Nepal Energy Outlook 2022

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Foreword

The Nepal Energy Outlook (NEO 22) is published with joint effort of Kathmandu University, Tribhuvan University Institute of Engineering, Niti Foundation and Nepal Energy Foundation. The document is useful for the energy experts, planners, and decision makers to realize the current energy context of Nepal.

The outlook has analyzed the Nepali energy settings in three major contexts on Sectoral Status Assessment: Context and Issues, Strategies (to address the pertaining issues) and the prominent recommendations and the way forward. The document has highlighted the shift of energy use pattern from traditional to modern energy with significant increase in consumption of commercial fuel. This consumption pattern of energy is shifting towards unsustainability. This insecure movement is witnessed due to changing demographic pattern in rural and urban setting. The outlook also highlights the current deficiency and possibilities of future surplus of hydroelectricity. With the given context, the document has presented the energy security threat such as import dependent on commercial fuel with only limited days of storage capacity. Additionally, NEO 22 has spelled the transition of cooking fuel from kerosene to LPG. The document also highlights the issues with trade deficit, foreign exchange reserves and the balance of payments to be marginally surplus. However, the current electricity trade with India is quite inspirational and can be expected to minimize the existing balance of payments. Overall, the NEO 22 has concisely articulated the Nepalese energy context with potential recommendations.

Moreover, the Government of Nepal (GoN) has made significant policy provisions to address the potential threats but that does not mean energy transitions in the years ahead will be free of volatility. The current Nepalese context underlines the value of the analysis carried out for NEO 22 on energy availability and energy security risks in transitions. This analysis presents the potential way forward and recommendations to address the prospective vulnerabilities that should be on focus of policy makers, politicians and the other decision makers as the country and the region foresee this deeply challenging era of energy systems.

The collaborating agencies would like to express gratitude to those that has supported in preparing the outlook. Thank you.

Summary

This Nepal Energy Outlook 2022 is developed with joint effort from Kathmandu University, Institute of Engineering, Nepal Energy Foundation, and Niti Foundation. The document summarizes the current national energy scenario, policy provisions extended by Government of Nepal, issues & gaps, and the potential recommendations to mitigate the gap.

This document is expected to set a strong foundation for energy sectoral reform for the Government of Nepal and identifies the potential areas to undertake further cooperation.

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Abbreviations

AEPC	Alternative Energy Promotion Centre
BoP	Balance of Payment
COP26	UN Climate Change Conference of the Parties
GoN	Government of Nepal
IPPs	Independent Power Producers
IOE	Institute of Engineering
KU	Kathmandu University
NEA	Nepal Electricity Authority
NPC	National Planning Commission
PRoR	Peaking Run of the River
RoR	Run of River
RE	Renewable Energy
ToE	Tons of Oil Equivalent

Table and Figures

Figures

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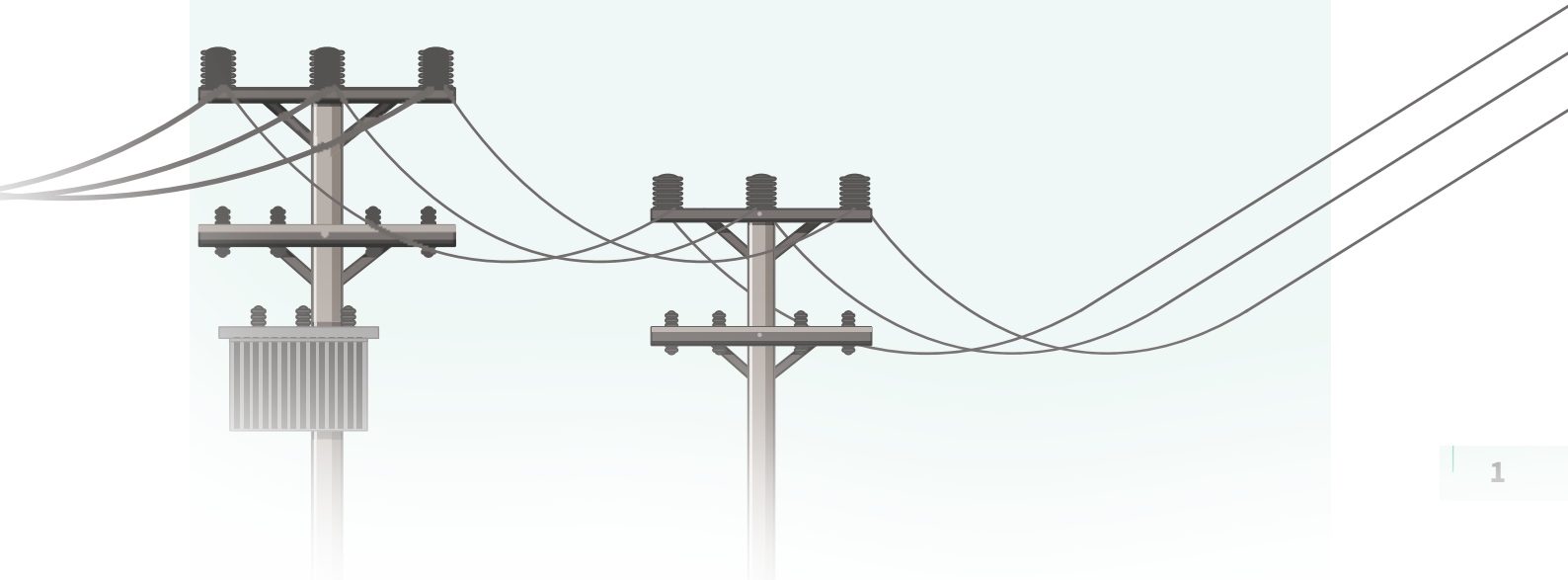
Image: SWNepal

CHAPTER 1

Sectoral Status Assessment: Context and Issues

CONTEXT —



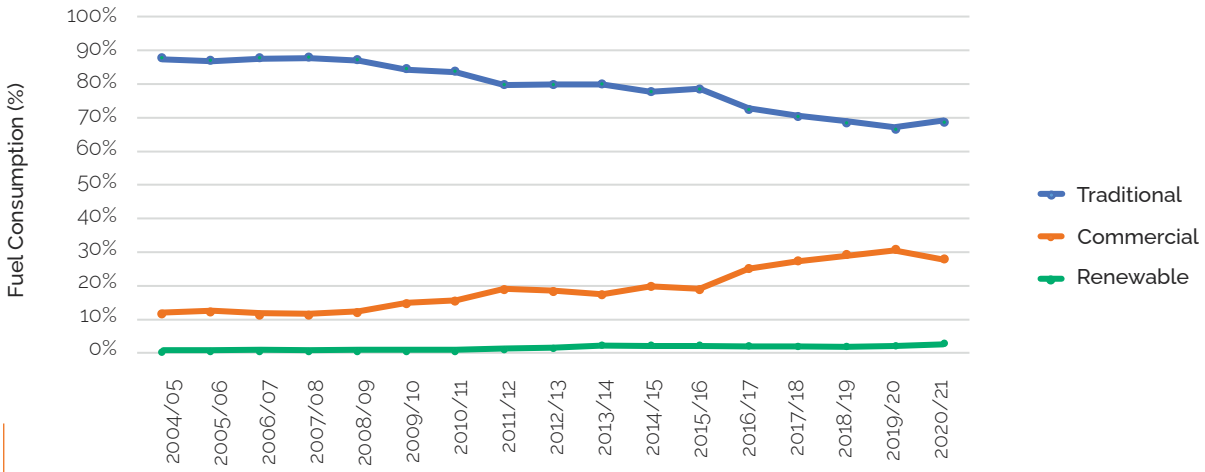
Introduction

Modern energy, electricity, petroleum and renewable, accounts around 20 % of total energy consumption of Nepal and its share is gradually increasing. Modern energy is used in urban areas, industrial production and for commercial use. Specifically, there has been a shift in household energy use from traditional to modern energy due to the rise in living standards and urbanization. Among modern energy sources, consumption of petrol is highest with share of around 65 % of total consumption; the share of electricity stands at around 15 % and remaining 20 % is of other modern energy like coals and others. Also, Nepal has increasing demand of electricity with limited access. The situation is severe in remote areas of Nepal. Varieties of renewable energy sources are available for energy access; limited to lighting and cooking. In line with sustainable development goal no. 7, "Ensure access to affordable, reliable, sustainable and modern energy for all", Nepal has set its own targets and indicators". Additionally, in COP26 Government of Nepal (GoN) has promised to achieve a net-zero emission by 2045 and increase the share of clean energy in the country's energy demand to 15 % and forest cover to 45 % by 2030.

"Shift in household energy use from traditional to modern energy is witnessed and is due to the rise in living standards and urbanization"

Despite the sustainable development goal no. 7 and the targets, Nepal's energy consumption scenario is shifting towards unsustainability, refer to **Figure 1**.

Figure 1. Fuel consumption pattern of Nepal



"The fuel consumption pattern in Nepal is shifting towards unsustainability"

Energy Scenerio

Figure 1. depicts the regular decrease in consumption of traditional fuel with almost stagnant consumption of renewable energy.

The 15 years' data as presented in **Figure 1** depicts that traditional fuel consumption is decreased from nearly 90 % to less than 70 % (in 15 years). But total energy consumption of the same period which was 8,616,000 tons of oil equivalent (ToE) has increased to 14,464,000. This increase in energy consumption is slightly covered from renewable sources and the majority is covered from commercial energy sources. Further, the figure indicates that consumption of commercial fuels has increased from nearly 10 % to 30 % i.e., the regular decrease in consumption of traditional fuel is increasing the consumption of commercial fuel. However, petroleum and coal, the major commercial fuel consumed in Nepal is entirely imported thus the trade deficit is ever increasing. Thus, the fuel consumption pattern in Nepal is shifting towards unsustainability.

> "Figures indicate that consumption of commercial fuels has increased from nearly 10 % to 30 %"

Hydro-electricity Scenerio

Though long disputed, various literature has backed up the most entrusted theoretical and economical hydropower potential to be 83 GW and 42 GW respectively as shown in Table 1.

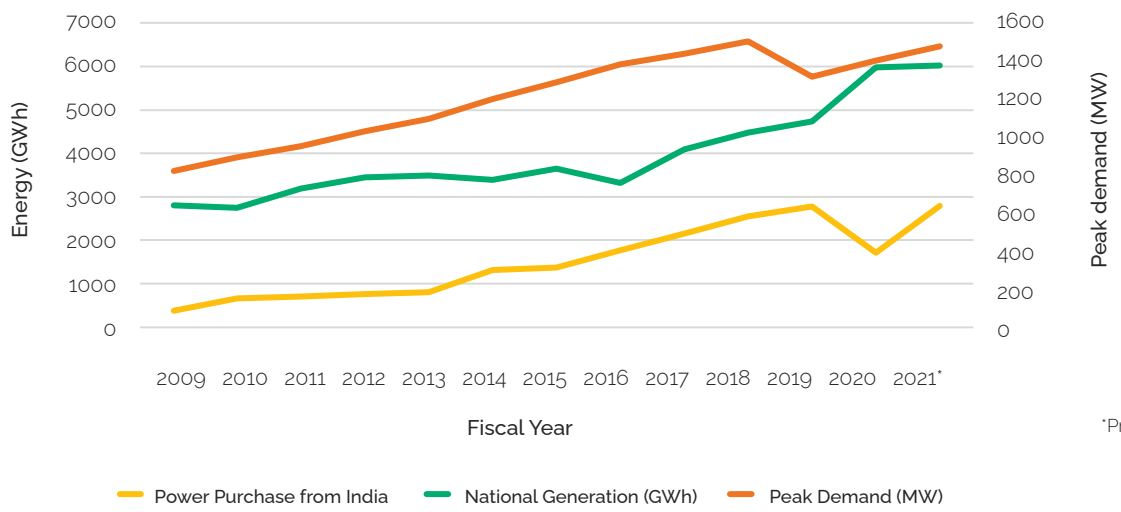
Table 1 Basin wise hydropower potential in Nepal

River basin	Annual flow (billions of m3)	Catchment area (km2)	Theoretical value (GW)	Economically feasible (GW)
Karnali and Mahakali	49	47,300	36.18	25.1
SaptaKoshi	33	28,140	22.35	10.86
Sapta Gandaki	50	31,600	20.65	5.27
Southern Rivers	42	5,410	4.11	0.88
Total	**174**	**112,450**	**83.29**	**42.11**

Tremendous hydro potential is due to more than 6000 perennial rivers and rivulets with an average annual flow of 174 billion m3 as shown in Table 1.

Further, **Figure 2** indicates the trend of electricity generation, demand, and import from India to meet the gap. As shown in **Figure 2**,highest actual electricity demand in 2021 is recorded 1441.35 MW during peak hours. Whereas out of 8878 GWh of total energy available, NEA has generated 2811 GWh from their own hydro and thermal generating units, 3241 GWh is purchased from independent power producers (IPPs) and 2826 GWh is imported from India. Nevertheless, the combined generation and the installed capacity of IPPs and NEA is in the increasing trend. The sudden reduction in peak demand in 2020, is attributable to reduction in electricity demand due to nationwide lockdown placed to curb pandemic situation of COVID-19.

Figure 2. Trend of electricity generation, demand, and import



The above-mentioned demand and insufficient available supply from domestic generation sources are contributing to the energy imbalance in the country and import from India consequently resulting in trade deficit.

Currently, hydro-power plants and other renewable energy plants (grid and or off-grid PV plants) are being installed at a high pace. Country is turning from an energy deficit country to near surplus country. Seasonal energy surplus is predicted to be an issue in future contrary to the baseline status of energy deficiency. There are clear indications that, with the commencement of the 456 MW Upper Tamakoshi Hydropower Project in September 2021, Nepal has surplus electricity generation during the wet season.

At present total installed power plant capacity is 2265 MW, out of which, 74 MW is off-grid, and 2191 MW is connected to grid. Among the grid connected generation facilities, 49.76 MW is solar, 53.4 MW is thermal, 6 MW is biomass, and the rest 2082 MW is hydro. Off-grid isolated generation capacity of 74 MW developed through different sources by Alternative Energy Promotion Centre (AEPC) is also included in the installed capacity.

Further, demand during peak hours is close to 1800 MW and 1000 -1450 MW during off peak hours. Even if we assume availability of generating plants during wet season to be 90 %, substantial surplus during off peak hours is apparent which is expected to grow rapidly in forthcoming years. However, due to majority of domestic generating plants being of ROR nature, supply availability from these plants has high seasonality with generation only one third of installed capacity during winter and dry months. This supply availability during dry months is not enough to fetch the demand and import from India remains imperative to manage the supply. Nepal Electricity Authority (NEA) in this connection has projections that with increased generation capacity, Nepal will be electrical energy self-sufficient even in winter and dry season by 2022-23.

Despite the dramatic increase in per capita electricity consumption, from 63 kilowatt-hours (kWh) per annum in 2000 to 260 kWh per annum in 2021, energy consumption in Nepal remains among the lowest in the world. While, the bulk of electricity demand is for household uses, industrial and domestic demand is expected to grow in the future.

- Nepal will continue to have electrical energy surplus; may lead to wastage of energy. This intensity is likely to be higher in future.
- Efficient utilization of the excess energy is going to be a foremost challenge.
- Recently there has been indication of energy export to India.

This trend in power sector growth is expected to continue along with rapid urbanization and a growing number of energy-intensive industries. The unconstrained demand for electricity is expected to increase from an estimated 10,138 gigawatt-hours (GWh) in 2019–2020 to 31,196 GWh in 2029–2030 (NPC 2018).

Demographic Pattern of the Country

Department of Statistics, Government of Nepal has recently published preliminary highlights of the National Census 2021, Table 2 presents few of the highlights.

Table 2 Highlights of Nepalese demograhpics pattern

S.N.	Particulars	Details
1.	Total population of the country	29,192,480
2.	Total number of houses	5,343,945
3.	Members per house	5.46
4.	Population living abroad	21,69,478
5.	Population living in the country (Inferred from 4)	270,23,002
6.	Population living in urban areas @66.08 %	19,290,391
7.	Population living in rural areas @ 33.92 %	9,902,089
8.	Population in the mountain region	1,778,104
9.	Population in the hilly region	11,748,548
10.	Population in Terai region	15,665,828

The census highlights demonstrate followings as shifts in demographic patterns of the country:

a. Substantial internal migration from rural areas to urban areas and from mountain and hilly regions to Terai region is noticed.

b. Two third of the population lives in urban areas and only one third in rural areas. This statistic challenges the notion that Nepal is primarily agrarian country since Agriculture is not the main activity in urban areas.

c. Nearly 7.5 % population is living abroad and many of them may be permanent settlers there.

Energy Use Patterns

There is apparent correlation between demographic pattern and the energy use pattern. Population living in the urban areas have already accessed or tending to access to modern fuels (LPG, Biogas and Electricity) for their kitchen and are less dependent on biomass fuel like firewood. So, increase in urban population implies increase in demand of modern fuels for kitchen and other household uses. Not a parameter of the census but the general observation of society reveals that increasing urban population means rapidly increasing number of owners of personal vehicles that need modern fuel. Similarly, increased population in urban areas supports industrial activity and stepping up the industrialization. Industrialization further increases the demands for more modern energy. This means that trend of change in demographic pattern is pushing the gradual shift in energy use pattern from traditional sources of energy towards modern fuels. **Figure 1** supports the energy consumption and the shift pattern.

> "Change in demographic pattern is pushing the gradual shift in energy use pattern"

Change in Energy Use Pattern

The change in energy use pattern is increasing pressure for supply of more and more modern fuels for meeting the energy requirements.

Electricity is the only major modern energy that is indigenous to the country, but its use is limited to only 3 % of total energy consumption. A large pie of the required modern energy is imported including electricity (on seasonal basis). This trend of change in the energy use is inviting energy vulnerability in the country for three reasons:

a. Even with the current level of import of modern fuels, cash outflow has surpassed the net income from all exports by the country which is alarming.

b. With the limited foreign currency reserves, Nepal may not afford to purchase, and import required quantity of modern fuels in near future.

c. With the depletion of natural reserves of modern fuels especially the fossil fuels, prices of such fuels are rocketing in the international market and may be unaffordable in future for a country like Nepal.

- Nepal is shifting towards unsustainable energy patterns on generation and consumption
- Government of Nepal must timely get prepared to avert the possible energy vulnerability
- Recently the GoN is initiating to promote the use of electrical energy replacing fossil fuels (petroleum and LPG)

Images: The Kathmandu Post

ISSUES —

Energy Security

Nepal is the second least energy secured country among the 127 evaluated countries. The factors that affect the energy security of Nepal are but not limited to the followings:

a) Import dependent

Nepal's 100 % reliance for the supply of petroleum products has made energy security extremely vulnerable. Additionally, it has a possibility of undue advantage of encroachment on domestic and international affairs of the country.

b) Diversity of electricity generation

In the FY 2020/21, 31.8 % of the total electrical energy available was imported from India, while the rest were generated from hydro-power plants within the country. Energy-mix within electricity generation is conservative. The total installed capacity is 2265 MW, out of which, 2191 MW is grid connected and 74 MW is off grid. Even within hydro generation, appropriate mix of ROR, PROR and seasonal storage projects is missing. This inappropriate mix is contributing to seasonal supply differentials as surplus and deficits.

> "Nepal's storage capacity of petrol, diesel, kerosene, and aviation fuel is enough for 6, 8, 86, and 20 days respectively"

c) Energy storage

Integrated Nepal Power System (INPS) is hydro-dominated where the base and intermediate power demands are covered primarily by run-of-river hydropower and the peak demands by seasonal storage, few pondage run-of-rivers and two diesel power plants. Nepal Oil Corporation (NOC) does not seem to have increased petroleum storage capacity since a decade while the consumption is skyrocketing. According to sales of 1-22 Poush 2078, Nepal's storage capacity of petrol, diesel, kerosene and aviation fuel is enough for 6 days, 8 days, 86 days, and 20 days respectively (refer Table 3) (NOC, 2022). While the refined oil storage capacity of Israel is 270 days, the Republic of Korea is 240 days, United States is 137 days(Asian Development Bank, 2017), India is 12 days (Pathak, 2019). According to an agreement on an International Energy Programme, each IEA country has an obligation to hold emergency oil stocks equivalent to at least 90 days of net oil imports (International Energy Agency, 2018). Though NOC has a long-term plan of making the storage enough for 90 days, no concrete step is evidenced.

> "NOC has a long-term plan of making the storage enough for 90 days; however no concrete step is evidenced"

Table 3 NOC storage capacity (as of Poush 23 2078)

Particulars	Petrol	Diesel	Kerosene	Aviation Fuel
Storage Capacity (in kL)	10,892	44,774	4,328	8,127
Sales (1-22 Poush 2078) (in kL)	43,847	121,259	1,162	9,410
Daily Sales (in kL)	1,906	5,272	51	409
Storage enough for (Days)	6	8	86	20

Source: Nepal Oil Corporation, 2022

Fossil Fuel v/s Economy

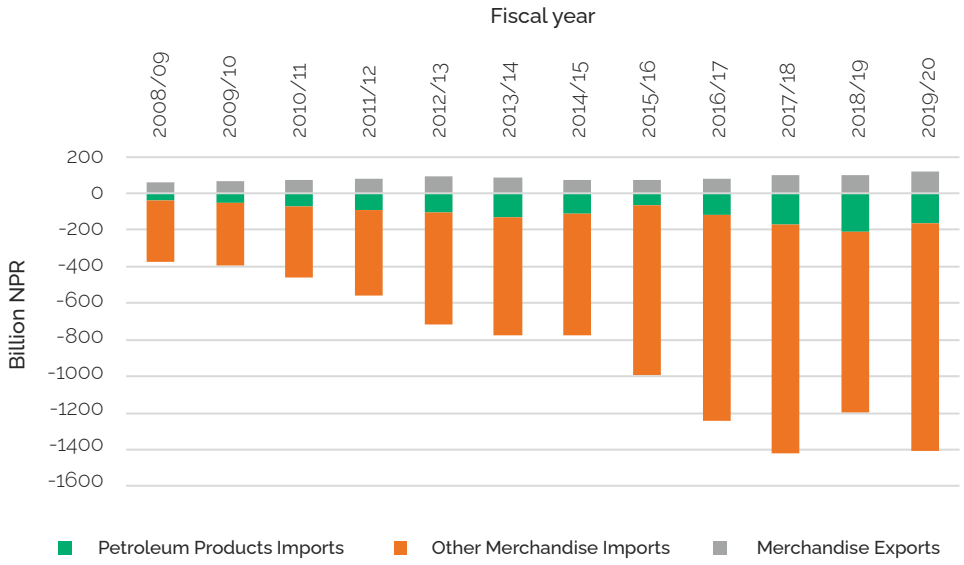
As the demand for petroleum products have increased by 2.47 times within a decade (2009/10: 775 ktoe: NRs 51.6 billion, 2018/19: 2633 ktoe: NRs 213.4 billion), the cost on petroleum import has increased by 4.13 times. Meanwhile, the trade deficit has widened 3.31 times within the period. In the fiscal year 2018/19 the cost of import of petroleum constituted 18 % of the total import and was 2.18 times greater than the total export (MoF, 2021). Despite the economic burden associated with the import of petroleum, displacement of petroleum products cannot be thought of, as it fuels almost 95 % transportation sector of Nepal.

According to annual report of Nepal Rastra Bank (NRB) 2020-21,

- In 2020/21, total merchandise exports reached to Rs. 141.12 billion increasing by 44.4 %, and imports stood at Rs. 1539.84 billion increasing by 28.7 % respectively. As a result, trade deficit recorded Rs. 1398.71 billion which is 32.8 % of GDP.
- In 2020/21, the current account remained at deficit of Rs. 333.67 billion but the balance of payments (BOP) remained at surplus of Rs. 1.23 billion. Total foreign exchange reserves remained at Rs. 1399.03 billion in mid-July 2021. The foreign exchange reserves in USD amounted 11.75 billion.

- In 2020/21, trade deficit recorded Rs. 1398.71 billion which is 32.8 % of GDP.
- Total foreign exchange reserves remained at Rs. 1399.06 billion (USD 11.75 billion) in mid-July 2021
- The overall Balance of Payments (BOP) remained marginally surplus due to high increment in imports, rise in crude oil prices in the international market, and contraction in service income.

Figure 3.Cost of petroleum import compared to total import and export



Connectivity within the country is pre-requisite for the operation of market economy and improve the productivity. Transportation system has comprehensive ramifications that extends beyond transportation's basic purpose of moving goods and people from one point to other. It is essential for the overall development. Transportation sector is considered a stimulant of growth as plays a crucial role in shaping overall development and social well-being.

An efficient transportation network and mode of transportation can

a. improve business's ability to deliver goods and services along,
b. enhance people's access to education,
c. improve employment and services opportunities
d. optimize the transportation costs and curb on environmental pollution

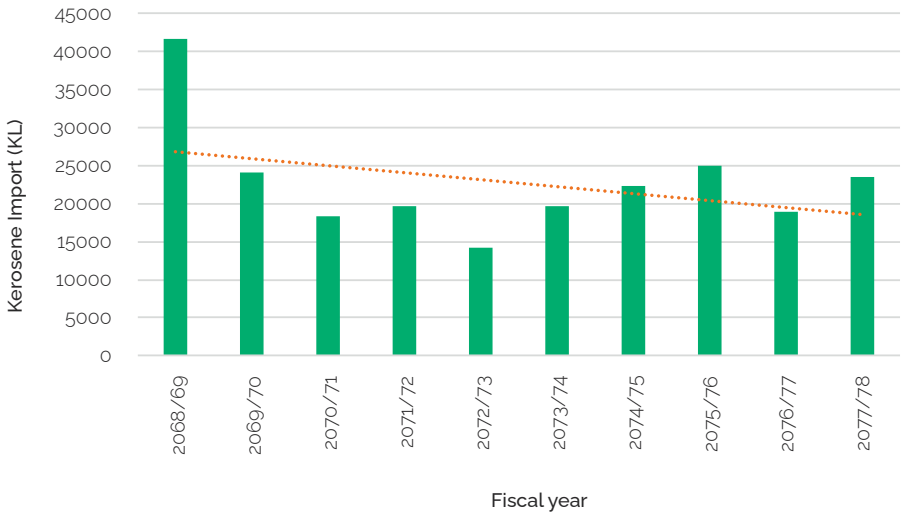
This will lead to increase in economic productivity and development. It is required in every sector of society and economy, be it education or employment, government revenue or health service, business or security, construction, or manufacturing. Usually, improvements in transport increase the scale and scope of economics (mostly for freight) and social interactions (mostly for passengers).

"Transportation system has comprehensive ramifications that extends beyond transportation's basic purpose of moving goods and people from one point to other"

Cooking fuel

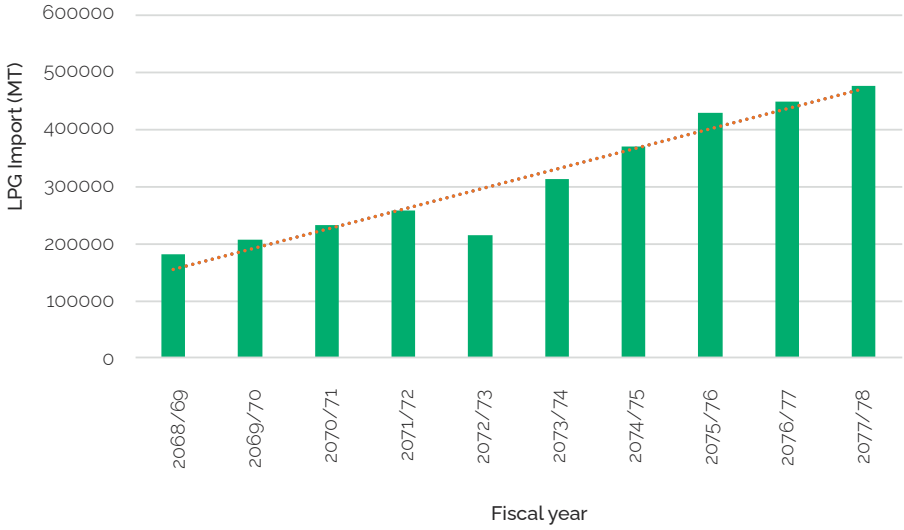
Kerosene and Liquefied petroleum gas (LPG) are the prime source of cooking fuel in urban areas. Both fuels are imported from India. The scenario of those cooking fuels is presented as below.

Figure 4.Kerosene (kL) import scenario of a decade (developed from NOC)



Pattern of import of kerosene is found fluctuating in last 10 years although the overall trendline of kerosene import is in decreasing order indicating a decrease in consumption of kerosene over the period.

Figure 5.LPG (MT) import scenario of a decade (developed from NOC)

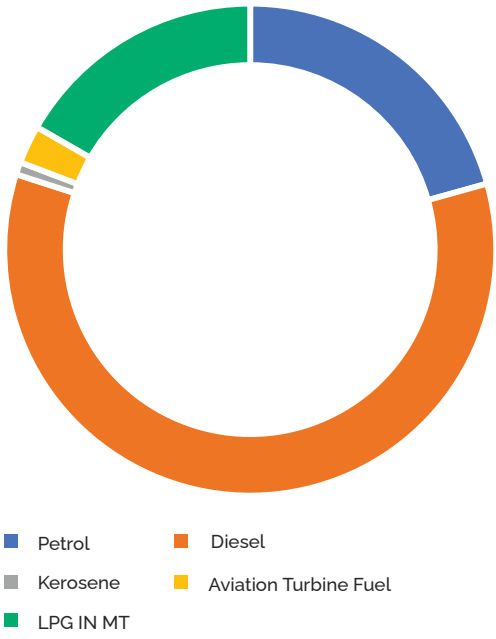


Import of LPG in last 10 years is ever increasing. This implies that, Nepalese households are switching from kerosene to LPG as their source for cooking fuel.

Figure 6 presents the overall import scenario of petroleum products for year 2077/78. The figure shows that, diesel, petrol, and LPG are the major petroleum products imported to Nepal.

The core issue is the country's dependence on imported petroleum products which is increasing over the time, while huge hydropower potential remains unutilized. This signifies the vulnerability of Nepal's energy sector. There is distinct need to address this issue. There is a need to develop a plan for increasing the consumption of electricity in domestic sector (electric cooker and use of other appliances), transport (use of electric vehicles) and other commercial sectors (hotel and other service sector). And there is a need to change the pattern of use of energy for production such as use of electricity energy in industry, agriculture, and food, and service sector.

Figure 6. Import of petroleum products [in KL except for LPG] for year 2077/78



- Well planned transport sector will lead to increase in economic productivity and development
- Improvements in transport increase the scale and scope of economics and social interactions
- Transition of cooking fuel from imported LPG to nationally generated hydroelectricity will help to minimize the trade deficit

In overall, Nepal is facing double trouble in modern energy sector:

a. **Phasing out fossil fuel:** There is a sustained rise in import of fossil fuel from India. The cash outflow is worth Rs. 250 billion on import of fossil fuels from India, contributing to wider trade deficit. Thus, there is an urgent need to substitute imported fossil fuels by traditional or renewable energy.

a. **Surplus electrical energy:** NEA declared that the country has surplus electricity production after the 456 MW Upper Tamakoshi came in operation in September 2021. The government has target to increase the generation of electricity to 3,000 MW by the end of this fiscal year. This surplus energy, especially during wet season need to be utilized in the country itself and balance the demand of commercial fuel.

Image: Nepali Times

CHAPTER 2

Strategies

Policy Interventions

In the given energy context of Nepal, existing Nepalese energy policies and provisions which remain appropriate in promotion and upliftment of overall energy sector in Nepal are summarized with specific policy concentrations in Table 4.

Table 4 Nepalese energy policies and strategies

S.N.	Policy Provisions	Policy Concentration
1.	Nepal Electricity Authority Act, 1984	NEA Act 1984 created scope to manage activities related to electricity generation and distribution in the country.
2.	Water Resources Act, 1992	Water Resources Act, 1992 expedite the scope for the balanced utilization and conservation of water resources in the country.
3.	Hydropower Development Policy 1992 and 2001	Hydropower Development Policy 1992 and 2001 encourages the private sector investment through various fiscal and other incentives for the development of hydropower in the country.
4.	Local Self-Governance Act, 1998	Local Self-Governance Act, 1998 provided local authority for the formulation, implementation, distribution, and maintenance of mini and micro hydropower projects.
5.	NEA Community Electricity Distribution Byelaws, 2003	NEA Community Electricity Distribution Byelaws, 2003 provided opportunity for community electrification through country and community participation.
6.	National Water Plan 2005	National Water Plan 2005 is the only document with a time-bound target for rural electrification.
7.	Rural Energy Policy 2006	Rural Energy Policy 2006 has provisioned for rural energy and electrification activities in rural areas through Renewable Energy Technologies (RETs).
8.	Renewable Energy Subsidy Policy 2000-2016	Renewable Energy Subsidy Policy 2000-2016 has provisioned for a direct financial subsidy to off-grid electrification in rural areas.
9.	RE Subsidy Delivery Mechanism for Special Program 2018	RE Subsidy Delivery Mechanism for Special Program 2018 has provisioned in subsidy for special renewable energy programs.
10.	National Energy Efficiency Strategy 2018	National Energy Efficiency Strategy 2018 has a national target of energy efficiency in Nepal which is to double by the year 2030 A.D.

Additionally, some recent initiatives but not limited to the followings:

- SAARC framework agreement for energy cooperation (electricity).
- Electricity regulatory commission, 2018.
- Agreement between the government of Nepal and the government of the Republic of India on electric power trade, cross-border transmission interconnection, and grid connectivity.
- The federal government has planned to incentivize the use of electricity in various ways, including the announcement of its plan to replace fossil fuel vehicles with electric vehicles by 2030, and the recently announced renewal and road tax waiver for electric vehicles for next five years (Budget FY2021/22).
- Electricity Regulatory Commission Rules, 2018

SDG commitments

- The proposed specific targets for SDG 7 include accessibility of 99 % households' to electricity, reduction to 10 % -from nearly 75 % now - the households who resort to firewood for cooking, limiting the uses of LPG to less than 40 % of the households, generation of at least 15000 MW of electricity, increase per capita electricity to 1500 kwh and decrease the commercial energy use per unit of GDP from 3.20 ToE/mRs in 2015 to 3.14 ToE/mRsin 2030 (Source: Nepal's Sustainable Development Goal, Baseline Report, June 2017).

Fiscal year (FY 2079/80) budget provisions – Energy perspective

- Hydroelectricity generation, transmission line expansion and community electrification
- Concentration on green hydrogen and green ammonia
- Electricity export
- Diversification of hydropower plants based on reservoir, peak run-of-rivers, etc.
- Promotion of electric vehicles and the charging stations
- Promotion of LPG with slogan:

  "एल.पि. ग्यास छोडौ, बिजुली जोडौ"
- Reduce the consumption of petroleum products

- GoN of Nepal has quality of strategies and policies
- Budget is envisioned to be energy friendly
- However, GoN requires a detailed and workable implementation interventions to ensure proper balance between generation and consumption of modern energy within country and substitute the imported fuels.

Plan for phasing out the imported fossil fuels in residential, transport, industries and other similar sectors by electricity and other modern energies produced within country.

Image: Freepik

CHAPTER 3

Recommendations and Way Forward

Recommendations

Government of Nepal should refine strategic plans considering the trends in energy consumption pattern and quantify the requirements accordingly. The fuel whose supply shocks can potentially trigger humanitarian crisis and collapse economy need to be managed considering the social, economic, and national security perspective. Specifically, followings are the most prominent recommendations:

a. Develop and timely update the contextual energy resource assessment.

b. Plan for round the clock (daily and seasonal) adequate supply of electricity to domestic consumers as well as export of perceived seasonal surplus during rainy season.

c. Import of deficit electricity during dry season until adequate all-season electricity from in-country generation becomes available.

d. Better energy planning to address the demand-supply gap.

e. Develop a scenario plan to address demand and supply management of electricity energy, for replacing fossil fuel by using energy produced by renewable energy.

f. Plan for producing commercially viable other forms of modern energies apart from electricity.

g. Plan for phasing out the imported fossil fuels in residential, transport, industries and other similar sectors by electricity and other modern energies produced within country.

h. Identification of intervention to be applied for use of domestically produced electricity and other modern energies to the extent possible.

i. Develop contextual electricity power trade and cross-border transmission interconnection and grid connectivity and policy lobby to manage the surplus and the necessary import.

j. Promote research and development (R&D) on energy for converting the traditional fuels to modern or developing modern fuels.

This is expected to encompass:

a. Baseline status of energy demand and practical forecasts of future demands for all types of uses and economy of their supplies.

b. Strategic targets for supply of these demands through in-country produced modern energy and its economic impacts.

c. Strategic targets for penetration of domestically produced modern energies in rural areas to replace traditional biomass fuels before the imported modern fuels penetrate these areas and its economic impacts.

d. Clear outlook on the purpose of electricity generation expansion within the country.

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