects and the lack of adequate financial resources remained the significant barriers (Acharya, 2018). Furthermore, the absence of reliable and comprehensive digital mapping, lack of standardized technologies in rural areas and poor maintenance of projects hinder the progress of renewable energy development (Adhikari et al., 2024). To address these issues, the government needs to implement supportive policies, encourage investors, strengthen local capacity and support innovation to realize the full potential of renewable energy for a sustainable and clean energy future.

DATA AND METHODS

This study employed an explanatory sequential mixed-methods design to develop a comprehensive understanding of Nepal's efforts on energy transition from fossil fuel to renewable energy. The design was selected to enable an initial quantitative assessment of national energy trends, followed by a qualitative exploration that contextualized and explained

the statistical findings. All data were derived from secondary sources. Instead of collecting primary field data, the study relied exclusively on existing published materials, including institutional datasets, government reports, and relevant policy documents. Quantitative data on fuel supply, energy generation, and consumption were obtained from authoritative national institutions such as the Nepal Oil Corporation, the Alternative Energy Promotion Centre, and the Nepal Electricity Authority. Complementing this, the qualitative component consisted of an extensive review of governmental publications, renewable energy mandates, and import–export regulatory frameworks, enabling a deeper examination of policy directions and institutional priorities. The methodological framework was further informed by a review of academic literature to establish both the theoretical and practical grounding of Nepal's energy transition discourse. Additionally, a case study of the 2015 fuel blockade was incorporated to analyze the consequences of import dependency and to draw comparative insights relevant to current energy strategies. Overall, the analytical process was structured into two interconnected phases, first, a quantitative analysis focusing on statistical patterns in fossil-fuel and renewable-energy shares, and second, a qualitative analysis aimed at interpreting and elaborating on the quantitative results through policy and documentary evidence. The findings were discussed and compared with findings of similar studies and theories to draw the final conclusion.

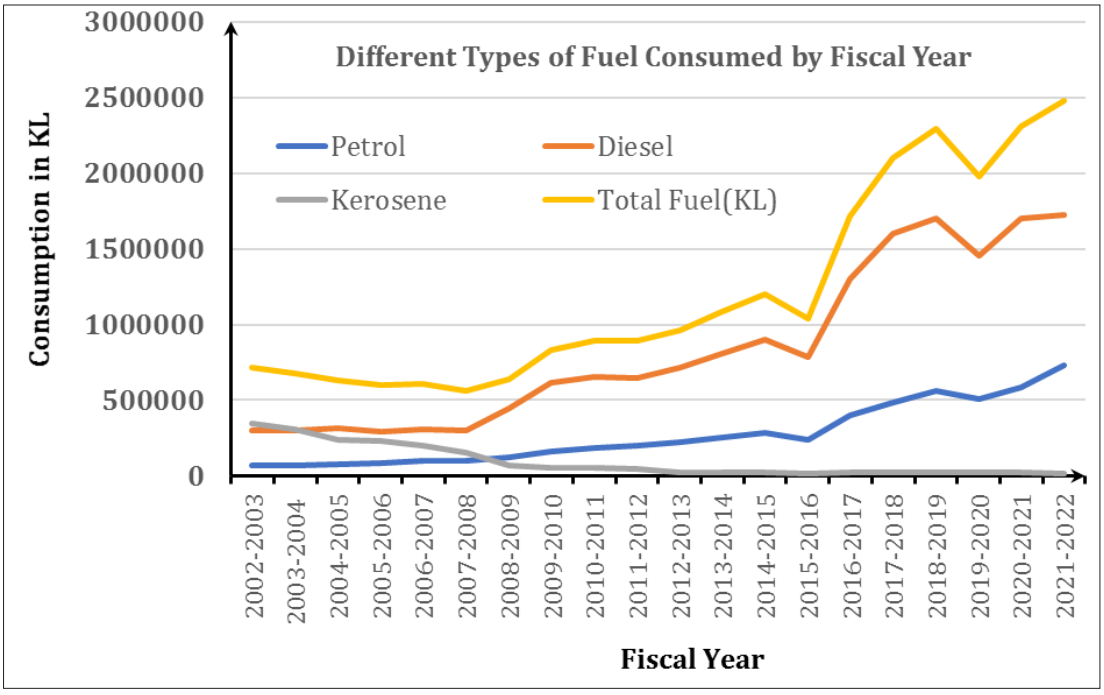
RESULTS AND DISCUSSION

Energy trends and Statistics

Figure 1 illustrates a detailed breakdown of Nepal's petroleum product consumption (diesel, petrol, and kerosene) across multiple fiscal years. The data reveals a consistent pattern of high fossil fuel consumption, particularly diesel which dominates the transportation and industrial sectors. Despite progress in renewable electricity generation, the sustained demand for petroleum products indicates Nepal's ongoing vulnerability to global oil price fluctuations and supply chain disruptions. The trend suggests that renewable energy adoption has not yet significantly penetrated, highlighting a critical gap in Nepal's energy transition strategy. This persistent dependence underscores the urgent need for policies promoting electric mobility and biofuel alternatives to reduce reliance on imported fossil fuels.

Figure 1

Consumption of Fuel by Types in Different Fiscal Year

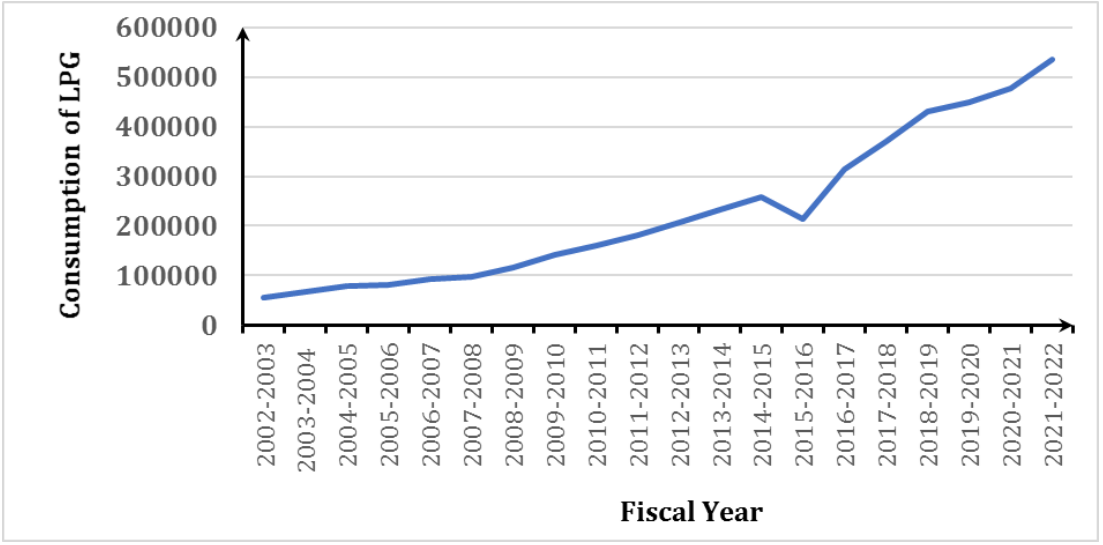


Source: Nepal Oil Corporation, 2025

The Liquified Petroleum Gas (LPG) consumption data shown in figure 2 with a steady upward trajectory, reflecting its growing importance for household cooking and small-scale industrial applications. This increasing demand demonstrates Nepal's energy transition from fuelwood to LPG in cooking in residential area and small-scale industries such as hotel and restaurant. The consistent growth in LPG use indicates that renewable alternatives like biogas and electric cooking solutions have not yet achieved sufficient market penetration. The figure highlights a significant opportunity for targeted interventions in the residential sector, particularly through subsidies for clean cooking technologies and infrastructure development for alternative energy distribution.

Figure 2

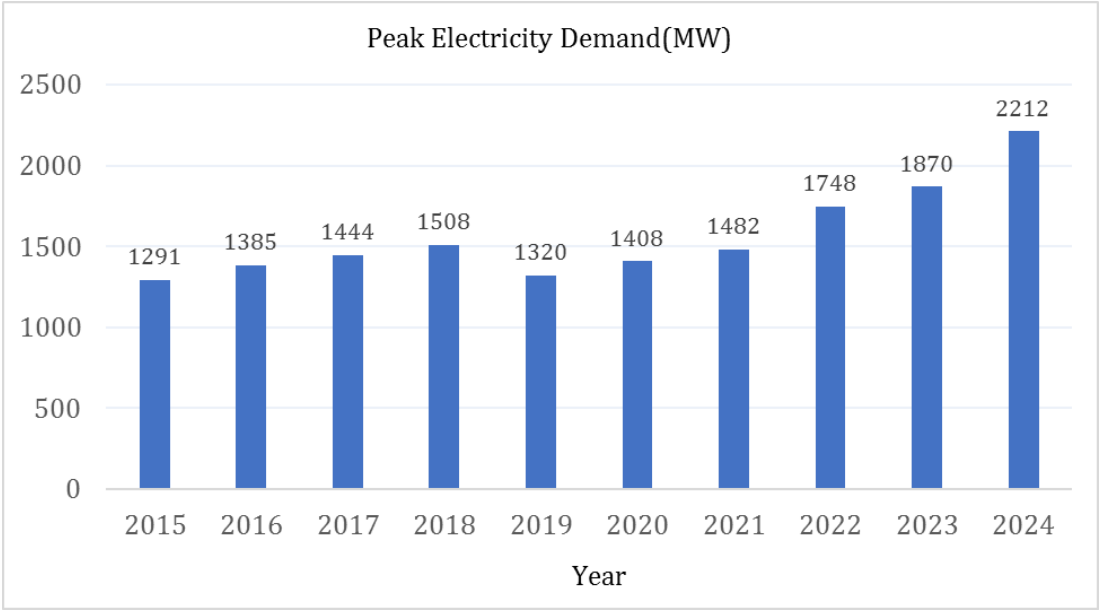
Consumption of LPG in Different Fiscal Year



Source: Nepal Oil Corporation, 2025

Figure 3

Peak Electricity Demand on Hydropower Sources in Megawatts (MW)



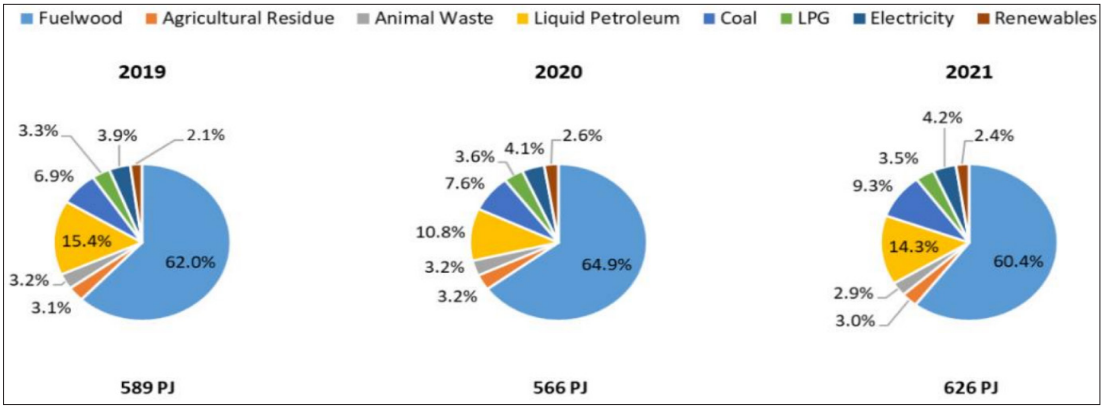
Source: Nepal Electricity Authority, 2025

Figure 3 illustrates Nepal's remarkable success in harnessing hydropower, which consistently meets over 90% of peak electricity demand. The data demonstrates the country's ability to generate clean electricity during periods of highest demand, showcasing hydropower's reliability as a base load power source. However, the figure also implicitly reveals limitations, hydropower's dominance in electricity generation hasn't translated to broader energy sector transformation. The seasonal variability nature of Nepalese hydropower suggests the need for complementary renewable sources to ensure year-round energy security and reduce dependence on any single generation method.

The year-by-year comparison of Nepal's overall energy consumption patterns was illustrated in figure 4. While hydropower generation has increased, fossil fuel consumption has remained consistent across the three-year period. This stagnation suggests that growth in renewable electricity has primarily met increasing demand rather than displacing fossil fuel use. The data reveals a fundamental challenge in Nepal's energy transition: progress in one sector (electricity) isn't automatically reducing dependence on imported fuels in other sectors. This calls for more integrated energy planning that addresses consumption patterns across all economic sectors simultaneously.

Figure 4

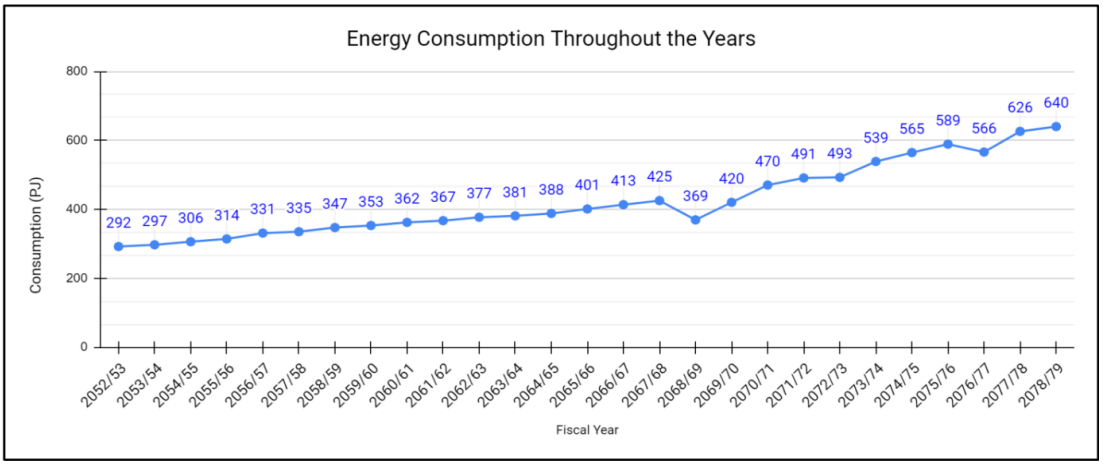
Energy Consumption of Nepal in 2019, 2020 and 2021



Source: Energy Synopsis Report 2022, WECS

Figure 5

Nepal Total Energy Consumption by Fiscal Year



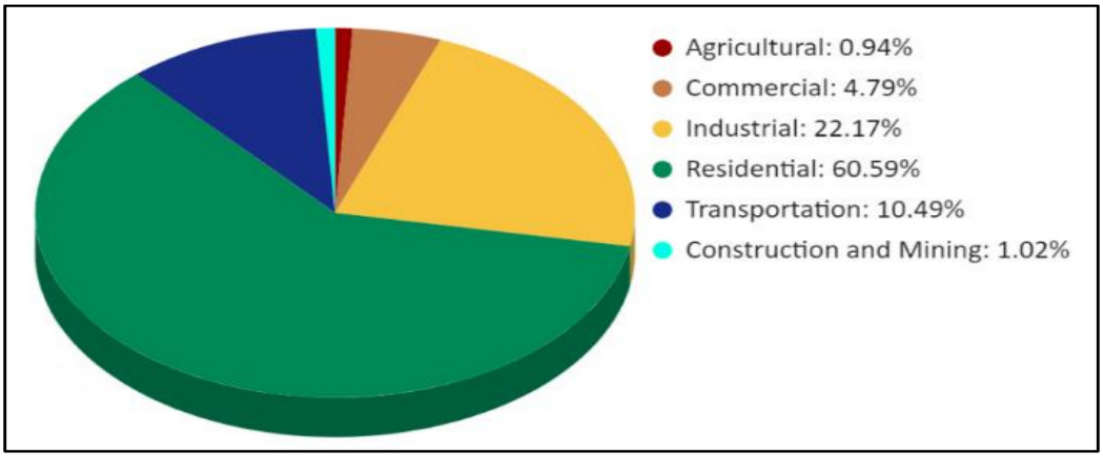
Source: Energy Synopsis Report 2022, WECS

Figure 5 shows the total energy consumption of Nepal. This trend in reference to figure 4 clearly shows fossil fuels maintaining their dominant position in Nepal's energy mix despite hydropower expansion. The data's most prominent revelation is the disproportionate share of petroleum products in the total energy picture, underscoring how electricity generation represents only part of Nepal's energy challenge. The persistent gap between renewable electricity production and overall fossil fuel dependence suggests that current policies may be too narrowly focused on generation rather than comprehensive energy substitution.

Figure 7 shows the composition of different energy forms in Nepal's total energy consumption. Residential sector has the highest share on total consumption with more than half energy (60.59%). Industrial being the second highest consumption followed by transportation. These data clearly pointed that the dominance of energy consumption was the fossil fuels and traditional fuel such as fuelwood in residential sector. Therefore, the transition of fossil fuel to renewable energy should focus on replacing the end use devices used in residential sector like LPG stove, traditional fuelwood cooking stoves and in transportation sector by replacing electric vehicle or other renewable energy-based mobility.

Figure 6

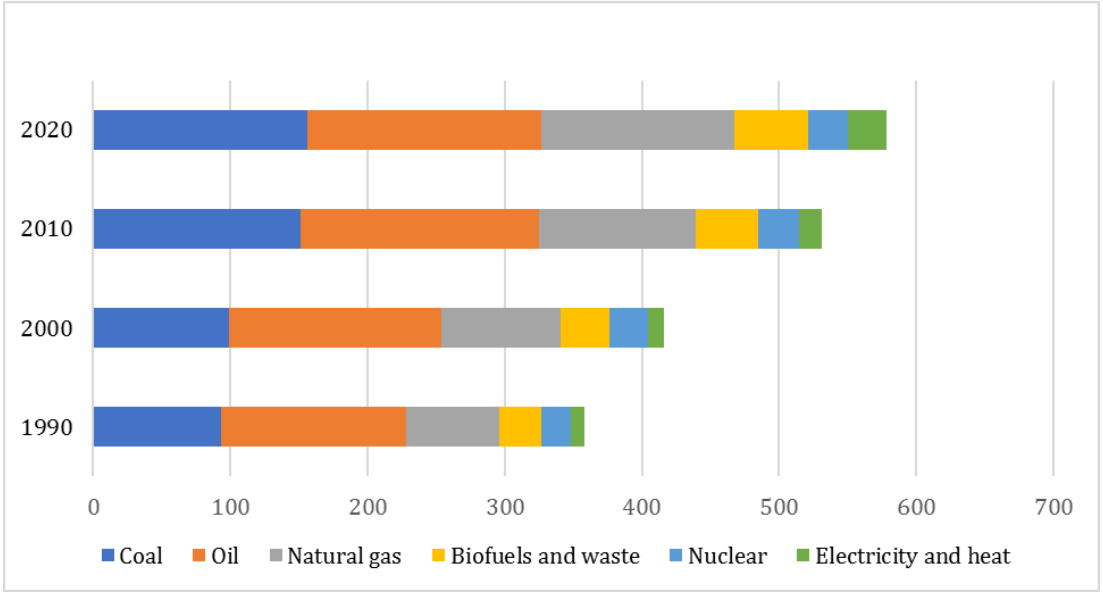
Sectoral Energy Consumption of Nepal in FY 2021-22



Source: Energy Synopsis Report 2022, WECS

Figure 7

World Energy Scenario by Different Sources



Source: Energy Statistics 2023, UN

Figure 7 shows the energy mix of different years of Nepal. While many nations are diversifying their renewable portfolios with solar, wind, and other technologies, Nepal

remains overwhelmingly dependent on hydropower for its renewable generation. The global comparison highlights Nepal's untapped potential in other renewable sectors and suggests that the country's current path may be too narrow for long-term energy security. The figure underscores the importance of broadening Nepal's renewable energy strategy to include a more diverse mix of technologies, particularly those that can address the transportation and industrial sectors where hydropower has limited applicability.

Case Study: The 2015 India-Nepal Fuel Blockade and Dependency Theory

Nepal is a landlocked country situated between India and China, with India being its primary supplier of petroleum products, including diesel, petrol, and liquefied petroleum gas (LPG). Nearly 100% of Nepal's fossil fuel imports come from India, making it entirely dependent on its southern neighbor for energy supplies. This dependency is rooted in historical, geographical, and economic ties, as well as the open border agreement between the two countries. However, this reliance has also made Nepal vulnerable to political and economic pressures from India.

In September 2015, Nepal adopted a new constitution, which was met with protests by certain ethnic groups in the southern Terai region, who felt marginalized by the new federal structure. India, which has close cultural and political ties with the Madhesi and Tharu communities in the Terai, expressed concerns over the constitution and called for amendments to address their demands. When Nepal's government did not immediately comply, India unofficially imposed an economic blockade, severely restricting the flow of petroleum products and other essential goods across the border. While India denied imposing a formal blockade, the supply constraints were widely perceived as a political move to pressure Nepal into amending its constitution.

The blockade lasted for nearly five months, from September 2015 to February 2016, and had devastating effects on Nepal's economy and daily life. Fuel shortages led to long queues at petrol stations, with prices skyrocketing on the black market. Transportation systems were paralyzed, affecting the movement of goods and people. Industries, hospitals, and schools faced severe disruptions, and the tourism sector, a key contributor to Nepal's economy, suffered significant losses. The blockade also coincided with the aftermath of the April 2015 earthquake, further exacerbating the country's challenges in reconstruction and recovery.

Nepal's dependency on India for fuel imports left it with few alternatives during the crisis. While the government attempted to diversify its energy sources by importing fuel from China, logistical challenges, including the lack of adequate infrastructure and the mountainous

terrain, limited the effectiveness of these efforts. The crisis highlighted Nepal's vulnerability as a peripheral state dependent on a core state for critical resources.

The 2015 fuel blockade underscores the core-periphery relationship described in dependency theory. India, as the core state, wielded significant influence over Nepal, a peripheral state, by leveraging its control over a critical resource. The blockade demonstrated how economic dependency can be used as a tool for political coercion, reinforcing the unequal power dynamics between the two countries.

Nepal's lack of diversification in energy imports and its reliance on a single supplier exemplify the structural weaknesses inherent in dependent relationships. The blockade exposed the limitations of Nepal's energy infrastructure and its inability to respond effectively to external shocks. Furthermore, the crisis revealed the geopolitical constraints faced by landlocked countries, which often have limited options for trade and resource diversification.

The blockade also had long-term implications for Nepal's energy policy. In the aftermath of the crisis, Nepal sought to reduce its dependency on India by exploring alternative energy sources and strengthening ties with China. However, these efforts have been constrained by geographical challenges, financial limitations, and the entrenched nature of Nepal-India economic ties.

The 2015 India-Nepal fuel blockade is a stark illustration of dependency theory in action. Nepal's reliance on India for petroleum products created a relationship of vulnerability, which India exploited to exert political pressure. The crisis highlighted the need for Nepal to diversify its energy sources, strengthen its infrastructure, and reduce its dependency on a single supplier. While the blockade prompted some efforts toward energy security and geopolitical diversification, the structural challenges of dependency remain significant. This case study serves as a cautionary tale for other developing countries about the risks of over-reliance on a dominant partner for critical resources. This case was important to know the Nepal's dire need to transform possible end use consumption to renewable energy to reduce dependence.

Linking SDGs and Transition from Fossil Fuels to Renewable Energy

Table 1 shows the linking of SDG to transition from fossil fuel to renewable energy. The transition of fossil fuels to renewable energy would support and link to SDGs in many ways. For instance, using renewable energy cuts pollution which supports good health and well-being. Further, renewable energy development supports the clean and affordable energy and renewables energy development cut carbon emissions which helps Nepal meet its climate

commitments. Therefore, in many ways transition of fossil fuel to renewable energy supports the Sustainable development.

Table 1

Linking SDGs and Transition from Fossil Fuels to Renewable Energy

SDG 1 (No Poverty)	Renewable energy reduces energy costs, improving affordability and lifting rural communities out of energy poverty.
SDG 2 (Zero Hunger)	Clean energy supports sustainable agriculture through solar-powered irrigation and biogas for fertilizers.
SDG 3 (Good Health and Well-Being)	Replacing fossil fuels cuts air pollution, reducing respiratory diseases and improving public health.
SDG 4 (Quality Education)	Reliable electricity enables digital learning and extends study hours in off-grid schools.
SDG 5 (Gender Equality)	Renewable microgrids empower women by reducing time spent collecting fuel and enabling income-generating activities.
SDG 6 (Clean Water and Sanitation)	Hydropower and solar energy can power water pumps and purification systems.
SDG 7 (Affordable and Clean Energy)	Directly achieved by expanding renewables like hydropower, solar, and wind.
SDG 8 (Decent Work and Economic Growth)	Green jobs in renewable energy sectors boost employment and local economies.
SDG 9 (Industry, Innovation, and Infrastructure)	Renewable energy strengthens resilient and sustainable infrastructure.
SDG 10 (Reduced Inequalities)	Decentralized energy ensures equitable access for marginalized and remote communities.
SDG 11 (Sustainable Cities and Communities)	Clean energy reduces urban pollution and supports smart city development.
SDG 12 (Responsible Consumption and Production)	Shifting from fossil fuels promotes sustainable resource use.
SDG 13 (Climate Action)	Renewables cut carbon emissions, helping Nepal meet its climate commitments.

SDG 14 (Life Below Water)	Reduced fossil fuel dependency minimizes oil spills and water pollution.
SDG 15 (Life on Land)	Clean energy mitigates deforestation for fuelwood and lowers habitat disruption.
SDG 16 (Peace and Strong Institutions)	Energy independence reduces geopolitical risks tied to fuel imports.
SDG 17 (Partnerships for the Goals)	International cooperation and green financing accelerate Nepal's renewable transition.

Nepal's current energy landscape presents a clear paradox. On one hand, the country has made remarkable progress in expanding clean electricity generation, with more than 90% of peak demand now met through hydropower (Nepal Electricity Authority, 2025). This trend was supported by broader regional findings that identify hydropower as the dominant source of electricity generation in Nepal (Raihan et al., 2024). On the other hand, the overall national energy mix remained overwhelmingly dependent on fossil fuels, as demonstrated in Figures 4 and 5 (WECS, 2022). This contradiction indicated that while renewable electricity supply has expanded, it has largely met new or rising demand rather than replacing existing fossil fuel usage. Consequently, Nepal's energy transition remains confined primarily to the power sector, leaving the broader economy reliant on imported petroleum products and susceptible to external energy shocks.

The sectoral analysis further revealed critical bottlenecks that constrain Nepal's move toward energy independence. The steady rise in petroleum consumption particularly diesel and petrol illustrated in Figure 1 corresponds with the transportation sector's substantial share of petroleum use. As shown in Figure 6, transportation alone accounts for 52% of total petroleum consumption, followed by the industrial sector at 28% (WECS, 2022). This heavy reliance on imported fuels explained why improvements in hydropower capacity have not yielded reductions in the national fuel import bill. Similar challenges were evident in the residential sector, where the uptake of electric cooking technologies has been slower than anticipated. Despite policy directives outlined in the National Renewable Energy Policy (2011) and the Renewable Energy Subsidy Policy (2016), LPG consumption continued to rise steadily, indicating that households remain dependent on imported LPG for cooking needs (Acharya, 2018). This persistent reliance had maintained a major vulnerability in household energy security and highlighted the limited impact of policy measures intended to promote electrical alternatives.

Theoretical insights drawn from Dependency Theory further illuminate Nepal's structural vulnerabilities. As Frank (1967) argued, countries in the periphery often remain dependent on core states due to resource constraints, a pattern clearly mirrored in Nepal's complete reliance on India for fossil fuel imports. The 2015 fuel blockade demonstrated how geopolitical tensions can be exacerbated through energy dependence. Data presented in Figures 1 and 4 confirm that, despite this major national crisis, Nepal has not significantly reduced its reliance on imported petroleum products. This enduring dependency underscores the urgent need for systemic changes that reduce geopolitical exposure.

Finally, the results highlighted the risks associated with Nepal's mono-centric focus on hydropower. Although Figure 3 reflects Nepal's impressive hydropower expansion, Figure 7 situates Nepal globally as an exception among countries that typically diversify their renewable energy portfolios (UN, 2023). Unlike European systems analyzed by Balode and Blumberga (2023), which integrate hydropower, solar, wind, and storage technologies to ensure energy security and system stability, Nepal's overreliance on a single renewable source leaves it vulnerable to climatic variability, seasonal shortages, and drought-induced fluctuations. Achieving the goals of the Energy Crisis Mitigation and Electricity Development Decade (2016) and strengthening long-term energy security was therefore require deliberate diversification. Expanding solar and wind energy systems, along with regulatory support for microgrids and storage solutions as emphasized by Agupugo et al. (2024) was essential not only for electricity generation but also for strengthening energy supply for transportation and industrial sectors. Together, these findings reinforced the urgent imperative for Nepal to broaden its renewable energy strategy and transition toward a more resilient, diversified, and self-reliant energy system.

Alternative Framework: Integrated Renewable Transition Model (IRTM)

To address the challenges identified in the analysis, this study proposes an Integrated Renewable Transition Model (IRTM) as a comprehensive framework for Nepal's energy transition. The IRTM is designed to integrate policy, technology, finance, and community engagement into a unified strategy.

Policy Integration: Establish a unified Ministry for Energy Transition to streamline the roles of the AEPC, NEA, and other relevant bodies. Develop a cohesive national energy policy that mandates renewable energy quotas for industries (e.g., 30% by 2030) and aligns with global sustainability goals.

Technology and Infrastructure: Invest in hybrid energy systems, such as solar-hydro hybrids, to address seasonal variability and ensure a stable energy supply. Develop smart grids and digital mapping tools to improve energy distribution and maintenance, particularly in rural areas.

Financial Mechanisms: Mobilize international climate funds, such as the Green Climate Fund (GCF) and World Bank financing, to support large-scale renewable projects. Introduce green bonds and public-private partnerships to attract investment in rural microgrids and decentralized energy systems.

Community-Centric Approaches: Promote co-ownership models for local hydropower and solar projects to ensure community participation and benefit-sharing. Implement training programs to build local capacity for the maintenance and operation of renewable energy technologies.

Cross-Sectoral Electrification: Encourage the adoption of electric vehicles (EVs) through tax breaks and incentives, supported by solar-powered charging stations. Promote bioenergy solutions for industrial heat processes to reduce reliance on fossil fuels.

End use Diversification: Motivating people to use electric vehicles or other renewable energy dependent mobility, electric stoves to reduce LPG in cooking, renewable energy technologies and co-generation industries through incentive and awareness.

Global Lessons: Nepal can draw valuable lessons from the European Union's Renewable energy plan, which emphasizes rapid policy implementation and diversification of energy supply. Similarly, Bhutan's community-based hydropower projects offer a model for decentralized energy solutions tailored to Nepal's unique geographical and socio-economic context.

CONCLUSION

Nepal's pursuit of a sustainable and secure energy future was shaped by a complex interplay of structural constraints, policy choices, market dynamics, and geopolitical realities. The analysis of national energy trends demonstrates a persistent dependence on imported fossil fuels, despite steady progress in domestic hydropower generation and emerging renewable technologies. Quantitative patterns reveal that Nepal's energy mix continues to be dominated by petroleum products, leaving the country vulnerable to supply shocks, foreign exchange pressures, and external political events. The qualitative review of institutional reports and policy documents further highlights gaps in implementation, inadequacies in regulatory enforcement, and

fragmented coordination across government agencies. Together, these challenges underscore that Nepal's energy transition is not solely a technical matter but a broader governance and development issue that requires integrated planning, long-term investment, and social acceptance.

At the same time, the findings reveal significant opportunities that position Nepal favorably for a renewable energy transformation. The country possesses vast hydropower potential, growing solar prospects, and increasing local capacity in decentralized technologies such as mini-grids and biogas. Policy reforms especially those promoting private-sector investment, regional electricity trade, and renewable energy subsidies indicate that the state was gradually moving toward a more diversified and resilient energy architecture. The qualitative insights derived from the 2015 fuel blockade further illustrated the strategic urgency of reducing import dependency and enhancing domestic energy autonomy. The lessons from this crisis emphasized that energy security must be understood not only in economic terms but also as a critical pillar of national sovereignty and social stability.

Against this backdrop, Nepal's transition from fossil-fuel dependency to renewable-energy self-reliance emerges as both a complex and achievable national objective. The proposed Integrated Renewable Transition Model (IRTM) offers a comprehensive framework to address the interconnected policy, financial, technological, and socio-economic barriers that currently impede progress. In sum, a successful transition would not only strengthen national energy independence but also enhance Nepal's contribution to global climate action and long-term sustainable development.

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