Energy Synopsis Report 2023

FY 2078/79

2023

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Acronyms & Abbreviations

AEPC	Alternative Energy Promotion Centre
ATF	Aviation Turbine Fuel
CBS	Central Bureau of Statistics
DoC	Department of Customs
DoED	Department of Electricity Development
DoFSC	Department of Forest and Soil Conservation
DRE	Department of Renewable Energy
FNCCI	Federation of Nepalese Chamber of Commerce and Industry
FY	Fiscal Year
GJ	GigaJoule
GWh	GigaWatt hour
GDP	Gross Domestic Product
GVA	Gross Value Added
IPP	Independent Power Producers
IPPAN	Independent Power Producers' Association Nepal
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
kL	Kiloliter
kW	Kilowatt
kWh	Kilowatt Hour
kWp	Kilowatt-peak
LNG	Liquefied Natural Gas
MW	Mega Watt
MTOE	Million Tons of Oil Equivalent
MoEWRI	Ministry for Electricity, Water Resources, and Irrigation

MoALD	Ministry of Agriculture and Livestock Development
MoF	Ministry of Finance
MoFE	Ministry of Forest and Environment
MoPE	Ministry of Population and Environment
NPC	National Planning Commission
NEA	Nepal Electricity Authority
NOC	Nepal Oil Corporation
OL	Other Lands
OWL	Other Wooded Land
PJ	Peta Joule
PV	Photovoltaic
PPA	Power Purchase Agreement
SWHS	Solar Water Heating Systems
SAARC	South Asian Association for Regional Cooperation
STEPS	Stated Policies Scenario
TOE	Tons of Oil Equivalent
WECS	Water and Energy Commission Secretariat

Executive Summary

Energy plays a crucial role in the global economy and has a significant impact on a country's economic standing. In Nepal, energy resources are classified into three categories: traditional, commercial, and alternative sources. Traditional sources, including firewood and bio-energy, serve as the primary energy sources for households. However, the country's economy is largely driven by commercial sources such as coal, electricity, and petroleum products. Electricity usage has been steadily increasing over the years. There has been significant progress in expanding the electricity infrastructure and improving access to power. However, Nepal still faces challenges in meeting the growing demand for electricity. Additionally, alternative sources such as solar, wind, and hydropower are gaining increasing importance.

The report focuses on the energy supply and consumption situation for various fuel sources in Nepal. Energy sources are categorized as traditional, commercial and modern renewable resources. Among them, the resources can be classified as renewables (such as fuelwood, agri-residue and other biomass, animal waste, hydro, solar, and wind power generation) and non-renewables (coal and petroleum products). The information was gathered from various institutions, including the Ministry of Forest and Environment, Ministry of Agriculture and Livestock Development, Department of Forest and Soil Conservation, Department of Electricity Development, Department of Customs, Alternative Energy Promotion Centre, Nepal Oil Corporation, Nepal Electricity Authority, etc.

Traditional Resources

According to the national-level forest resource inventory study conducted by FRA Nepal (2010-2014) under DFRS (2015), the forest covers 5.96 million ha, which is equivalent to 40.36% of Nepal’s total area. Furthermore, Other Wooded Land (OWL) covers 0.65 million ha (4.38%), and Other Land covers 8.16 million ha (55.26%). Within OWL, shrub-covered areas accounted for 0.12 million ha (0.79%), and areas with tree crown cover ranging from 5% to 10% cover 3.59% of the total area (0.53 million ha). In total, the combination of forest and OWL cover 6.61 million ha, which represents 44.74% of the country’s total area. Community forests cover nearly half of Nepal’s total forest area (MOFE, 2020) and represent the second largest management regime after government-managed forests. Among the provinces, Bagmati has the largest coverage of community forests, encompassing 593,495 ha (18.66%), followed closely by Lumbini with 576,570 ha, and Koshi with 551,791 ha. The province with the lowest coverage of community forests is Madhesh, accounting for 125,947 ha (3.96%). According to DFRS/FRISP (1999), the existing forest resources can sustainably provide about 12.16 million tons of fuelwood including 11.94 million tonnes per year from forest areas and 0.22 million tons per year from other wooded lands.

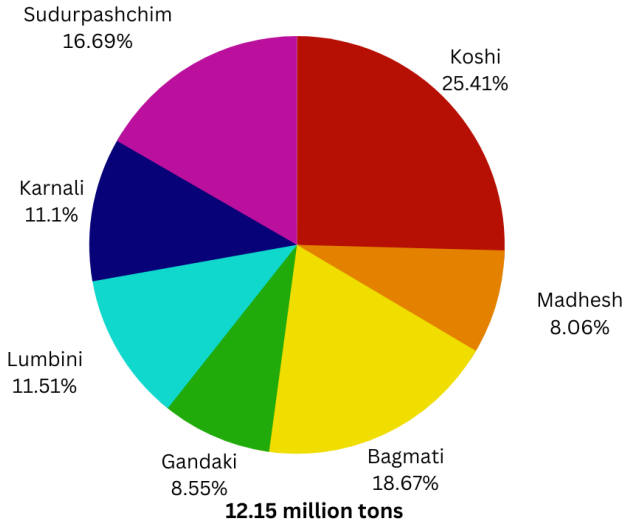


Figure 1: Proportion of Annual Sustainable Wood Yield

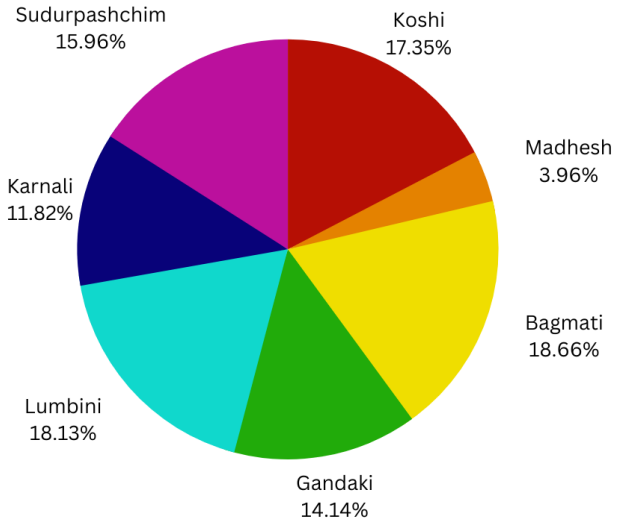


Figure 2: Community Forest Coverage in Different Provinces

Agri-residue is another traditional source of energy for people in Nepal as more than 60% of the population is involved in agriculture contributing 40% to GDP. The total potential supply of agri-residue in 2008/09 was 19 million tons, providing an estimated energy of 243 million GJ. In 2019, the total potential supply of residue was estimated at 23 million tons, generating an estimated energy of 406 million GJ. Similarly, in 2020, the total potential supply of residue was estimated to be 24 million tons, contributing to an estimated energy of 416 million GJ, and in 2021 was estimated to be 26 million tons resulting in an estimated energy of 442 million GJ.

Commercial Energy Sources

Electricity

NEA (Nepal Electricity Authority) is solely responsible for operating and distributing electricity in Nepal. By 2022, NEA has achieved a total installed capacity of 626.7 MW, resulting in the generation of 3,242.5 GWh of energy. There has been a significant increase of 14.61% in electricity generation compared to the previous fiscal year. The annual national peak demand for

electricity has reached 1,748 MW. During FY 2078/79, Nepal also exported 493.6 GWh of energy. The Hetauda diesel power plant is currently the only operational thermal power plant, with an installed capacity of 14.41 MW and generating 32.51 MWh of energy. There are currently eight active projects under development, contributing a total capacity of 943.1 MW. Furthermore, there are eleven planned and proposed projects that have the potential to further enhance Nepal's power generation capacity, with a combined capacity of 3,450 MW.

In addition to NEA, Independent Power Producers (IPP) also has a significant role in electricity generation in Nepal. As of 30 Poush 2079, IPP has successfully installed projects with a total capacity of 1,709 MW. Furthermore, there are 134 ongoing projects that have achieved financial closure, with a combined capacity of 3,253.3 MW. Additionally, there are 89 projects under development, currently without financial closure, but with a capacity of 1,857.4 MW. The electrification status in Nepal has made notable progress in recent years, with national electricity access increasing from 93% in 2020/21 to 94% in 2021/22. The government's objective is to achieve 100% electricity access throughout the country by 2024.

Petroleum Products

The Nepal Oil Corporation (NOC) has the exclusive authority to import and distribute petroleum products in Nepal. Currently, the NOC operates storage facilities with a capacity of 68,427 kiloliters for all essential petroleum products, except for LPG, which is bottled and distributed by private companies. In 2021, there was an increase in sales for petrol (10.87%), diesel (12.6%), kerosene (21.61%), and LPG (6.19%). However, the sales of ATF decreased significantly by 65.32%. In 2022, the sales of petrol saw a nearly fourfold increase of 40.43%. Similarly, the sales values of diesel, LPG, and ATF increased by 32.24%, 11.5%, and 74.55%, respectively. However, the sales of kerosene declined by 4.99%.

Coal

The production of coal in the nation was 7250.1 tons in FY 2076/77. This value increased to 11303.9 tons in FY 2077/78 and dropped in FY 2078/79 to 6927.04 tons. A total of 9 licenses were issued in each fiscal year 2076/77 to 2078/79 for coal production. The leading consumer of coal in Nepal is the brick-manufacturing industry.

Modern Renewable Sources

Micro/pico hydro plants offer practical and cost-effective solutions for providing electricity in rural and remote areas of Nepal where extending the national grid is challenging. The installation of these small hydro systems is showing a positive trend, indicating an increasing utilization of these technologies. In 2020, the installation rate reached 34,870 kW, an 8.09% increase from the previous year's value of 32,159 kW. This value continued to rise by 3.15% in 2021 and by 4.74% in 2022, reaching 37,734 kW.

Biogas is also an ideal alternative energy source in Nepal due to the abundance of biomass from agriculture. A recent study by Adhikari and Adhikari (2021) highlighted that approximately 1.9 million households (42% of the total) have the potential for household biogas system

installations. As of 2022, there have been a cumulative 439,547 installations, including 355 large biogas installations.

According to the Solar and Wind Energy Resource Assessment (SWERA) conducted by the Alternative Energy Promotion Centre (AEPC), Nepal has an estimated commercial potential of around 2,100 MW for on-grid solar PV systems. As of 2022, a total of 974,000 residential solar PV systems have been installed, mainly concentrated in remote districts of Western Nepal where access to grid electricity is limited. The installation of Solar Home Systems (SHS) faced challenges after the 2015 earthquake and subsequent trade issues. The discontinuation of power cuts in 2017 temporarily decreased the demand for SHS but rebounded the following year. The impact of COVID-19 and related restrictions had a relatively minor influence on SHS installations.

Despite having a significant potential for wind energy, there has been limited development in the wind energy sector in Nepal. With 10% of Nepal's area having a wind power density of 300 W/m2, the country has the potential to produce 3,000 MW of electricity from wind. The total capacity of solar-wind hybrid mini-grid systems reached 1,500 kW as of 2022. In 2018, the total installed capacity of wind turbines was 113.6 kW, including turbines provided by AEPC, Practical Action, and the private sector. The Asian Development Bank supported the installation of two 5 kW wind turbines with a 2 kW solar hybrid system in Nawalparasi, Dhaubadi VDC.

Consumption Situation

In FY 2078/79 (2022 AD), Nepal's total energy consumption reached 640 PJ, showing a slight increase compared to the previous year. Traditional energy sources still dominate the energy mix, comprising 64.17% of total consumption. Fuelwood remains the primary fuel type consumed, accounting for 58.53% of total fuel consumption. The consumption of commercial fuels has decreased to 28.35% while electricity consumption has increased to 4.96%. The usage of renewable energy contributes only 2.52%.

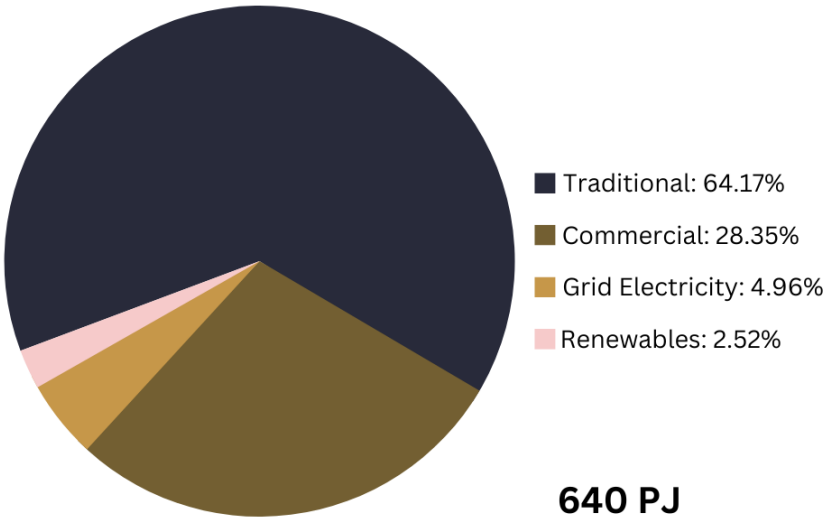


Figure 3: Overall Energy Consumption in Nepal in 2022

Energy Intensity

The energy intensity serves as an important indicator of energy consumption rates and energy efficiency. Nepal's energy intensity is relatively high compared to the global average and India's average, reflecting higher energy consumption and lower energy efficiency. However, there have been positive developments in energy intensity, particularly in the residential sector, where improvements in energy access and the adoption of clean energy technologies have led to a decrease in intensity from 14 GJ per capita to 13.3 GJ per capita in 2019.

Table 1: Final Energy Intensities

Parameter	Unit	2075/76	2076/77	2077/78	2078/79
Final Energy Intensity	GJ per 1000 NRs Value Addition	0.28	0.27	0.29	0.28
	GJ per capita	20.62	19.82	21.92	21.94
Agriculture	GJ per 1000 NRs	0.01	0.02	0.02	0.02
Commercial	GJ per 1000 NRs	0.03	0.04	0.04	0.04
Industry	GJ per 1000 NRs	0.76	0.78	0.97	0.91
Residential	GJ per capita	13.27	13.51	13.86	13.30
Electricity	kWh per 1000 NRs	3.08	3.2	3.52	3.63
	kWh per capita	228	232	265	305
Residential Electricity	kWh per HH	218	251	296	649

In terms of energy shares, traditional biomass energy remains a significant portion of Nepal's energy mix (64.17%). However, its unsustainable use and inefficient technologies contribute to pollution, necessitating a reduction in its share. On a positive note, the proportion of renewable energy, including hydropower, is on the rise (7.48%). However, the reliance on imported energy sources, including petroleum, coal, and electricity, remains high (28.35%), calling for improved energy management practices.

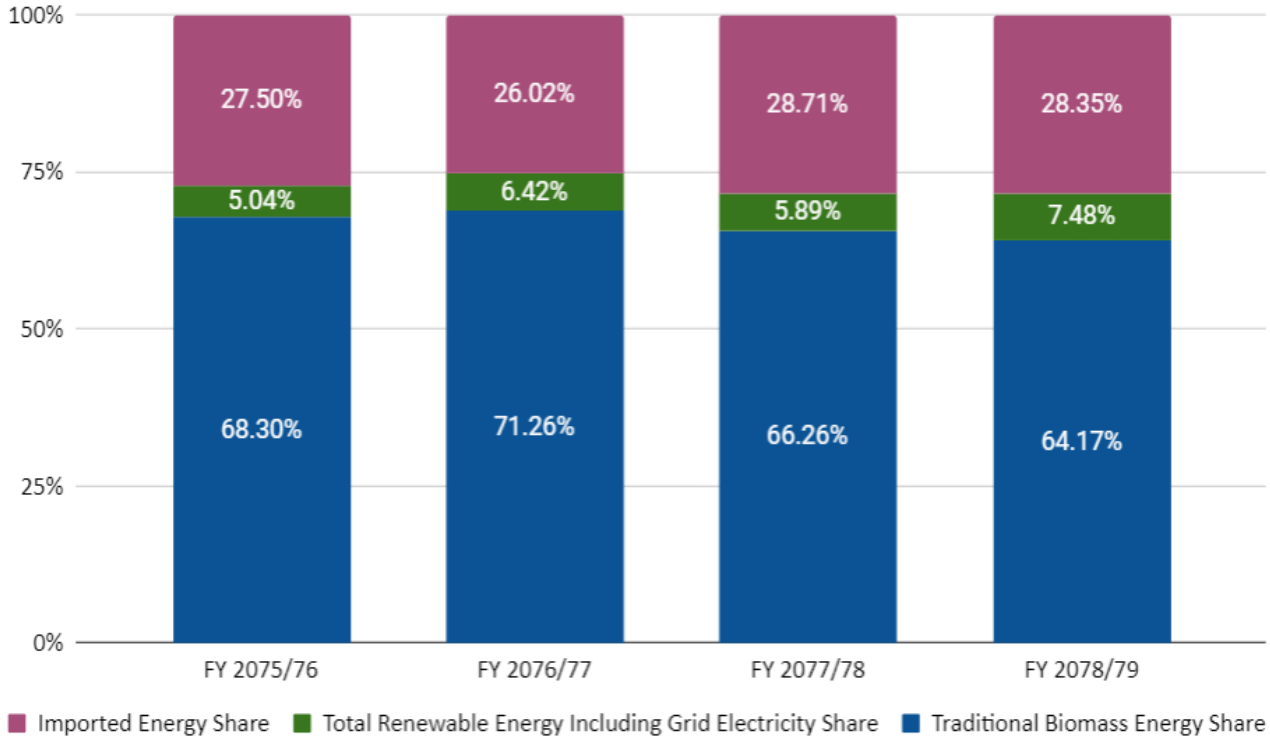


Figure 4: Total Energy Shares in National Consumption

The national consumption is dominated by the residential sector accounting for 60.59% of the total consumption. Despite over 60% of the population engaging in agricultural activities, the traditional and less energy-intensive practices have led to the agriculture sector only accounting for 0.94% of the total consumption.

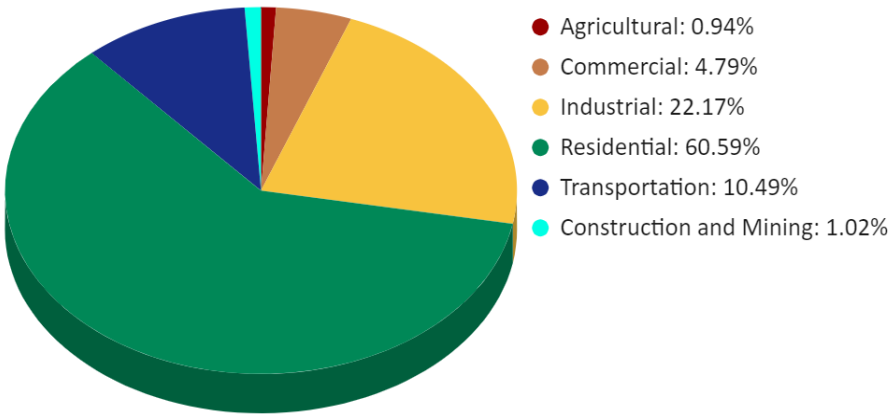


Figure 5: Sectoral Energy Consumption of Nepal in 2022

In 2022, significant progress has been made in Nepal towards achieving Sustainable Development Goal 7. Currently, 94% of the population has access to electricity, with a steady increase in electrification expected to reach 100% by 2024. The provinces have varying levels of electricity access, with the Madhesh region having nearly universal access at 99.95%. Furthermore, 6.9% of the population has access to renewable energy sources. The share of renewable energy in the total final energy consumption mix is 2.52%, equivalent to 16.11 PJ. Additionally, 92.2% of households rely on electricity as their primary source of lighting. These

advancements demonstrate Nepal's commitment to expanding electricity access and transitioning to sustainable energy sources. Similarly, some progress has been made towards achieving the targets of NDC, and the 15th five-year plan as well:

- 7.48% out of targeted 15% of energy is supplied from clean energy sources.
- 59 km out of the targeted 200 km electric rail network to support mass transportation of goods.
- 12,015 new domestic biogas plants installed out of targeted 200,000.
- 80 large biogas plants installed out of the targeted 500.

Chapter 1: Introduction

Energy consumption is an important measure of a country's development which reflects the country's economic activity and progress. Accurate data on energy usage is essential for setting provincial and national targets, as well as for formulating policies and sustainable energy planning. Therefore, a well-organized energy database serves as a foundation for effective decision-making and long-term energy strategies. For this purpose, the Water and Energy Commission Secretariat (WECS) plays a vital role by collecting and providing energy data, facilitating target setting, supporting policy formulation, enabling sustainable energy planning, and assisting in the development of long-term energy strategies.

WECS conducted Sectorial Energy Supply/Demand Profiles at the regional level and Residential Energy Supply/Demand Profiles at the district level from 1990-1995, with updates in 1995/96. A survey on Industrial Sector Energy Consumption was completed in 1998/99, covering traditional and modern sectors. Surveys on commercial, transport, and agricultural energy consumption were conducted in 1998/99, 1999/2000, and 2000/01, respectively. WECS published the Energy Synopsis Report in 2010, providing baseline information on energy resources and their distribution in different regions of the country. Similarly, in 2011/12, WECS conducted a National Survey of Energy Consumption and Supply Situation in Nepal, analyzing energy demand and supply across economic sectors and regions. The National Energy Strategy and Vision 2050 was prepared in 2013, forecasting future energy demand and conducting scenario analysis for energy planning. The Energy Synopsis Report published by WECS in 2020 included the energy consumption and supply situation in Province 1, i.e. Koshi, and Madhesh Province.

1.1 Country Profile

Nepal is a small landlocked country having an area of 147,516 sq. km. It is a south-Asian nation at 26° 22" North to 30° 27" North latitude and 80° 4" East to 80° 12" East longitude. The country stretches 885 km from east to west and about 193 km from north to south (at its widest point). It exists between two macrocosmic nations–China and India, with China at the north and India covering the other three directions. The country is also divided into three main physiographic regions–Terai, Hilly, and Himalayan region–from east to west.

The lowland Terai region in the south covers approximately 23% of the total area. The Hilly region in the north covers approximately 42%, and the Himalayan region in the far north covers approximately 35% of the total area. These regions have an altitude ranging from about 60 m to 8848 m above sea level. The Hilly region includes valleys, flat lands, hills, and mountains with elevations ranging from 600 to 3,000 m. The Himalayan Region comprises 200 peaks having elevations greater than 6,000 m and 13 peaks with elevations of over 8,000 m. This includes the world's highest mountain Sagarmatha (Mount Everest) which is 8848 m high.

Nepal has three major river systems–Koshi, Narayani, and Karnali (spanning from the east to the west). These rivers are the major tributaries of the Ganges in northern India. Nepal lies within the subtropical climate zone and its climate varies with the seasons, topography, and altitude. The climate ranges from tropical in the Terai region to alpine and tundra in the northern parts of the country and experiences a variation in temperature throughout the year. In Terai, the temperature

ranges from 5℃ to 47℃ and the temperature in the Hilly region ranges from 0℃ to 28℃. The Himalayan region experiences temperatures ranging from 16℃ to below 0℃. The precipitation level varies from east to west with the eastern part receiving more rainfall than the west. However, certain areas in the central parts of the country receive a consistently high amount of precipitation. About 80% of the annual rainfall occurs during the monsoon season.

Despite its small land area, Nepal boasts rich biodiversity and ranks at 49th position on the biodiversity index. The country is home to diverse species of flora and fauna. However, the country's natural resource base is often considered insufficient to meet its economic needs. One area of concern is the scarcity of commercial fuel resources. While some methane gas reserves have been discovered, significant petroleum reserves have yet to be found. Renewable resources, particularly arable land, hold great economic importance, but the potential of hydropower remains largely untapped. Among the available metallic minerals, copper, gold, lead, and zinc are the most abundant, but only lead and zinc have proven to be commercially viable. On the other hand, nonmetallic minerals such as marble, talc, and limestone have shown commercial viability, and there are also deposits of dolomite and magnesite.

Nepal has been administratively divided into 7 provinces. These 7 provinces are Koshi, Madhesh Pradesh, Bagmati, Gandaki, Lumbini, Karnali, and Sudurpashchim Province. The provinces are further divided into 77 districts which incorporate 753 local units. The 753 local units further incorporate 6 metropolitan municipalities, 11 sub-metropolitan municipalities, and 276 municipalities.

1.2 Demography

The study of demography in the energy profiling of a nation helps to analyze its demands, generation, and consumption. It acts as an indicator of the development status of the country.

The total population of Nepal is 29,164,578 (Census Report 2021). The population density is 198 persons per sq. km. The annual population growth rate is 0.92%. As per the report, there are 6,666,937 households. The average household size is 4.37 persons per household. 66.2% of the nation’s population lives in the urban area, and 33.8% live in the rural area.

Most of the population lives in the Terai region with 71.8% of its population in the urban area and 28.2% in the rural area. In the Hilly region, 63.3% and 36.7% of the population live in the urban area and the rural area respectively. In the Mountain region, 35.6% of its population is in the urban area and 64.4% in rural areas. Kathmandu, the country’s capital, is the most densely populated district, housing 7% of the total population. Madhesh Province is the most densely populated province with 633 persons per sq. km.

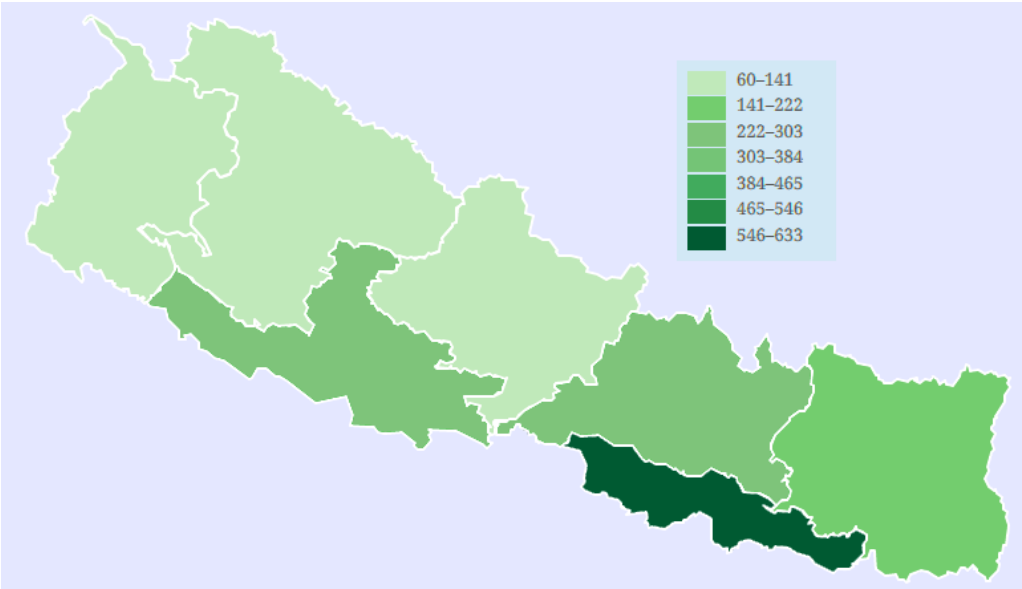


Figure 1-1: Population Density by Province

1.3 Economy and Finance

The global economy contracted by 3.3% in 2020 because of the worldwide spread of the COVID-19 pandemic. Three years later the mutation of the virus is still affecting the world. However, the availability of vaccines has facilitated the movement of socioeconomic lives back into normalcy. Additionally, the ongoing Russian-Ukraine war has also impacted the global economy.

As per the Economic Survey Report 2022, the national economy was expected to expand by 5.84% in 2021/22 because of a gradual recovery from the pandemic. This has encouraged an expansion of the energy sector. Nepal's economic growth at basic prices was estimated at 5.49%, and in 2019/20 the economic growth was negative by 2.37% compared to 4.25% in the previous FY. The total GDP in 2021/22 is 4851.62 billion (consumer price) and the per capita GDP is estimated to reach Rs. 164,598.

In 2021/22, the total value added by the agriculture sector was estimated to increase by 2.30% and that of the non-agriculture sector was 6.88%. The total value added by the agricultural sector is expected to grow despite the decline in the production of paddy by 8.7%. The total value added by the non-agricultural sector is also expected to expand in the upcoming fiscal year because of increases in the industrial sectors such as electricity, construction and mining.

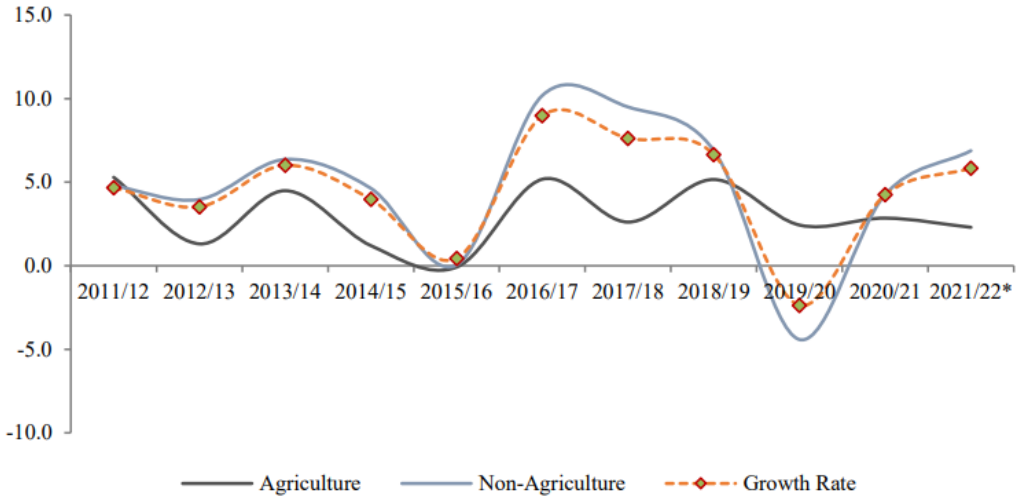


Figure 1-2: Gross Domestic Production Growth Rate (in %) *(*estimated)*

The estimated consumption shares for the government sector, private sector, and non-profit organizations in 2021/22 were 8.2%, 80.8%, and 1.7% respectively. The ratios only varied slightly from 2020/21 where the shares were 8.4%, 82.2%, and 1.7% respectively.

In 2019/20 the total investment had shrunk by 25.9%. This value has increased in the last two years following the recovery from the effects of the pandemic. In 2020/21, the investment has increased by 29.3% and is estimated to increase by 18.1% in 2021/22 reaching Rs.1807.29 billion. Despite the increments, the total investment is expected to grow marginally because of a liquidity crunch in the bank and financial sectors and low capital expenditures in the current fiscal year. Additionally, in 2021/22, the total fixed capital formation is estimated to increase by 11.6%. The share of the private sector, public sector, and state-owned public enterprises in total fixed capital formation is expected to be 74.7%, 19.3%, and 6.0% respectively.

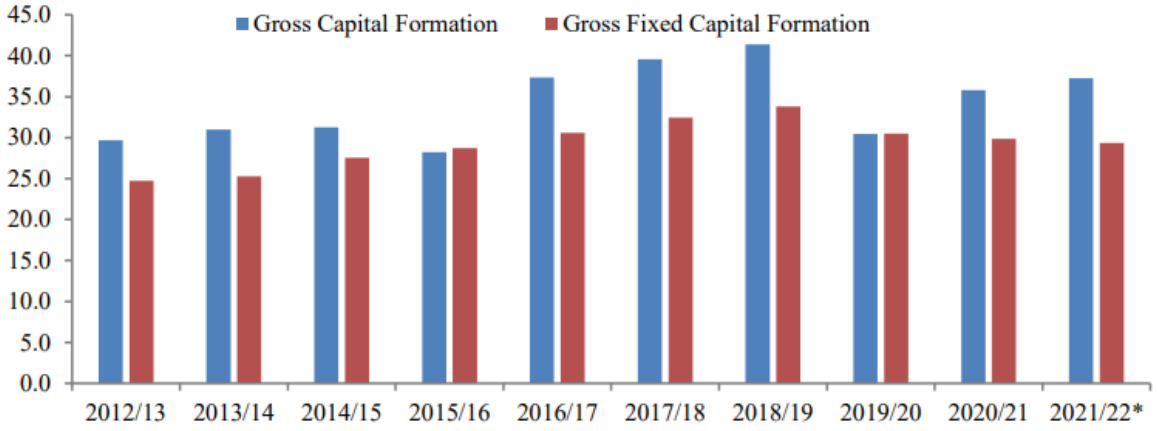


Figure 1-3: Gross Capital Formation Trend (As a Percent of GDP) *(*estimated)*

In 2020/21, the per capita gross national income (at current prices) was US$ 1,246. In 2021/22, such income is expected to increase by 10.8% reaching US$ 1,381. The per capita national disposable income has reached US$ 1,683 in the current fiscal year which is greater than the income of US$ 1,557 in 2020/21.

In 2020/21 the total value addition of electricity, gas, water, and air condition supply services increased by 2.57%. In 2021/22, it is estimated to increase by 36.67%. The completion and operation of the Upper Tamakoshi Hydropower Project aided in increasing the growth rate of this sector. The contribution of this sector in 2021/22 to the GDP is estimated to be 1.37% which is greater than the previous FY with 1.14%.

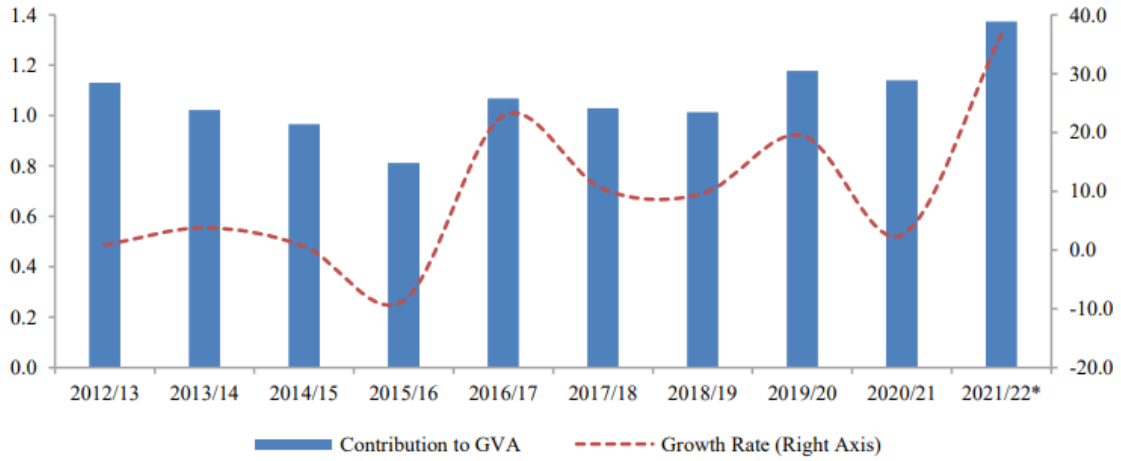


Figure 1-4: Growth Rate and Contribution of Electricity, Gas, and Air-condition Supply Sector to Gross Value Added (In Percent)

1.4 Past Energy Status

Based on the annual NEA report 2021-22, the following are the key progress made by NEA in the past year:

1. **Increased Power Generation:** NEA's own generation capacity reached a record high, including the successful commercial operation of the Upper Tamakoshi Hydropower Project. This achievement contributed to a reduction in electricity imports from India.

2. **Expansion of Electricity Trading:** NEA has enhanced electricity trading with India, exporting up to 364 MW of power from six hydropower projects to India in the Day Ahead Market of Indian Energy Exchange. This helps in the management of seasonal surplus energy and reduces the trade deficit with India.

3. **Improved Access to Electricity:** Electrification has been extended to an additional 10 districts. In total 94% of the population of Nepal has access to electricity. The number of NEA consumers reached 4.77 million.

4. **Infrastructure Development:** NEA completed the construction of crucial transmission lines such as 220 kV Marshyangdi-Kathmandu, 132 kV Soul Corridor, and 220 kV Koshi Corridor, along with various substation projects. These projects have enhanced grid connectivity and facilitated the transmission of increasing electricity generation.

5. **Financial Performance:** NEA achieved a record high net profit of NRs 16,165 million in the fiscal year under review. Factors contributing to this profit include increased sales, reduced system loss, increased generation capacity, and effective cost control.

6. **Credit Rating and Investment Capability:** NEA has received an AA++ rating from the International Credit Rating Association (ICRA), Nepal, establishing itself as a highly secure organization with sound financial capacity. This rating has opened avenues for issuing an initial public offering (IPO) at a premium value, enhancing NEA's investment capability for future infrastructure projects.

7. **Embracing Technology:** NEA has implemented various information and communication technology (ICT) tools such as Enterprise Resource Planning (ERP), Revenue Management System (RMS), Geographical Information System (GIS) Mapping, Smart Metering, and Substation Automation. These digital initiatives aim to transform NEA into a more efficient and technologically advanced organization.

1.5 Energy Policies and Planning

1.5.1 Current National-Level Plans and Policies

Nepal has designed energy policies to optimize the use of hydropower to meet the nation's electricity needs and promote renewable energy. The policy includes subsidy mechanisms to ensure access to energy and energy-efficient technologies. The National Rural Energy Programme (NREP) serves as a framework for implementing energy policies in local communities throughout Nepal. The policy aims to diversify the country's energy consumption pattern by increasing renewable energy use in industrial and commercial sectors, with a target of a 20% expansion in the energy mix.

1.5.1.1 Ministry of Electricity, Water Resources, and Irrigation (MoEWRI)–White Paper 2075

The Ministry for Electricity, Water Resources, and Irrigation (MOEWRI) released a white paper 2075 in July 2018. The objectives set by the paper are to elevate hydropower and renewable energy generation in ten years, plan the movement of the country on the path of sustainable development, and improve per capita electricity consumption from the current 700 kWh to 1500 kWh in the upcoming decade. Efficient electricity reach in all sectors is required to achieve the aforementioned targets. MOEWRI planned to generate 3000 MW of hydropower by 2021, upgrade the generation capacity by 5000 MW in the coming five years, and by 15,000 MW within 10 years. It also predicts an increase in the domestic demand to 10,000 MW in the coming decade. Additionally, the Government plans to generate 200 MW of solar power from Madhesh Province.

1.5.1.2 Ministry of Population and Environment (MoPE)

The Ministry of Population and Environment (MOPE) has formulated a comprehensive Low Carbon Economic Development Strategy (LCEDS) with the aim of propelling Nepal towards becoming a developing nation through low-carbon green economic growth. This strategy advocates for the widespread adoption of renewable energy across all sectors of the economy, emphasizing the reduction of national greenhouse gas (GHG) emissions. The LCEDS serves as a

roadmap for attaining sustainable development by prioritizing sector-specific implementation plans that target low GHG emissions. The strategic sectors outlined in the strategy encompass energy, agriculture and livestock, industry, transportation, and commercial activities.

1.5.1.3 Second Nationally Determined Contribution

In December 2020, the Government of Nepal submitted its enhanced Nationally Determined Contribution (NDC) for the period 2021-2030 under the Paris Agreement. The NDC aligns with Articles 4.2 and 4.11 of the Paris Agreement, Decision 1/CP.21 paragraphs 23 and 24, and other relevant provisions. The key targets include increasing energy generation from approximately 1,400 MW to 15,000 MW, with 5-10% coming from mini and micro-hydropower, solar, wind, and bio-energy. The NDC also aims to achieve 90% sales of e-vehicles in the private passenger vehicle sector. In the residential sector, the focus is on raising electric cookstove usage to 25% of households by 2025, installing improved cookstoves in rural areas, and promoting household and institutional biogas plants.

1.5.1.4 Nepal: Sustainable Development Goals Status and Roadmap 2016-2030

The National Planning Commission (NPC) has developed a roadmap to achieve Nepal's Sustainable Development Goals (SDGs) by 2030 and aims to lift Nepal out of the Least Developed Countries by achieving rapid economic growth of at least 7% over the coming years. It identifies clean energy, agriculture, and tourism as the key sectors for sustainable prosperity. The roadmap highlights the following milestones and interventions to achieve the targets of SDG:

a. Increase access to electricity in 99% of households
b. Limit usage of LPG to less than 40% by promoting electric cooking
c. Increase per capita consumption of electricity to 1500 kWh
d. Generate 15,000 MW of installed capacity to meet the rising demand

1.5.1.5 Nepal Electricity Regulatory Commission Act 2074

In 2017, the Nepal Electricity Regulatory Commission Bill was passed to establish a transparent regulatory body responsible for overseeing electricity production, transmission, distribution, trading, and management. The objectives of this regulatory body include maintaining a balance between supply and demand, setting electricity tariffs, fostering competition in the market, and safeguarding consumer rights. The establishment of this regulatory body is expected to promote a competitive market for electricity that ensures accessibility, affordability, and reliability for all stakeholders involved.

1.5.1.6 Nepal's Energy Sector Vision 2050 A.D.

The Energy Vision 2050 was formulated in 2013 and it aims to meet Nepal's energy demand sustainably by exploring the country's potential energy resources. It focuses on reducing dependency on imported petroleum products by utilizing indigenous hydropower and other renewable energy sources. The vision highlights hydropower as the primary resource to meet long-term energy needs, with power capacity targets of 4,100 MW, 11,500 MW, and 31,000 MW

by 2020, 2030, and 2050 respectively. To achieve these targets, it is estimated that the energy sector should contribute approximately 2.4% to the country's GDP.

1.5.1.7 Nepal's 20-Year Renewable Energy Perspective Plan 2000-2020

The renewable energy perspective plan aims to accelerate the development of renewable energy in Nepal to meet the growing energy demands. It sets targets to increase the installed renewable capacity from 35 MW in 2015 to 894 MW by 2030 and to raise the share of renewable energy in total consumption from 2% to 15% by 2030. The plan also outlines goals for small/micro hydropower, wind, solar, biomass, domestic biogas plant installation, and improved cook-stove adoption, along with the necessary institutional framework, policies, capacity building, and implementation mechanisms to achieve these objectives.

1.5.1.8 National Energy Strategy of Nepal, 2013

The Nepal Energy Strategy provides a comprehensive framework for energy policy, addressing various issues such as poverty, electricity access, clean energy, hydropower generation, environmental conservation, and indoor air pollution. It emphasizes integrated energy planning, guided by socioeconomic development and environmental sustainability. The strategy aims to replace 30% of the demand for diesel and petrol cars with electric and hybrid vehicles by 2030, improve efficiency, and promote the use of clean fuels while discouraging traditional energy sources.

1.5.1.9 Nepal's Long-Term Strategy (LTS) for Net-Zero Emissions, 2021

In 2021, the Ministry of Forest and Environment formulated the Long-term strategy for Net-zero emissions, which was presented in the COP6 by the Nepal Government. The strategy aims to achieve net-zero carbon emissions from both energy and non-energy sectors by 2045 through rigorous mitigation measures, bold policy-making, social transformation, and technological advancements. The strategy sets ambitious sectoral targets, including the electrification of all potential end-use services, and acknowledges the need for substantial financial resources from domestic and international funding institutions to achieve its goals.

1.5.1.10 Five-Year Plan (2076/77-2080/81)

The fifteenth five-year plan (2076/77-2080/81) prioritizes the rapid production of hydropower to ensure energy security and promote clean energy availability. The plan focuses on increasing hydropower production, encouraging the consumption of electric energy across various sectors, and promoting regional trade of electricity to reduce petroleum imports. Additionally, the plan aims to enhance renewable energy production and utilization to ensure universal access to energy.

1.5.2 Sustainable Development Goals

The Sustainable Development Goal is also known as the 2030 Agenda for Sustainable Development. It was adopted by all United Nations Member States in 2015. It provides a shared blueprint for peace and prosperity for people and the planet, for the present and the future. At its core are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries in a global partnership. They recognize that ending poverty and other deprivations must

go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth while tackling climate change and working to preserve our oceans and forests.

Figure 1-5: Sustainable Development Goals

Among these 17 sustainable goals, SDG-7 is related to the energy sector. It is a dedicated and stand-alone goal on energy to “ensure access to affordable, reliable, sustainable and modern energy for all". This will eventually create new economic opportunities and jobs. These sustainable energy goals consist of five different targets and each target has its indicators.

1.5.2.1 SDG-7 Targets and Their Indicators

The following table shows the targets of the SDG-7 along with their corresponding indicators.

Table 1: SDG 7 Targets and Indicators

Target	Description	Indicators
7.1	By 2030, ensure universal access to affordable, reliable, and modern energy services.	7.1.1 Proportion of the population with access to electricity
		7.1.2 Proportion of the population with primary reliance on clean fuels and technology
7.2	By 2030, increase substantially the share of renewable energy in the global energy mix.	7.2.1 Renewable energy share in the total final energy consumption
7.3	By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP
7.a	By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.	7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including hybrid systems.
7.b	By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programs of support.	7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)

Targets 7.a and 7.b specifically focus on developed nations.

1.6 Global Energy Scenario

In recent years, a new energy economy of renewable energy sources has emerged. There has been massive growth in the wind energy and solar energy sector in the past few years. Clean (green) energy technology has become one of the major areas for investment and employment in recent years. These renewable energy resources along with the rising use of electricity have facilitated a more efficient, interconnected, and clean energy economy for the future.

Despite the world moving towards sustainable energy, petroleum, and natural gases still own the majority of the energy market. In 2021 the world observed the second-largest annual increase in CO_2 emissions in the history of humanity (Global Energy Report). The high emission has led to the rise in global temperature and has posed a global threat. Different strategies and policies are

being employed by different countries and global organizations. The IEA published a landmark in May 2021 "Net Zero Emissions by 2050 Scenario (NZE)", which presents the plans and targets to eliminate these emissions due to fossil fuels. This is a very narrow but achievable road map to 1.5°C stabilization in rising global temperatures towards controlling the rapidly growing global warming and achieving energy-sustainable goals.

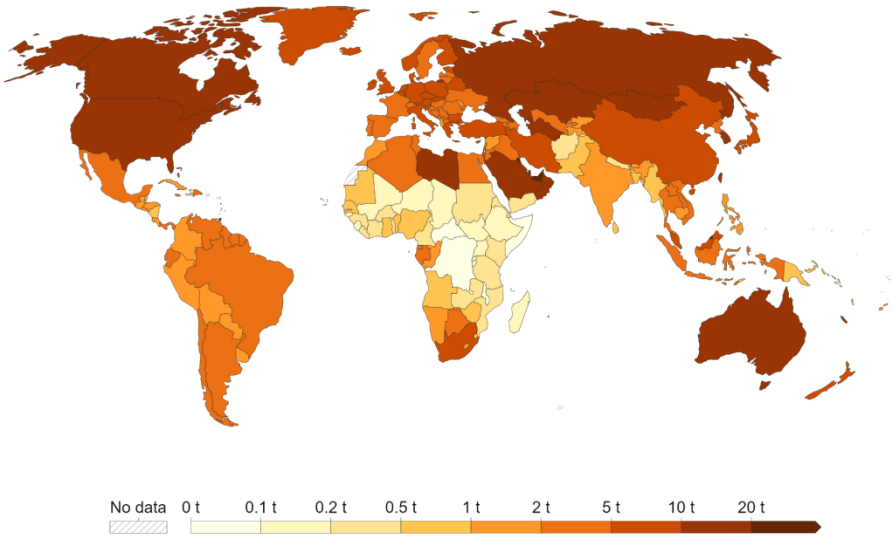


Figure 1-6: Per Capita CO_2 Emission of the World in 2021

(Source: Our World in Data)

Additionally, the report also shows that the energy sector accounts for ¾ of the total emissions and which has visible effects on the global temperature rise and unnatural climate change. The world population is increasing rapidly and with it the energy demand. Therefore, there are added difficulties in controlling emissions. According to the report, various countries globally, including the European Union, have announced their climate pledges to meet net zero emissions. If implemented as per plan, by 2030 the emission curve will fall and the low-emission energy resource like solar PV and wind will account for the vast majority of energy generation contributors (annual addition of 500 GW by 2030). This will lead to a 40% decrease in CO_2 emissions related to the energy sector by 2050.

A lot more effort has to be made by different countries to meet the aforementioned goals in addition to recovering from the economic recession due to COVID-19 and the impacts of the ongoing Russia-Ukraine war. As a result of the latter, the prices of natural gases and crude oil have also sharply increased in the past few years.

The World Energy Outlook 2022 published by the International Energy Agency has discussed the present status of global energy generation, supply, and consumption. The report has explored the energy economy of the current world and has included a database of the traditionally used fuels and new emerging fuels. The database is based on the current demands, generation, and consumption patterns, and prediction of future demands. Energy efficiency, energy security, energy economics, sustainability, and clean energy are the major topics discussed in this report. Further, the report has also incorporated the effects of the pandemic on the energy economy (both demand and supply). It also presents different climate pledges and scenarios made by different

countries globally to reduce emissions. The report has given a lot of priority regarding the emission status of different sectors and has reviewed the progress on the announced pledges to achieve zero emissions. The supply and demand and consumption of different fuel types from the past few years were analyzed and presented in this report. As the world is moving towards electrification, electricity demand supply and economics are also a part of this report. It has also pointed out possible future fuels and more priority has been given to sustainability and emission status.

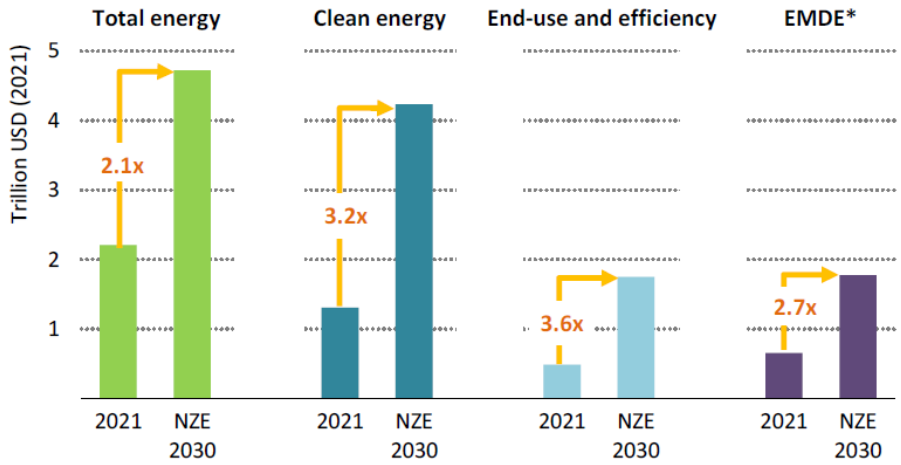


Figure 1-7: Energy Investment in the NZE Scenario (2021 and 2030)

(Source: World Energy Outlook 2022)

1.6.1 Energy Scenario of Neighboring and SAARC Countries

1.6.1.1 India

India, one of the closest neighbors of Nepal, is one of the rapidly growing economies (currently 5th largest). With a population of over a billion, it is the third-largest energy-consuming country. With the increase in the economy and living standards, the use of energy has doubled since 2000. Universal energy access was obtained in 2019 with 900 million people with electricity reach. The energy consumption patterns in India show the primary energy consumption of 929 Million Tons of Oil Equivalent (MTOE) in 2019 which is expected to grow to 1,237 MTOE in 2030. As of now, coal is the major contributor to the primary sources of electricity which covers more than 60% of the total energy demand.

The report "India Energy Outlook 2021" has presented the database of India's total energy supply, demand, and consumption. The report outline consists of the present energy status, energy system, different types of fuel types used, outlook of energy demand and supply, sustainable development goals, and India's progress toward achieving the set targets. After the pandemic, India's energy demand is expected to increase by 35% till 2030 and if it continues at this pace it is expected that India will have the largest increase in energy demand in the world by 2040. As per the report, coal accounts for nearly 70% of total electricity generation, and solar accounts for only 4% of electricity generation. India expects to reach 450 GW of renewable energy generation by 2030. Despite this, there is no replacement for coal and it is expected to

grow its demand in the near future. With the boom in economy and urbanization, the report suggests an increase of emissions by 50% in India.

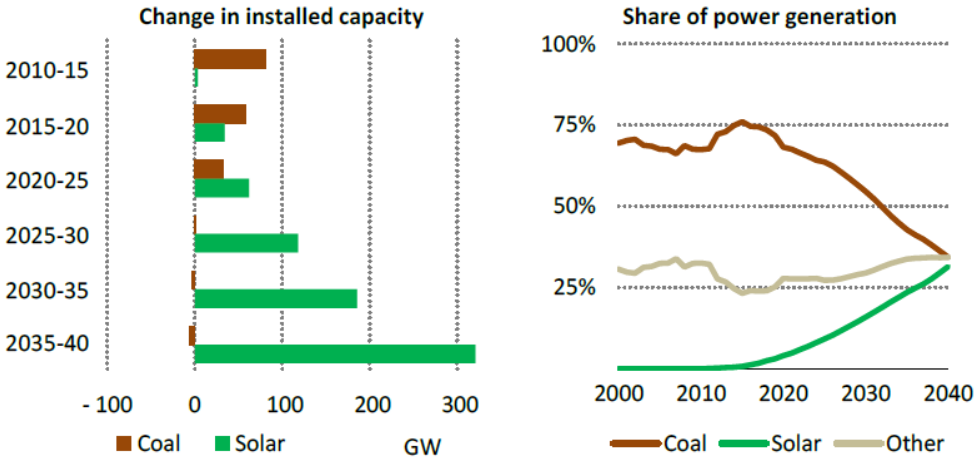


Figure 1-8: Changes in coal and Solar Capacity and Share of Power Generation in India in the STEPS (2000-2040)

(Source: India Energy Outlook 2021)

1.6.1.2 Bangladesh

Bangladesh has seen a blooming economic development due to the development of its industrial sector. It is also one of the growing economies in the world. Due to rapid urbanization and industrialization, energy demand is constantly increasing. In 2018, the energy consumption pattern in the country showed a primary energy consumption of 37.6 MTOE. This demand is now expected to rise to 85.3 MTOE in 2030. Natural gas is a major contributor to the country's primary energy as it covers two-thirds of its primary energy consumption. The current stats show that the production of gas within the country is decreasing and its energy security is at high risk due to its dependency on the import of coal and LNG. In recent decades Bangladesh has substantially improved its economy and energy sector. The capacity of electricity generation has increased from 5GW (2009) to 25.5GW in 2022. The government claimed in March 2022 that 100 percent of the population had access to electricity. Nevertheless, the reliability and quality of electricity remain major issues in Bangladesh.

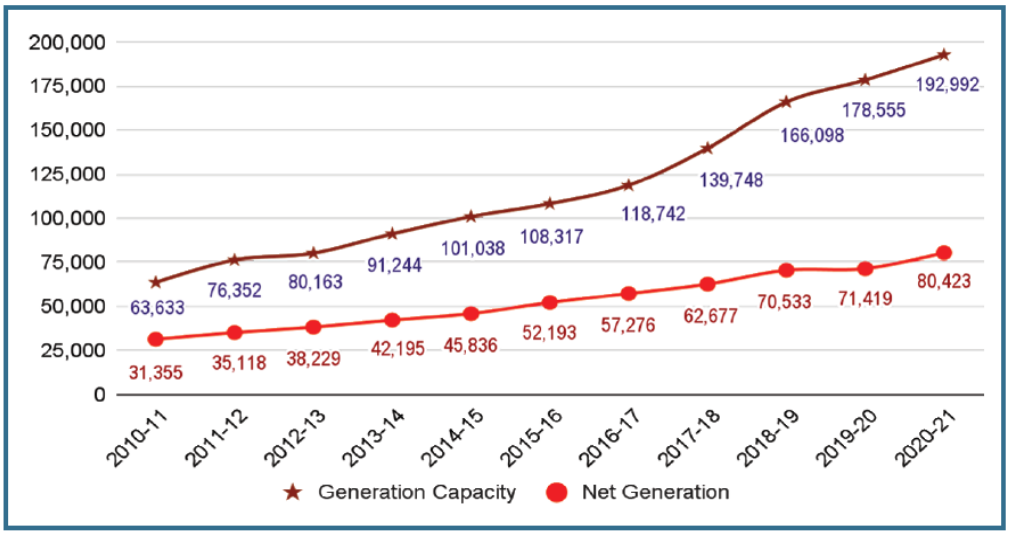


Figure 1-9: Generation Capacity and Net Generation of Bangladesh

(Source: Analysis by the Student Team Based on BPDB Annual Report, 2020-2021)

1.6.1.3 Bhutan

Bhutan, like Nepal, is a landlocked country and shares similar geography. It has an installed capacity of 2,335MW, which accounts for 7 percent of the country's total hydropower potential. The country's energy demand grew by 6% annually from 2010 to 2021. The Energy Data Directory 2015 reported that in 2014, the total energy supply in the country was 650,220 tons of oil equivalents (TOE). Out of the total energy supply, thermal energy accounts for 72%, and the remaining 28% is generated by electricity. The government plans to generate around 10,000MW of power through hydroelectric, solar, wind, and other forms of renewable energy sources by 2030. The government is taking steps towards increasing energy efficiency and promotes sustainable energy use. Additionally, several hydropower and mini hydropower projects are also in progress. The country has installed solar water heating systems (SWHS) with a daily heating capacity of 30,000 liters, as well as 1000 solar home lighting systems and a 180 kilowatt (KW) solar water project. The Department of Renewable Energy (DRE) is currently developing a comprehensive renewable energy master plan, including a renewable energy resource assessment report and a national energy efficiency and conservation policy. In 2021 it generated a total of 11,059 GWh of which 73.9% (8,178.38GWh) was exported to India.

1.6.1.4 Maldives

The Maldives has a total energy consumption of around 103.5 GWh per year. According to the data from World Data, the country has seen a steady increase in its energy consumption over the past decade, from around 80 GWh in 2010 to around 103.5 GWh in 2019. The country's main source of energy is still fossil fuels, specifically diesel and heavy fuel oil, accounting for around 96% of the total energy consumption. Despite this, there has been a small but growing use of renewable energy in the form of solar and wind power. The Maldives has a total electricity consumption of around 99 GWh per year, and 100% of the population has access to electricity. The Maldives has set a goal to generate 100% of its electricity from renewable sources by 2030, to decrease its dependence on fossil fuels and become more self-reliant. Overall, the country is

working towards a more sustainable energy future by increasing the use of renewable energy and decreasing its dependence on fossil fuels.

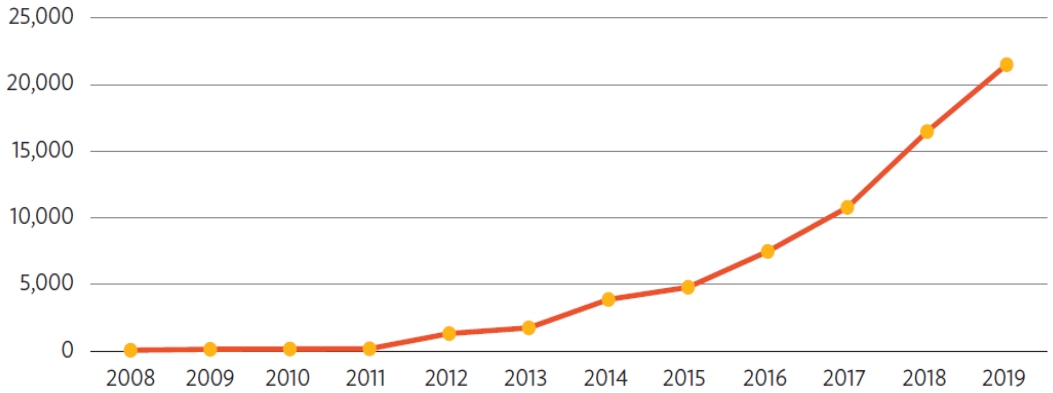


Figure 1-10: Evolution of Renewable Energy Installations in Maldives (kW)

(Source: A Brighter Future for Maldives Powered by Renewables: Road Map for the Energy Sector 2020–2030)

1.6.1.5 Pakistan

Pakistan's energy sector is facing several challenges, including a significant energy deficit, high dependence on fossil fuels, and a lack of investment in renewable energy. As of 2020, its primary energy consumption was around 131 MTOE, with a majority of it (around 60%) met through fossil fuels, particularly natural gas and oil. Coal also plays an important role in the country's energy mix, accounting for around 15% of total primary energy consumption.

On the other hand, Pakistan has great potential for renewable energy resources such as hydropower, wind, solar, and geothermal, but the utilization of these sources is still limited. The Government of Pakistan has set a target to increase the share of renewable energy in the power mix to 30% by 2030. However, the development of renewable energy projects in the country faces numerous barriers, including a lack of clear policies and regulations, financial constraints, and technical expertise.

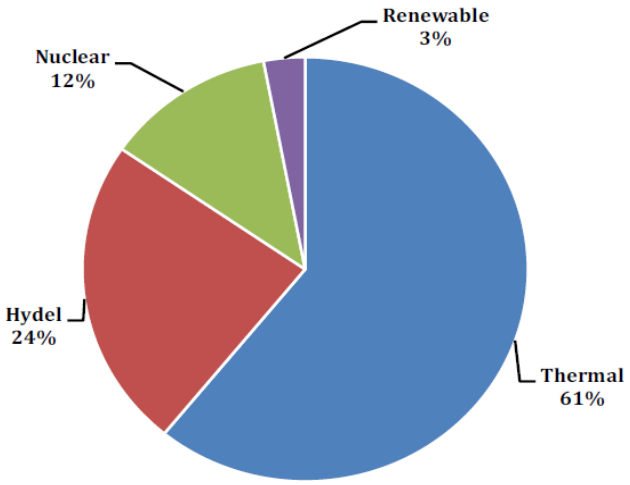


Figure 1-11: Pakistan’s Share in Electricity Generation

(Source: Pakistan Economic Survey 2021-22)

1.6.1.6 Afghanistan

Afghanistan is a country with a low level of energy consumption. In 2018, total primary energy consumption in Afghanistan was around 3.4 MTOE, with a majority of it (around 80%) being met through the consumption of biomass in the form of traditional fuels such as firewood and dung. The remaining 20% of energy consumption is met by oil products, mainly used for transportation and electricity generation. The use of coal and natural gas is almost negligible.

Less than half of the population has access to electricity, with a total installed capacity of 1 GW generated mostly by small hydroelectric plants and diesel generators. A small contribution of electricity comes from grid-connected power plants that are mostly imported from neighboring countries, such as Turkmenistan, Uzbekistan, and Iran. The total electricity generation in Afghanistan is around 6 TWh, which is less than 10% of the total electricity consumption. Renewable energy resources such as solar, wind, and hydro have significant potential in the country but are hindered by a lack of infrastructure, limited financial resources, and security issues. Despite setting a target of increasing renewable energy's share to 40% by 2030, Afghanistan faces challenges of inadequate investment and a lack of clear policy frameworks in the sector.

1.6.1.7 Sri Lanka

In Sri Lanka, the power and industry sectors are the primary consumers of energy. The country's energy mix is mainly composed of coal and oil. Sri Lanka has a total installed electricity generation capacity of around 8 GW, with hydro and thermal power being the main sources of electricity generation, and the country is working towards increasing the use of renewable energy in its energy mix.

According to the International Energy Agency’s (IEA) data on Sri Lanka, the country's energy consumption has been on the rise over the past decade. In 2019, total primary energy consumption was around 11 MTOE (Millions of tonnes of oil equivalent). The main source of energy in Sri Lanka is coal, accounting for around 42% of total primary energy consumption, followed by oil (38%), hydro (16%), and other renewable sources (4%). The power sector is the main energy-consuming sector, accounting for around 56% of total final energy consumption. The industry sector is the second-largest energy-consuming sector, accounting for around 25% of total final energy consumption. The government has set a target of generating 8% of the country's total electricity from renewable energy sources by 2025. Sri Lanka has also been looking to increase its Liquefied natural gas (LNG) imports in recent years as a way to reduce dependence on oil and coal. The country's first LNG terminal was opened in 2018, and the government aims to increase the share of natural gas in the energy mix to 20% by 2027.

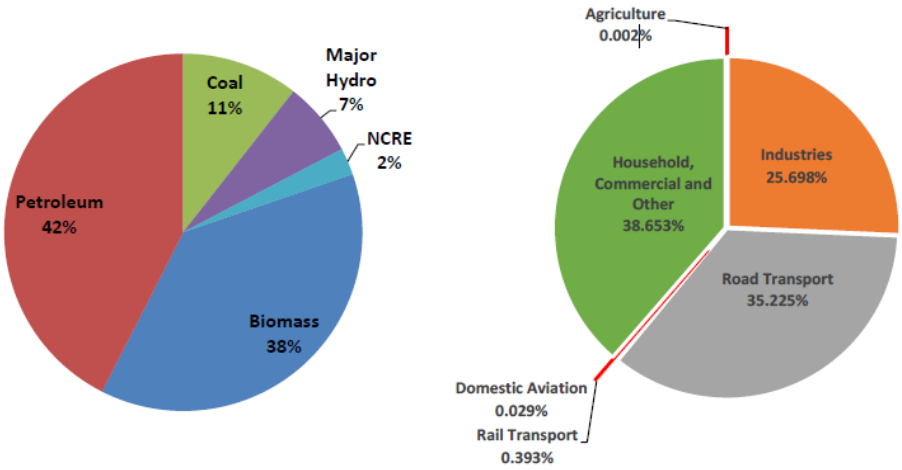


Figure 1-12: Energy Supply and Use in Sri Lanka (2017)

(Source: Sri Lankan Energy Outlook, 2019)

1.6.1.8 China

China is the world's largest energy consumer and producer. In 2020, primary energy consumption in China was 4,527 MTOE (million tonnes of oil equivalent). Coal remains the largest source of primary energy in China, accounting for 57% of the country's total energy consumption, followed by oil (19%), natural gas (8%), hydro (6%), and non-fossil renewables (7%). China is also the world's largest producer of hydroelectricity and wind power and the second-largest producer of solar power. The Chinese government has set a target of increasing the share of non-fossil energy in primary energy consumption to 20% by 2030.

China is also a major player in the global energy market, being a significant producer and exporter of oil and natural gas, and a major importer of oil and liquefied natural gas (LNG). The country is also investing heavily in clean energy technologies such as electric vehicles and renewable energy, to reduce air pollution and greenhouse gas emissions. However, China remains the world's largest emitter of carbon dioxide, which is the main greenhouse gas responsible for climate change. The Chinese government has pledged to peak its carbon dioxide emissions by 2030 and to achieve carbon neutrality by 2060. To achieve this, the country is actively investing in low-carbon technologies and promoting energy efficiency.

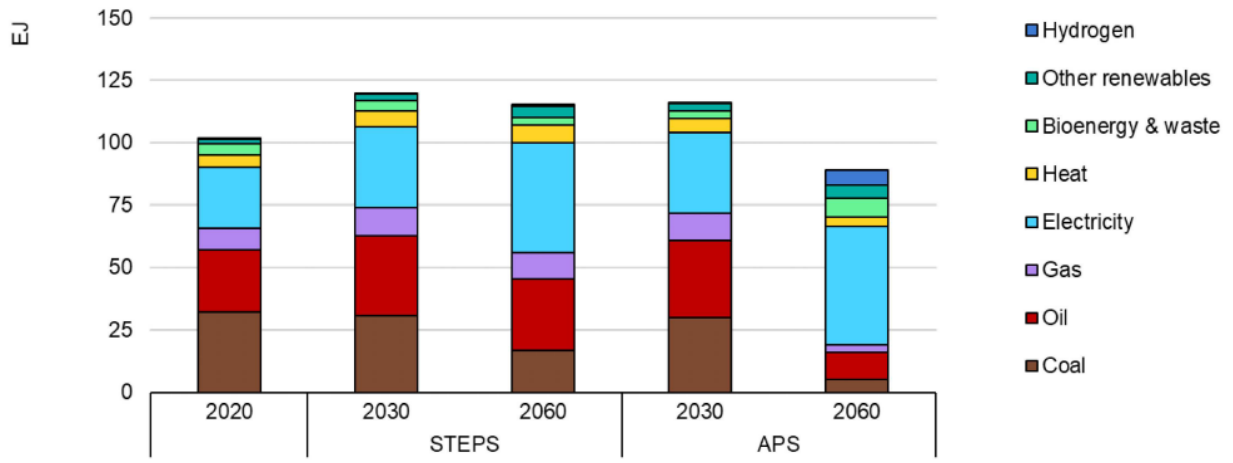
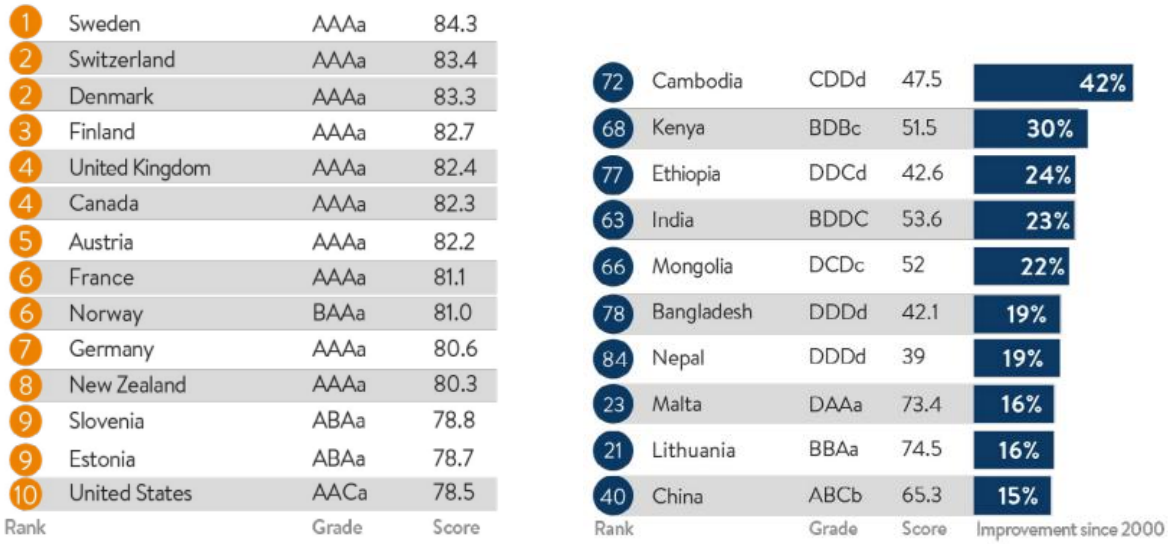


Figure 1-13: Final Energy Demand by Fuel and Sector in China by Scenario

(Source: IEA)

1.7 Energy Trilemma Index

The Trilemma framework strives to strike a balance between energy security, equity, and environmental sustainability. The ongoing COVID-19 pandemic and Russia's invasion of Ukraine have led to multiple energy crises worldwide, affecting both energy supply and demand chains, particularly natural gas. Furthermore, the occurrence of extreme weather events has heightened global climate emergencies. The World Trilemma Index serves as a tool for assessing how countries worldwide are responding to these challenges. According to the 2022 Trilemma Index Report, Sweden is the top performer with a score of 84.3 while Switzerland and Denmark are in the second position with scores of 83.4 and 83.3 respectively. Furthermore, Nepal has a rank of 84 with a score of 39 and has fallen under the top 10 countries with overall improvement.



(a) (b)

Figure 1-14: Top 10 Rank: (a) Overall Performers, and (b) Overall Improvers

(Source: World Energy Trilemma Index Report 2022)

According to the energy security rankings, Canada takes the top spot with a score of 79.6, while the United States follows in second place with a score of 74.1. Finland comes in third with a score of 73.8, and Sweden takes the fourth position with a score of 73.1. In terms of energy equity, Luxembourg is the leader with a perfect score of 100, with Qatar coming in second place with a score of 99.9. Kuwait and UAE share the third position with scores of 99.8 each. For environmental sustainability, Sweden takes the first position with a score of 87.5, followed by Switzerland with a score of 87.1, and Norway with a score of 85.8.

Nepal has been successful to improve in the energy security (+48%) as well as the equity sector (+69%) while China has ranked as the top improver in energy sustainability with a score improvement of +32%.

(a) (b) (c)

Figure 1-15: Top 10 Improvers in (a) Energy Security, (b) Energy Equity, and (c) Environmental Sustainability

(Source: World Energy Trilemma Index Report 2022)

Chapter 2: Methodology

The report has been prepared in three main phases: inception, analysis, and final phase (Figure 2).

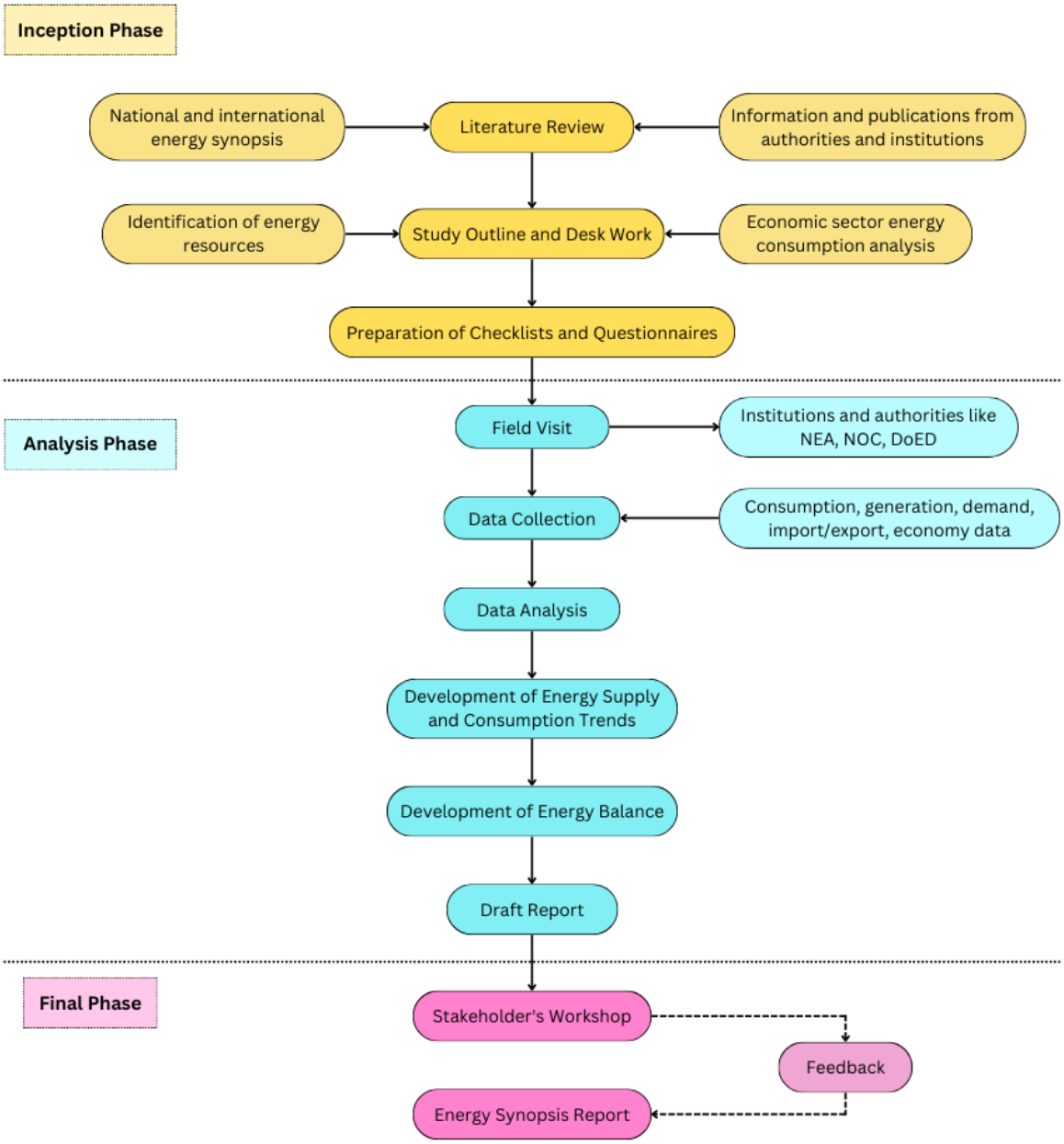


Figure 2: Methodology Chart

The first phase is the inception phase. Extensive desk work was conducted in this phase. Previously available national and international energy synopses and related publications and literature were studied. Relevant institutions and authorities to collect relevant data were identified. Checklists and questionnaires were prepared to aid further steps to be conducted. The inception report was prepared and workshops were conducted among the WECS officials.

The second phase is the analysis phase. In this phase, field visits were conducted to authorities and institutions identified in the inception phase for data collection. The data were analyzed based on the type of fuel and economic sector and based on provincial and physiographic regions. The analysis for the economic sector includes the residential, commercial, industry, agriculture, transport, construction, and mining sectors. Supply, consumption, and pricing patterns of the energy sources were carried out based on the obtained data for fiscal years (FY) 2075/76, 2076/77, 2077/78, and 2078/79. The corresponding years in AD are 2019, 2020, 2021, and 2022 respectively. Energy balance for the aforementioned periods was developed. Additionally, Nepal's progress in its set plans and policies, and the Sustainable Development Goal (SDG) (SDG-7) were also analyzed. Lastly, a draft was prepared for the final report.

In the final phase, the draft is submitted to the stakeholders and a workshop is conducted to review the report. Feedback from the stakeholders is obtained and incorporated into the final report.

2.1 Energy Supply Potential Estimation

Nepal's energy resources can be categorized into three categories: traditional, commercial and modern renewable resources.

2.1.1 Traditional Energy

Nepal primarily relies on replenishable organic resources such as fuelwood, agricultural residue, and animal wastes. These resources have been used traditionally for a long time for thermal purposes.

2.1.1.1 Wood Fuel

Over 90% of the biomass is used in households for cooking and heating purposes. The forest serves as the primary resource for woody biomass, supplemented by fuelwood production from private farmlands. In 2016, the Ministry of Forest and Soil Conservation published the National Forest Reference Level (FRL) of Nepal for the period 2000-2010, providing detailed information on activities such as deforestation, fuelwood extraction, grazing, and forest enhancement (afforestation/reforestation) (MoFSC, 2016). The FRL includes a methodology that utilizes the Dendro Energy Biomass (DEB) Mean Annual Increment (MAI) to estimate sustainable fuelwood supply potential. Sustainable fuelwood harvesting is determined by comparing the annual harvest to the DEB MAI for a given area, while excessive harvesting beyond the DEB MAI leads to unsustainable practices and forest biomass loss. The estimated annual accessible supply potential for energy use is 15.7 million tons DM, which exceeds the annual fuelwood demand by 5.6 million tons DM. However, it should be noted that this surplus is purely theoretical, as demand and supply potential are unevenly distributed, with areas experiencing excessive fuelwood harvesting and others with untapped supply potential. The study estimating the Dendro Energy Biomass (DEB) stock was conducted between 2010 and 2014.

2.1.1.2 Agricultural Residues

In addition to fuelwood, agricultural residues from crops such as paddy, wheat, and millet are also utilized as an energy source. The resources are particularly used for cooking and heating

purposes. The theoretical national energy potential of crop residues was estimated to be approximately 234 million GJ, which accounted for around 61% of the country's total energy consumption in 2008/09, according to a study by WECS (2010). The estimation was based on the residue-to-product ratio (RPR) analysis, although actual RPR values vary depending on factors such as local conditions, crop species, and moisture content. In this study, cereal crops, including paddy, wheat, millet, and maize, were considered for residue production, and the total production figures were obtained from the Statistical Information on Nepalese Agriculture published by the Ministry of Agricultural and Livestock Development (MoALD). The respective RPR values, obtained from the study conducted by Adhikari in 2017, were multiplied by the total production to estimate the potential energy from agricultural residues. The net calorific value was used to calculate the energy content (Table 2-1).

Table 2-1: Residue to Product Ratio and Net Calorific Value

Crop Residue	Residue to Product Ratio	Net Calorific Value ($MJkg^{-1}$)
Paddy Husks	0.36	16.57
Paddy Straws	1.97	15.80
Wheat Husks	0.82	17.46
Wheat Straws	1.46	17.46
Corn Stalks	2.12	15.44
Corn Cobs	0.28	15.57
Corn Ears	0.29	12.56
Millet Husks	0.14	12.56
Millet Straws	1.89	12.56

(Source: WECS, 2010; Adhikari & Denich, 2019)

2.1.1.3 Animal Waste

Animal waste is widely used in rural areas of Nepal as a traditional biomass energy source for cooking and heating. However, its direct use is considered less efficient due to its low heat content. Animal waste is also utilized for the production of biogas plants, serving as a clean renewable energy source. The estimation of potential animal waste supply takes into account the total livestock population, with the dry waste production per animal based on a study by Adhikari & Denich (2019). The actual dry dung production is estimated considering an average accessibility and collection factor of 70%. The potential energy from animal waste is determined using the calorific value of dry dung, estimated to be 14.92 MJ/kg. Additionally, approximately 17% of animal waste is assumed to be used for biogas production in Nepal, according to the study conducted by Adhikari & Denich (2019).

2.1.2 Commercial Fuels

Commercial fuels encompass a range of energy commodities that are traded commercially. These fuels exist in solid, liquid, or gaseous states, including converted forms such as electricity. With the exception of coal, these fuels are typically refined or converted from their original form.

2.1.2.1 Petroleum Products

Petroleum products in Nepal are primarily imported from India, with a smaller amount imported from other nations. The Nepal Oil Corporation (NOC) is responsible for the importation of petroleum products, and data regarding imports and sales were obtained from NOC regional offices. Additional data regarding import values were obtained from the Department of Customs (DoC). Consumption patterns of petroleum in different sectors were determined through a literature review.

2.1.2.2 Coal

The industrial sector in Nepal is the main consumer of coal, predominantly for heating and boiling processes in brick, lime, cement production, and steel processing. While Nepal has minor coal reserves, the majority of coal for industrial needs is imported from India and other countries. The Department of Mines and Geology identifies the source, size, and current production capacity of coal, and industries have the option to import coal directly. Domestic data on coal were obtained from the Department of Mines and Geology, while import data were collected from the Department of Customs. The average calorific value of coal is taken as 24 MJ per kg.

Table 2-2: Calorific Values of Petroleum Products, Biogas and Coal

Fuel Type	Calorific Value (MJ)	
	per kg	per liter
Petrol	43.9	32.6
Diesel	42.8	36
Kerosene	43.2	35
ATF	43.1	35.4
Furnace Oil	43	35.7
LPG	46	
Biogas		20 MJ/m3*
Coal	23.8	
Anthracite	31.4	
Bituminous coal	29.3	
Sub-bituminous coal	18.8	
Lignite	31.4	
Peat	29.3	
Coke	28.5	
Briquettes	20.1	

2.1.2.3 Electricity

Hydropower is the primary source of electricity in Nepal, given the country's abundant potential due to its mountainous geography. During peak hours, the electricity demand not met by domestic generation is fulfilled through imports from India. Additionally, there are a few large grid-connected solar PV plants contributing to electricity generation. The Nepal Electricity Authority (NEA) is responsible for supplying electricity through the national grid, while various government organizations, such as the Department of Electricity Development (DOED), Alternative Energy Promotion Center (AEPC), and Ministry of Energy, Water Resources, and Irrigation (MoEWRI), are involved in licensing procedures for different types and sizes of electricity projects. Consumption patterns and data related to hydropower capacity, generation, NEA-operated plants, Independent Power Producers (IPPs), import and export of electricity, transmission and distribution loss, and energy usage patterns were collected from these organizations.

2.1.3 Modern Renewables

Modern renewable resources encompass renewable energy resources that are abundant in nature and have a short replenishment period. These technologies have been under development for some time and continue to advance.

2.1.3.1 Mini/Micro and Pico Hydropower Plants

Micro-hydro and pico-hydro systems are small-scale hydropower installations that generate electric power with capacities below 100 kW and 1 kW, respectively. As of 2021/22, the total installed capacity of mini, micro, and pico hydropower projects in various parts of the country amounts to approximately 37.7 MW (AEPC, 2022), reflecting a 4.74% increase compared to the previous year. These decentralized hydroelectric systems play a significant role in providing electricity to rural communities and meeting the energy needs of small-scale applications.

2.1.3.2 Solar

Nepal has an advantageous location and its high-altitude topography with slopes facing south, receives ample solar radiation for harnessing solar energy. The average solar radiation ranges from 3.6 to 6.2 kWh/m^2/day, and approximately 300 sunny days per year. This makes the development of solar energy technology highly promising in many parts of the country. According to the Solar & Wind Energy Resource Assessment in Nepal (SWERA) report published by AEPC in 2008, the commercial potential for grid-connected solar power is estimated to be 2,100 MW. Nepal shows great potential for various solar energy technologies, including grid-connected PV, solar water heaters, solar lanterns, and solar home systems. Data on solar energy are primarily sourced from NEA and AEPC. NEA provides information on grid-connected solar PV, while AEPC supplies data on off-grid solar home systems, institutional solar PV systems, solar pumping systems, and solar/wind hybrid systems. The status report of solar water heaters from AEPC, UNDP country profile, and the Department of Customs are used for solar thermal water heating data.

2.1.3.3 Wind

Despite the abundant availability of wind, Nepal has yet to harness its potential as a clean energy source. According to the published report of AEPC in 2008 under Solar & Wind Energy Resource Assessment in Nepal (SWERA), there is a potential area of 6074 sq. km with a wind power density greater than 300 watts/m2. If we consider 10% of this area feasible for wind energy production, Nepal has a potential of 3,000 MW of wind energy, assuming a rate of 5 MW per sq. km. The study indicates that the most potential areas are located in the high and middle mountains of the country. However, the commercially viable wind potential is estimated to be only about 448 MW. Several wind-solar hybrid projects, including a 20 kW power system, have been implemented in different locations, providing electricity to rural households.

2.1.3.4 Biogas

Biogas primarily relies on animal waste and is mainly used in rural areas, although there is a growing trend of constructing large institutional biogas plants. Additionally, commercial production and sales of biogas have also commenced. Data pertaining to biogas were obtained from AEPC, including information on installed capacity, operation factors, and production potential based on livestock numbers, waste production, and biogas yield per kilogram of animal waste. Provincial-level estimates were made for annual biogas yield.

2.1.3.5 Other

Other energy resources include solid municipal wastes, industrial by-products such as bagasse, secondary wood sources like logging residue, saw-milling waste, furniture production scraps, as well as agricultural residues from crops and bushes. Additionally, hydrogen fuel is also a potential source of energy and research is ongoing. Data related to these alternative energy sources should be identified and obtained from the respective authorities for comprehensive analysis.

2.2 Sectoral Energy Demand Calculation

The six primary economic sectors that consume energy in Nepal are residential, commercial, industry, transport, agriculture, and construction & mining. The energy consumption in each sector has been calculated based on the following assumptions and factors:

- Traditional energy consumption is estimated using data from the economic survey, clean cooking assessment, and urban and rural energy consumption patterns.
- Renewable energy consumption is determined based on the number of installations and their capacity.
- Petroleum products and coal consumption are derived from sales data provided by the Nepal Oil Corporation (NOC), Department of Customs, and Department of Mines and Geology.
- Electricity consumption is calculated based on sales units reported by the Nepal Electricity Authority (NEA).
- Household traditional energy consumption is estimated based on per capita energy consumption.

- Fuel consumption in the transport sector is determined by considering the number of registered vehicles, their operation factor, fuel economy, and annual vehicle kilometers traveled.
- Commercial and agricultural energy consumption is linked to gross value addition and energy intensity.
- Industrial energy consumption is determined based on the number of established industries, manufacturing gross value addition, and energy intensity.

2.3 Preparation of Data Acquisition Formats

Data on energy supply and consumption were gathered from various energy institutions in Nepal. These institutions include the Water and Energy Commission Secretariat (WECS), Ministry of Forest and Environment (MoFE), Ministry of Agriculture and Livestock Development (MoALD), Department of Electricity Development (DoED), Department of Customs (DoC), Alternative Energy Promotion Centre (AEPC), Timber Corporation of Nepal (TCN), Nepal Oil Corporation (NOC), Nepal Electricity Authority (NEA), Independent Power Producers Association Nepal (IPPAN), Central Bureau of Statistics (CBS), and Ministry of Finance (MoF).

To collect the relevant information, visits were made to these organizations, and extensive interactions were conducted. Prior to these interactions, checklists, questionnaires, and specific data collection formats were prepared to ensure comprehensive data gathering. These tools facilitated effective discussions and information exchange with the respective institutions, enabling the collection of accurate and relevant energy supply and consumption data.

2.4 Data Collection

Data and information from various institutions and departments were collected for each energy sector. The following sources were consulted for specific data:

- Fuelwood supply and consumption data were obtained from the Department of Forests and Soil Conservation (DoFSC), Timber Corporation of Nepal (TCN), User Groups (e.g., Federation of Community Forests User Groups Nepal), and Forest Product Development Boards. The data were collected in a disaggregated form.

- Information and database related to renewable energy resources such as solar PV, wind, biogas, biomass, micro-hydropower, improved cookstoves, and other technologies were gathered from stakeholders like the Alternative Energy Promotion Centre (APEC), Solar Energy Association, Renewable Energy Confederation of Nepal, etc. The data included details on the number, capacity, and locations of installations over the years.

- Data and information on the storage, import, and sale of petroleum products in Nepal for specific fiscal years were collected from the Nepal Oil Corporation (NOC), the Department of Customs, and the Civil Aviation Authority of Nepal (CAAN).

- Data and information on indigenous production and import of coal, charcoal, and other energy forms in different years were collected from the Department of Mines and Geology and the Department of Customs.
- Electricity generation, sale, and consumption data by year and sectors were obtained from relevant institutions such as the Department of Electricity Development (DoED), Nepal Electricity Authority (NEA), and the Independent Power Producers Association of Nepal (IPPAN). Information on existing hydropower projects, potential projects, and projects in the pipeline, along with their respective capacities, was also acquired.
- Additional supporting databases and information, including socio-economic, technical, and environmental facts, were collected from relevant institutions and available literature related to energy supply and consumption.

The collected data and information were maintained in their original units as provided by the respective energy institutions. During data analysis, these original units were converted into standardized units such as GigaJoule (GJ) and Ton of Oil Equivalent (TOE).

2.5 Data Analysis

The collected data and information were subjected to analysis to assess the energy supply and consumption situation in the country. The analysis involved several components, including:

- Examining fuelwood supply and consumption patterns based on location and years.
- Estimating the availability of agricultural residues and animal waste by utilizing production data related to agricultural crops and livestock numbers over different years.
- Analyzing the production and generation information of each renewable energy resource.
- Assessing the individual energy consumption within various economic sectors, such as residential, commercial, industrial, transportation, agricultural, and construction & mining.
- Investigating the share of energy consumption across end-uses categorized by fuel type and economic sectors.
- Reviewing the historical pricing trends of energy in Nepal.
- Compiling an energy balance for three fiscal years: FY 2075/76, 2076/77, and 2077/78.

The outcomes of the analysis are presented in tabular and graphical formats, enabling a comprehensive understanding of the energy landscape in the country.

2.6 Reporting Outline

The report is prepared after conducting extensive analysis and synthesis of the collected and compiled data. The report follows the outlined structure provided below:

- Acronyms and Abbreviations
- Executive Summary
- Chapter 1: Introduction
- Chapter 2: Methodology
- Chapter 3: Energy Outlook of Nepal
- Chapter 4: Energy Indicators
- Chapter 5: Energy Balance
- Chapter 6: Energy Pricing
- Chapter 7: Provincial Energy Outlook
- Chapter 8: Conclusion
- References
- Annexes

Chapter 3: Energy Outlook of Nepal

3.1 Energy Resources (Supply and Generation) in Nepal

Nepal's Energy Supply System can be categorized into three types: traditional, commercial, and modern renewable. These categories are further classified as illustrated in Figure 3-1.

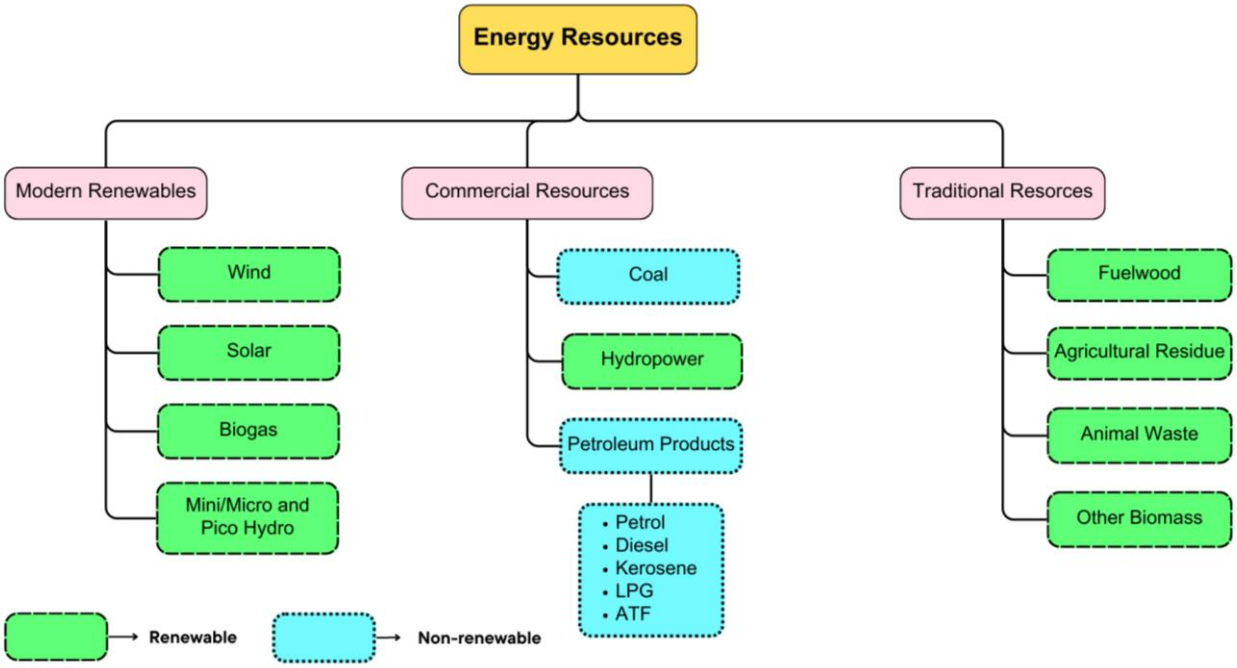


Figure 3-1: Energy Resources in Nepal

Among these categories, coal and petroleum products are classified as non-renewable resources, while all other energy resources are considered renewable. In terms of hydropower, there is a distinction based on scale. Mini/micro and pico hydropower plants, with their smaller capacity, are categorized as modern renewable. However, when referring to hydropower in general, including larger-scale hydropower plants, it is classified as a commercial resource. This classification takes into account the economic impact and integration of hydropower into the national electricity grid.

3.2 Traditional Energy Resources

3.2.1 Wood Fuel

Forest is a land with forest cover where the trees have a crown cover of more than 10%. These lands are primarily used for forestry and not for other purposes. These lands typically have a stand width greater than 100 m and may include small non-forest patches narrower than 5 m or smaller than 1 ha. Temporarily clear-cut areas that will be replanted are also considered part of the forest. In comparison, shrubs share a similar definition to forests, but they do not possess a well-defined stem.

Globally, over 1.6 billion people, which accounts for 25% of the total global population, depend on forests for their subsistence, livelihoods, employment, and income generation (FAO, 2017). In

Nepal, more than 65% of the population, particularly poor families, rely on forests for timber, fuelwood, and fodder (FRTC, 2019).

The first national-level forest inventory in Nepal was carried out in the 1960s, followed by several subsequent forest resource assessments, each varying in purpose, scale, scope, design, and technology used. The second national forest inventory took place in the 1990s, followed by the third most comprehensive national-level forest resource inventory conducted by FRA Nepal (2010-2014) under DFRS (2015). According to the study, the forest covers 5.96 million ha, which is equivalent to 40.36% of Nepal's total area. Furthermore, Other Wooded Land (OWL) covers 0.65 million ha (4.38%), and Other Land covers 8.16 million ha (55.26%). Within OWL, shrub-covered areas accounted for 0.12 million ha (0.79%), and areas with tree crown cover ranging from 5% to 10% cover 3.59% of the total area (0.53 million ha). In total, the combination of forest and OWL cover 6.61 million ha, which represents 44.74% of the country's total area.

Table 3-1: Forest Coverage by Province

Province	Total Area (ha)	Forest Area (ha)	Districts Included	Municipalities Covered
Koshi	2,590,500.00	1,134,250.00	14	137
Madhesh	966,100.00	263,630.00	8	136
Bagmati	2,030,000.00	1,090,880.00	13	119
Gandaki	2,150,400.00	817,290.00	11	85
Lumbini	2,228,800.00	974,380.00	12	109
Karnali	2,798,400.00	1,183,400.00	10	79
Sudurpashchim	1,987,400.00	1,147,110.00	9	88
Total	**14,751,600.00**	**6,610,940.00**	**77**	**753**

Out of the total forest area, 6.9% of the forest lies in the Terai region, 23.04% in the Churia region, 37.8% in the Middle Mountains and 32.25% in the High Mountains region.

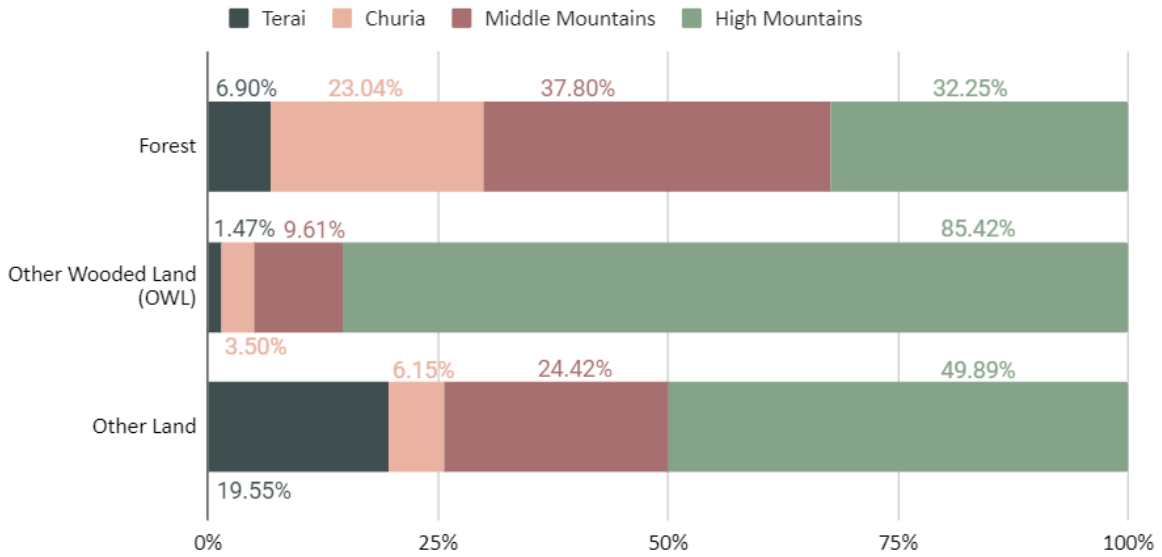


Figure 3-2: Portion of Land Cover in Each Physiographic Region

In total, 1.03 million hectares of the forest area lie inside the protected area, while 4.93 million hectares of forest lie outside the protected area. Protected areas are geographical regions that are legally protected and managed to conserve natural resources and biodiversity. Within the protected area, 0.79 million ha of forest fall under the core area, and 0.24 million ha are located inside the buffer zone. Among the core areas, the high mountains have the largest forest coverage, spanning 459,240 ha (57.95%), while the middle mountains have the lowest coverage with 16,669 ha (2.10%).

Table 3-2: Forest Coverage Inside and Outside Protected Area by Physiographic Regions

Physiographic Region	Outside PAs	Protected Area (ha)		Total
		Core Area	Buffer Zone	
Terai	314,660	69,847	27,074	411,581
Churia	1,043,194	246,750	83,799	1,373,743
Middle Mountains	2,226,273	16,669	10,865	2,253,807
High Mountains	1,345,309	459,240	118,360	1,922,909
Total	**4,929,436**	**792,506**	**240,098**	**5,962,040**
	Total	**1,032,604**		

3.2.2.1 Community Forest

Community forests are forest areas owned and managed by local communities. These communities are responsible for taking care of the forests, having the rights and responsibilities to sustainably use and benefit from forest resources while promoting conservation and community development. These forests cover nearly half of Nepal's total forest area (MOFE, 2020) and represent the second largest management regime after government-managed forests. Among the provinces, Bagmati has the largest coverage of community forests, encompassing 593,495 ha (18.66%), followed closely by Lumbini with 576,570 ha, and Koshi with 551,791 ha. The province with the lowest coverage of community forests is Madhesh, accounting for 125,947 ha (3.96%).

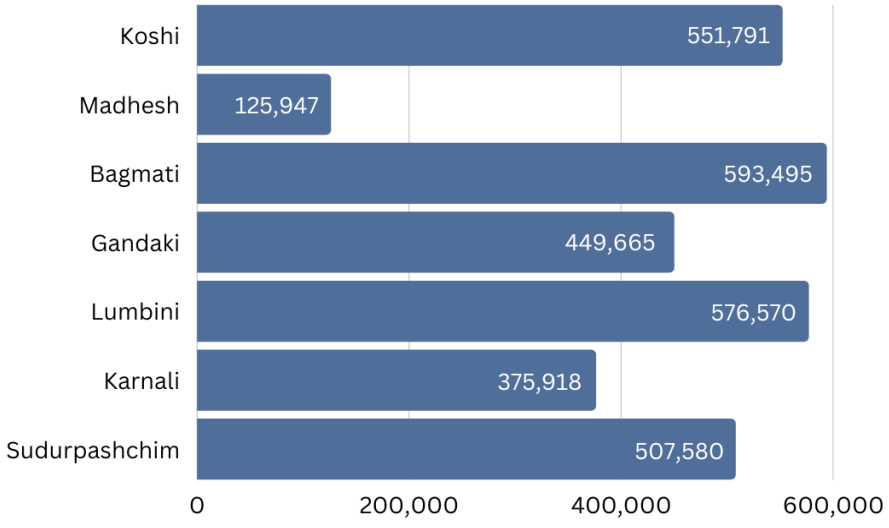


Figure 3-3: Community Forest Coverage in Different Provinces (ha)

3.2.2.2 Forest Cover Change

The forest coverage was observed to be decreasing, going from 41.14% in the 1960s to 24.70% in the 2005s. According to a study conducted by DFRS in 2015, the area of forest coverage increased to 40.36% in the 2010s. Similarly, the study showed increasing shrub area from the 1960s to 2005s going from 2.63% to 12.90% respectively. However, according to the report, there has been a drastic decrease in the shrub area in the 2010s, receding to 4.39%.

Table 3-3: Time Series Forest and Shrub Land Area of Nepal

Year	Forest Area (000 ha)	Shrub Area (000 ha)	Forest Area (%)	Shrub Area (%)
1960s	6,078.90	338.00	41.14%	2.63%
1970s	5,612.50	694.10	38.10%	4.70%
1980s	5,518.00	706.00	37.42%	4.79%
1990s	4,268.80	1,559.20	39.60%	10.59%
2000s	3,900.00	1,753.00	26.50%	11.90%
2005s	3,636.00	1,897.00	24.70%	12.90%
2010s	5,962.13	647.89	40.36%	4.39%

3.2.2.3 Sustainable Wood and Fuelwood Supply

According to the aforementioned 2015 report from DFRS, Nepal's total above-ground air-dried biomass is about 1,159.65 million tonnes. This is equivalent to 1,054.2 million tonnes of above-ground oven-dried biomass. It was observed that the High Mountains contributed the highest biomass accounting for 45% of the total biomass. The Middle Mountains, Churia, and the Terai region contribute 27.84%, 20.40%, and 6.74% respectively.

Table 3-4: Total Above-Ground Air-Dried and Above-Ground Oven-Dried Biomass
(In Million Tonnes)

Physiographic Region	Above-Ground Air-Dried	Above-Ground Oven-Dried
Terai	78.21	71.10
Churia	236.57	215.06
Middle Mountains	322.88	293.52
High Mountains	521.99	474.52
Total	**1,159.65**	**1,054.20**

(DFRS, 2015)

Nepal has a total of 3,183.25 million ha of accessible forest area. According to DFRS/FRISP (1999), the existing forest resources can sustainably provide about 12.16 million tons of fuelwood including 11.94 million tonnes per year from forest areas and 0.22 million tons per year from other wooded lands. The highest contribution to fuelwood comes from the Koshi province (25.4%) followed by Bagmati (18.67%), Sudurpashchim (16.69%), Lumbini (11.43%), Karnali (11.1%), Gandaki (8.63%), and the least by Madhesh (8.06%). The annual energy potential of sustainable fuelwood is estimated to be 203,578,923 GJ.

Table 3-5 Sustainable Fuelwood Supply and Energy in 2014

Province	Area in 000ha						Sustainable Wood (Million T) From Reachable			Energy (GJ)
	Forest		OWL		OL					
	Total	Reachable	Total	Reachable	Total	Reachable	Forest	OWL	Total	
Koshi	1,034.17	809.65	100.17	78.42	1,476.72	1,476.72	3.04	0.05	3.09	51,759,239
Madhesh	260.76	260.76	2.87	2.87	695.34	695.34	0.98	0.00	0.98	16,411,934
Bagmati	1,046.21	601.05	44.67	25.66	939.43	939.43	2.25	0.02	2.27	38,048,744
Gandaki	739.60	271.36	99.55	36.52	1,429.16	1,429.16	1.02	0.03	1.05	17,465,405
Lumbini	968.37	369.04	49.22	18.76	963.27	963.27	1.38	0.01	1.39	23,396,583
Karnali	902.82	344.06	215.52	82.13	1,828.31	1,828.31	1.29	0.06	1.35	22,557,306
Sudurpashchim	1,010.21	527.33	135.90	70.94	831.26	831.26	1.98	0.05	2.03	33,939,709
Total	**5,962.14**	**3,183.25**	**647.90**	**315.30**	**8,163.49**	**8,163.49**	**11.94**	**0.22**	**12.16**	**203,578,920**

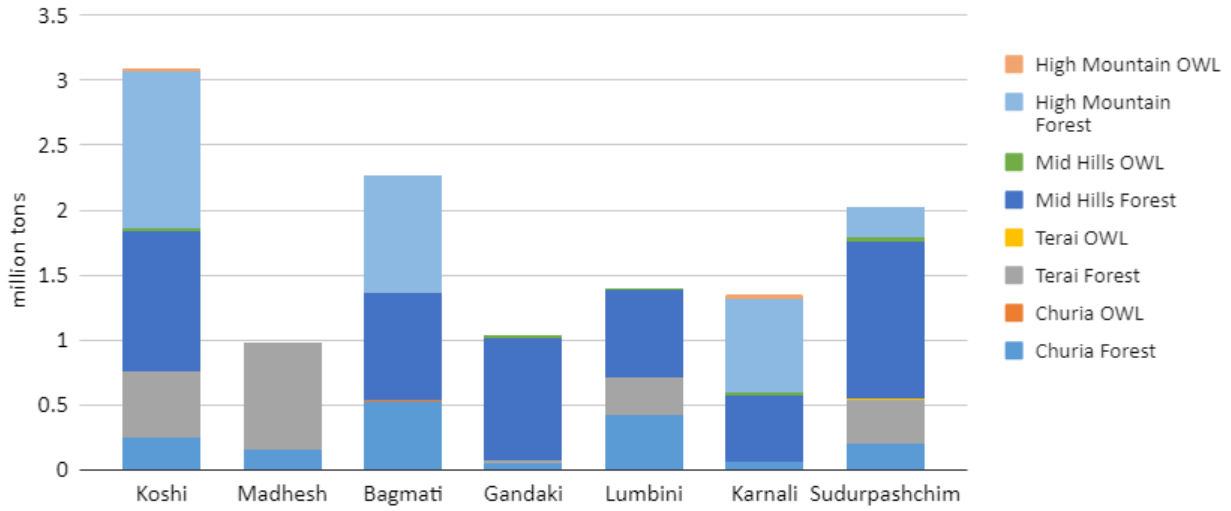


Figure 3-4: Proportion of Different Provinces in Different Physiographic Regions in Sustainable Annual Wood Yields

3.2.2.4 Community Forest Contribution to Sustainable Fuelwood Supply in 2014

According to the DFRS (2015) report, the annual sustainable fuelwood supply from community forest in Nepal amounts to 4.53 million tons. Koshi province has the highest annual supply of sustainable fuelwood, reaching 1.58 million tons. The lowest supply is contributed by the Madhesh province with only 0.29 million tons per year (Table 3-6).

Table 3-6: Annual Sustainable Fuelwood Supply and Energy by Community Forests in 2014

Province	Area in (000ha)			Sustainable Wood (million ton)	Energy (GJ)
	Forest	Reachable	Reachable (%)		
Koshi	536.68	420.17	78%	1.58	26,391,873.88
Madhesh	77.64	77.64	100%	0.29	4,876,954.71
Bagmati	374.80	215.32	57%	0.81	13,524,931.69
Gandaki	233.59	85.70	37%	0.32	5,383,219.72
Lumbini	394.88	150.49	38%	0.56	9,452,519.01
Karnali	316.30	120.54	38%	0.45	7,571,648.42
Sudurpashchim	265.09	138.38	52%	0.52	8,691,877.17
Total	**2,198.98**	**1,208.24**		**4.53**	**75,893,024.60**

According to Table 3-7, Karnali has the highest fuelwood supply (52.22%). Bagmati has the highest sales compared to other provinces.

Table 3-7: Supply of Forest Products by Each Province in 2075/2076 *(In chatta)*

Province	Fuelwood (Except household-level private consumption)	%
Koshi	3580	7.67
Madhesh	6197.07	13.28
Bagmati	4429.05	9.49
Gandaki	2320.65	4.97
Lumbini	4964.23	10.64
Karnali	24374	52.22
Sudurpashchim	805	1.72
Total	**46670**	**100**

(DoF, 2015)

1 chatta = 20x5x5 ft. (14.15 cu. m.) weighs 10.47 tons on average (Subedi, et al., 2014)

3.2.2 Agricultural Residue

Cereal crops like paddy, wheat, corn, and millet are the major sources of residues for energy production. Among them paddy is the major agricultural product, accounting for more than 50% of the total share. The energy production from each crop residue is based on their respective calorific value. The total energy generated from agricultural residue in Fiscal Year (FY) 2075/76 was 406 million GJ. Furthermore, in FY 2076/77, a total of 416 million GJ of energy was generated, while in FY 2077/78, it reached 442 million GJ. The production of residues in 2022 is estimated to be 457 million GJ. The residue production and the estimated energy for each province are shown in Figures 3-5 and 3-6 respectively.

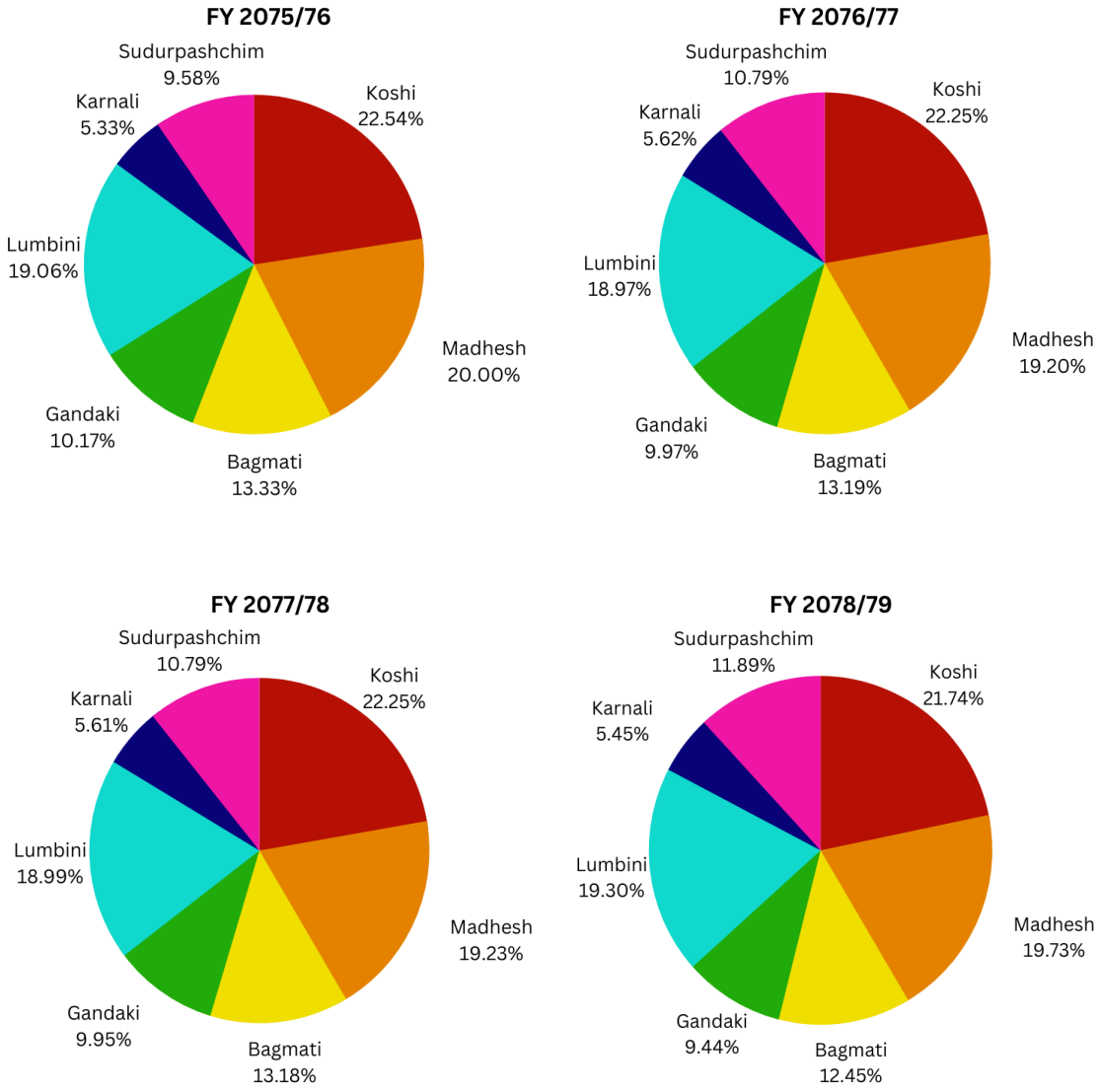


Figure 3-5: Agricultural Residue Production

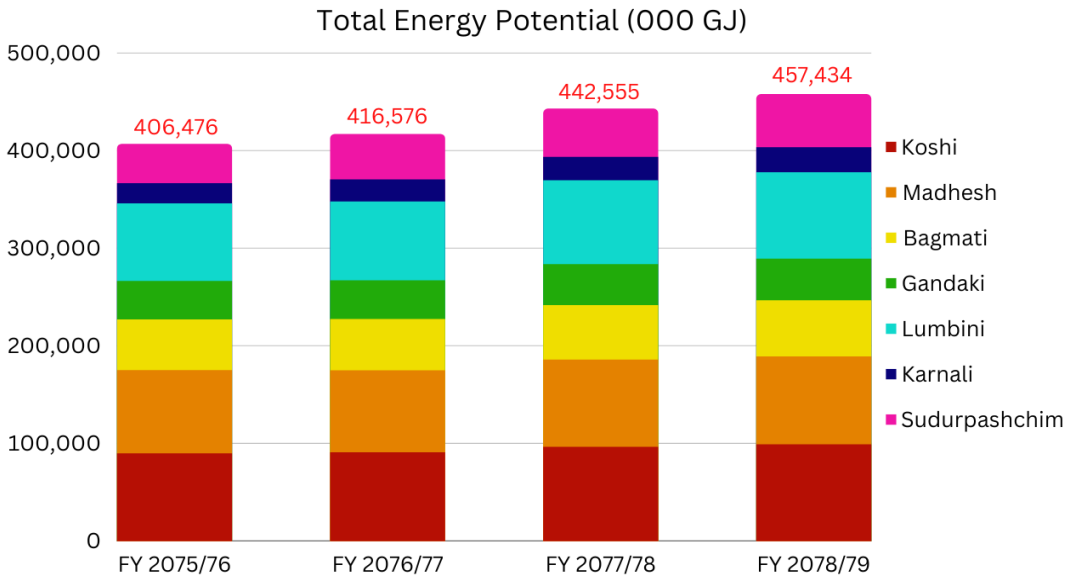


Figure 3-6: Energy Potential from Agricultural Residue

3.2.3 Animal Waste

The calculation for animal waste supply potential was done by considering the cattle and buffalo population, including the milking buffalo population. Based on the WECS 2010 report, the total potential supply of dry dung in 2008/2009 was 15 million tons. In 2019, the population of cattle and buffalo was 7.4 million and 6.9 million respectively. The corresponding dry dung yield was calculated as 6.8 million tons by taking into account the accessibility and collection efficiency of 70%. Additionally, the lower value in 2010 was due to the difference in conversion units as the recent value is based on the latest study in Nepal (Adhikari & Denich, 2019).

There has been only a slight increase in the production of dry dung in recent years. In FY 2077/78 the estimated production reached about 6.92 million tons and in FY 2078/79 was estimated to be 6.96 million tons. The total energy generated in fiscal years 2075/76, 2076/77, 2077/78, and 2078/79 are 101.7, 102.1, 103.2, and 103.8 million GJ respectively (Figure 3-8).

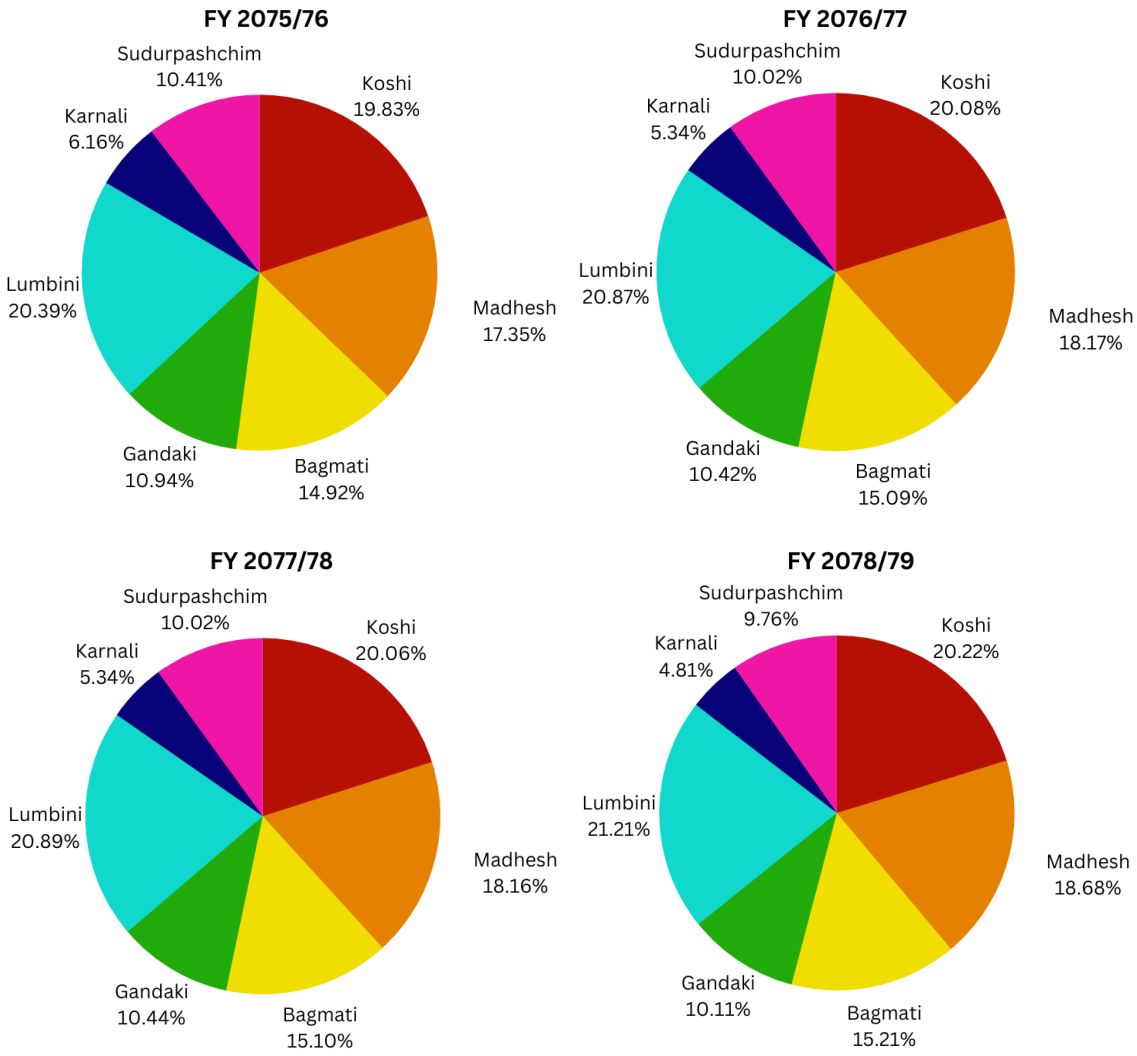


Figure 3-7: Animal Waste Production

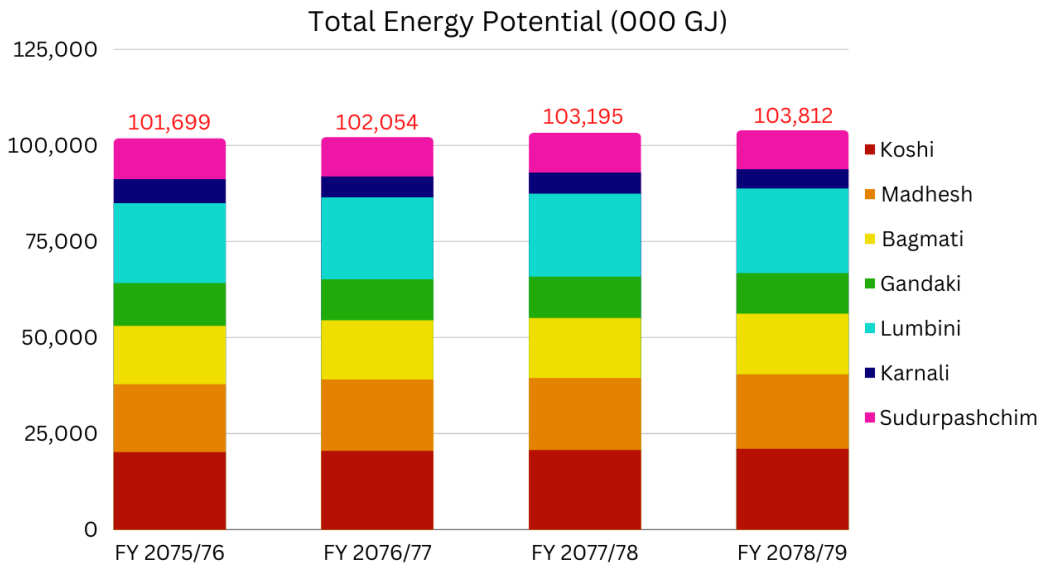


Figure 3-8: Energy Potential from Animal Waste (Dry Dung)

3.2.4 Other

Energy can also be derived from other sources such as logging residue, wood mills, carpentry, and craft industries, and specific food manufacturing sectors like sugarcane processing. However, establishing a standard baseline for logging residues is difficult due to variables like log size, quality, and sawing process. Similarly, wood mills and crafting industries lack traceability and standardized methods to track and account for the residues they produce. The 2010 WECS report determined that 50% of logs are converted into residue with a recovery factor of 60%, meaning that for every ton of residue produces from logs, it is possible to collect 300 kg of logging residue.

Sugarcane mills are another source of energy. These mills have the potential for energy cogeneration through the utilization of bagasse, which offers efficient heat and electricity production. Bagasse is the fibrous residue remaining after sugarcane is processed to extract its juice, and is used as a biofuel for heat and electricity generation in sugar mills. The annual sugarcane production over the past decade averaged around 3 million tons, experiencing a slight decline in the last three years, possibly due to Covid-related lockdowns, which are expected to rebound in coming years. Madhesh province, with the largest Terai plain land, has the highest sugarcane production, followed by Sudurpashchim and Lumbini provinces, while Karnali and Bagmati provinces have the lowest production. Also, considering 34% of sugarcane production can be converted into bagasse, an estimated 1.2 million tons of bagasse was extracted in 2021 (Pokharel et al., 2014).

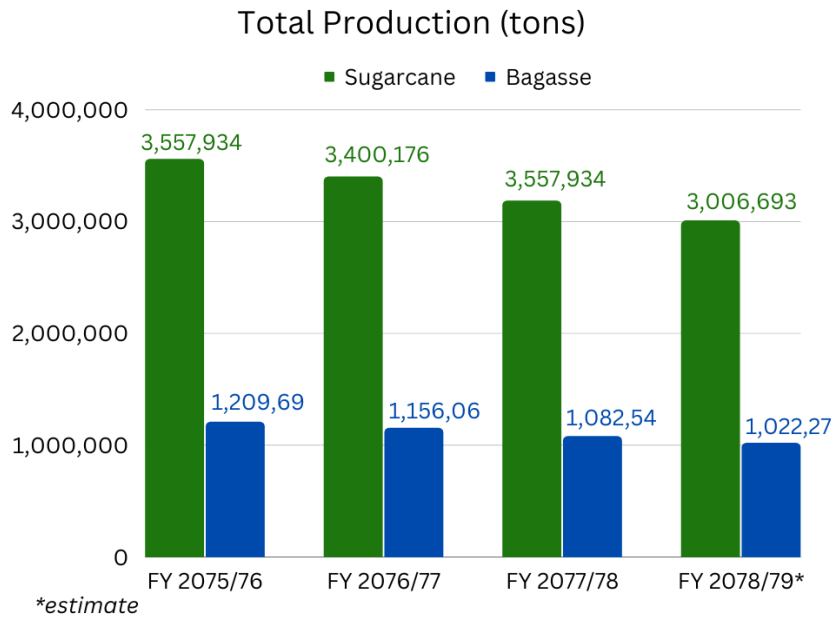


Figure 3-9: Sugarcane and Bagasse Production

3.3 Commercial Energy Resources

3.3.1 Coal

Nepal has an occurrence of low to medium-grade coal deposits and there are four types of coal in four stratigraphic positions:

a) Quaternary lignite
b) Siwalik coal: found along the Churia Hill
c) Eocene coal: found in the Dang-Puithan and the Tosh area of the Dang valley
d) Gondwana coal: No significant Gondwana coal has been encountered in eastern Nepal. Some anthracitic carbonaceous shale lenses have been encountered but they do not show a positive ignition test. Such characteristics are known to occur within the continental and marine rock series near the Barahachettra and Kamphughat areas of eastern Nepal. The coals from the locations Suija, Ajimara, and Abidhara of western Nepal are considered to be of Gondwana age. Surface exposures in these locations indicate promising characteristics favorable for exploration, unlike eastern Nepal.

The following tables summarize the location of coal reserves in the nation that are economically viable and/or under operation for mining, occurrences, and appearance.

The production of coal in the nation was 7250.1 tons in FY 2076/77. This value increased to 11303.9 tons in FY 2077/78 and dropped in FY 2078/79 to 6927.04 tons. In FY 2079/80* the production value was 1355 tons. A total of 9 licenses were issued in each fiscal year 2076/77 to 2078/79 whereas only two licenses have been issued in FY 2079/80* for coal production. The leading consumer of coal in Nepal is the brick-manufacturing industry.

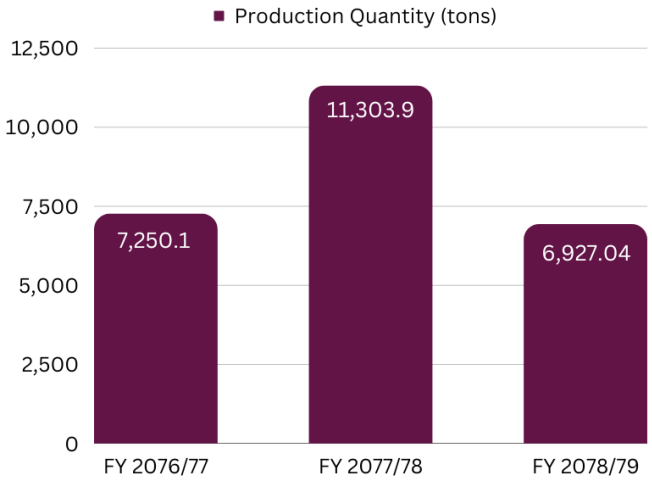


Figure 3-10: National Coal Production Data in Each Fiscal Year

The following table highlights the total national production of coal and total import from the years 2075/76 to 2078/79.

Table 3-10: Coal Production and Import in Nepal (in Kg)

	Year			
Production	**2075/76**	**2076/77**	**2077/78**	**2078/79**
National		7,250,100	11,303,900	6,927,040
Imports				
Anthracite, not agglomerated	3,201,287	2,982,833	110,479	96,559
Bituminous coal, not agglomerated	1,056	0	207,422	40,357,160
Other coal, not agglomerated, n.e.s.	1,664,409,818	1,337,212,825	1,911,595,559	1,740,764,608
Briquettes, ovoids, and similar solid fuels manufactured from coal	28,675	79,906	176,426	60,316,200
Agglomerated lignite	0	2	14,000	0
Lignite, not agglomerated	0	0	0	500
Coke and semi-coke of coal, of lignite or f peat; retort carbon	213,993,422	138,907,825	89,507,340	132,821,763
Coal gas, water gas, producer gas, and similar gases, not petroleum gases	326	0	0	0
Total	**1,881,634,584**	**1,486,433,491**	**2,012,915,126**	**1,981,283,830**

3.3.2 Petroleum Oils and Natural Gas

The Nepal Oil Corporation (NOC) holds exclusive authority over importing and distributing petroleum products within Nepal. The Petroleum Exploration Promotion Project (PEPP) has shown deposits of possible petroleum oil and gases in Dailekh, Surkhet, and other areas. However, action has yet to be taken for further exploration or extraction. As a result, all petroleum products are imported in refined form from India or other overseas countries. The refined form is the ready-to-use form that is suitable for direct consumption.

The NOC currently operates storage facilities with a capacity of 68427 kL for all essential petroleum products, besides LPG which is bottled and distributed by private companies.

Table 3-11: NOC Storage Facility (in kL)

Province	Location	Petrol	Diesel	Kerosene	Jet A1	Total
Koshi	Bhadrapur	0	0	0	83	83
	Biratnagar	560	7110	710	302	8682
Madhesh	Janakpur	30	140	70	92	332
	Amlekhgunj	3430	19840	760	0	24030
Bagmati	Kathmandu	6070	8400	760	7132	22362
	Manthali	0	0	0	27	27
Gandaki	Pokhara	1110	2280	0	157	3547
Lumbini	Bhairahawa	519	3040	140	494	4193
	Bhairahawa Pump	32	48	0	0	80
	Dang	0	0	0	41	41
	Nepalgunj	210	2280	140	303	2933
	Nepalgunj Pump	32	75	0	0	107
Karnali	Dhangadi	115	1590	70	63	1838
	Surkhet	0	0	45	82	127
Sudurpashchim	Dipayal	0	45	0	0	45
Total		**12108**	**44848**	**2695**	**8776**	**68427**

Figure 3-10 shows the total import of petroleum products from FY 2075/76 to 2078/79. After the decline in the import of petroleum products (except LPG) in 2076/77 due to the global pandemic caused by COVID-19, the import values for petrol, diesel, and kerosene increased in 2077/78 by 14.42%, 14.05%, and 21.93% respectively. The import of LPG continued to increase by 6.19%, except for ATF whose value decreased further by 62.15%. In 2078/79, the imports compared to the previous year increased for petrol, diesel, LPG, and ATF by 21.77%, 1.60%, 11.50%, and 73.99% respectively. The import of kerosene, however, declined by 30.52%.

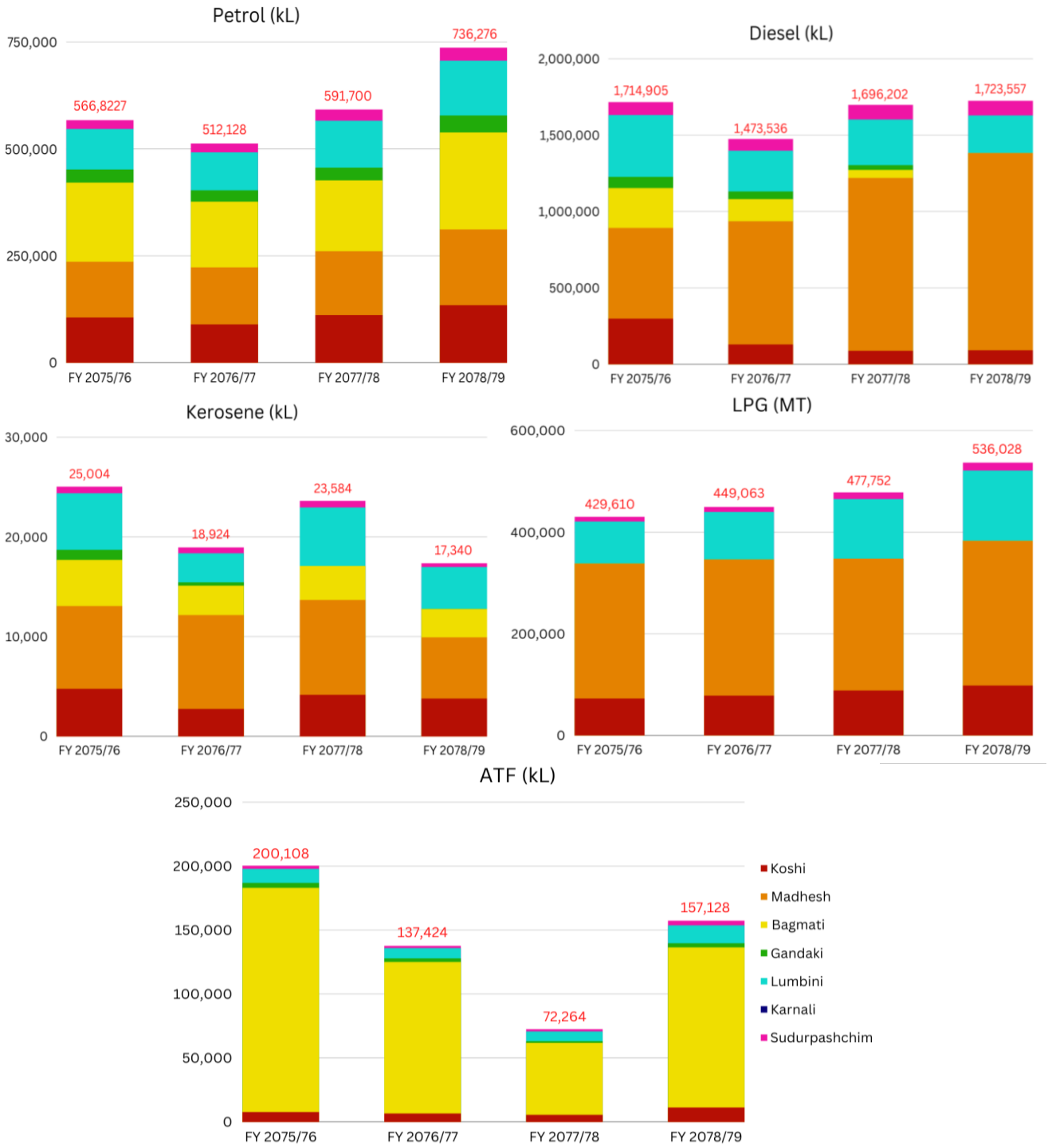


Figure 3-11: Total Import of Petroleum Products across Provinces in Various Fiscal Years

While the import graphs show the absence of imports in some provinces, most petroleum products are sold in almost all the provinces and thus are observed to be distributed. The depots that import, store, and distribute them are scattered throughout the country. Additionally, all the products are not completely sold out. Some quantity remains in stock which adds to the sales in the next period.

Corresponding to the import values, the sales value of petrol, diesel, kerosene, and ATF experienced a decline, except for LPG. In 2077/78, the sales increased for petrol (10.87%), diesel

(12.6%), kerosene (21.61%), and LPG (6.19%). The sales of ATF decreased further by 65.32%. The sale of petrol has increased by almost fourfold in 2078/79 reaching 40.43%. Similarly, sales values of diesel, LPG, and ATF increased by 32.24%, 11.5%, and 74.55% respectively. The value of kerosene has declined by 4.99%.

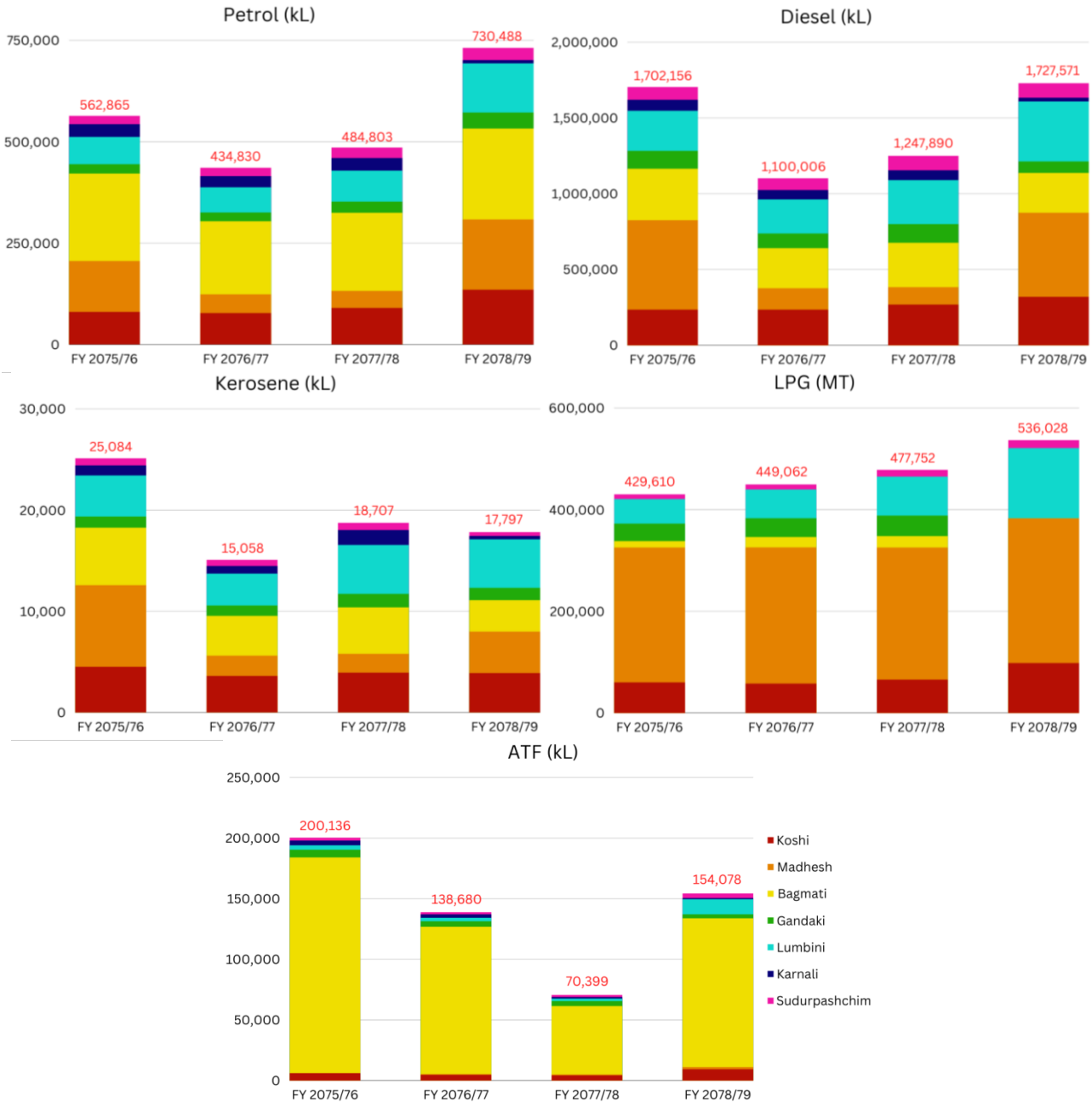


Figure 3-12: Total Sales of Petroleum Products across Provinces in Various Fiscal Years

It is important to note that Nepal's heavy reliance on imported petroleum products is posing significant challenges, with petroleum imports increasing at an alarming 15.2% annually. The country's energy security can be improved by adopting policy interventions that prioritize electrification, resulting in a reduction of Total Primary Energy Supply (TPES) requirement by 8.7% in 2040 compared to the reference scenario, alongside a need for an additional 3,706 MW of power generation capacity to meet the electricity demand *(Gautam, et al., 2023)*.

3.3.3 Electricity

3.3.3.1 Hydropower Potential in Nepal

The theoretical potential of hydropower in Nepal has been estimated at 83,000 MW. The technical and economically feasible potential is about 45,000 MW and 42,000 MW (Shrestha, 1996). Additionally, a study conducted by Bajracharya (2015) has shown that the total estimation of the annual mean flow is 103,341 MW.

Table 3-12: Theoretical Potential of Hydropower in Nepal

River Basin	Shrestha (1966) at 80% Efficiency	Bajracharya (2015)
Koshi	22,350	35,166
Narayani	20,650	32,086
Karnali	32,010	25,755
Rest of Small Basin	8,171	10,334
Total ROR Potential	***83,181***	***103,341***

The study carried out by WECS in 2019 for the estimation of the hydropower potential of Nepal shows a gross hydropower potential of 72,544 MW. This potential is distributed among three major river basins- Koshi, Gandaki, and Karnali- which account for 94% of the aforementioned total gross potential. The distribution of power potential within each province is shown in Table 3-13. Koshi province has the highest potential (22,619 MW) and Madhesh province has the lowest power potential (275 MW).

Table 3-13: Distribution of Gross Hydropower Potential among Provinces

Province	Power Potential (MW)	% of Basin Potential (MW)
Koshi	22,619	31.2%
Madhesh	275	0.4%
Bagmati	10,568	14.6%
Gandaki	14,981	20.7%
Lumbini	2,677	3.7%
Karnali	13,702	18.9%
Sudurpashchim	7,722	10.6%
Total	**72,544**	**100%**

3.3.3.2 Hydropower Projects Developed by NEA

NEA (Nepal Electricity Authority) holds the sole responsibility for the operation and distribution of electricity supply in Nepal. As of FY 2078/79, NEA has developed a total installed hydropower capacity of 626.7 MW, resulting in the generation of 3,242.5 GWh of energy. There has been a significant increase of 14.61% in electricity generation compared to the previous

fiscal year. The annual national peak demand for electricity reached 1,748 MW. In FY 2078/79, Nepal also exported 493.6 GWh of energy.

When it comes to thermal power generation, the functioning Hetauda diesel power plant stands as the only one, with an installed capacity of 14.41 MW and generating 32.51 MWh of energy.

3.3.3.3 Hydropower Projects under Development, Planned, and Proposed by NEA

Nepal's electricity sector is witnessing significant development with a number of projects underway. Currently, there are eight projects being actively developed, collectively contributing a total capacity of 943.1 MW. Additionally, there are eleven planned and proposed projects that hold the potential to further enhance the country's power generation capacity, with a combined capacity of 3,450 MW. These projects signify Nepal's commitment to expanding its energy infrastructure and meeting the growing demand for electricity.

3.3.3.4 Hydropower Projects under Development and Planned by IPP

Apart from the NEA, the Independent Power Producers (IPP) also plays a significant role in electricity generation in Nepal. As of 30 Poush 2079, IPP has successfully installed projects with a total capacity of 1,709.1 MW. Moreover, there are 134 ongoing projects that have achieved financial closure, with a combined capacity of 3,253.3 MW. Additionally, there are 89 projects under development, currently without financial closure, but possessing a capacity of 1,857.4 MW.

3.3.3.5 Electrification Status of Nepal

The electrification status in Nepal has shown significant progress over the past few years, with national electricity access increasing from 93% in 2077/78 to 94% in 2078/79. The government aims to achieve 100% electricity access across the country by 2023 (2079/80).

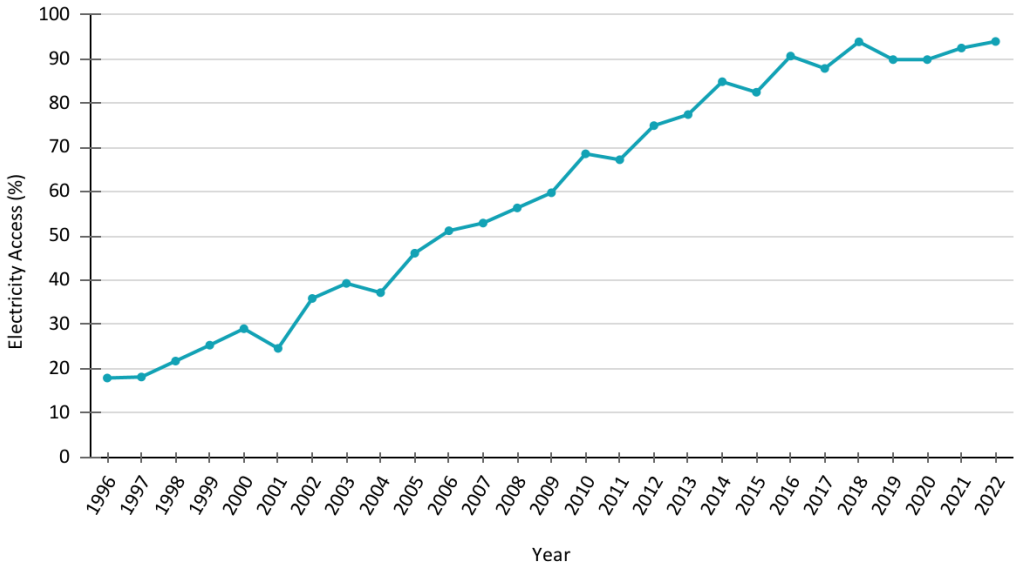


Figure 3-13: Share of Nepal's Population with Access to Electricity
(Source: World Bank and South Asia Energy Database)

Figure 3-13 offers an overview of the provincial electrification status in Nepal, in conjunction with the national electricity access, for the period spanning from 2075/76 to 2078/79. Provinces such as Koshi, Madhesh, Bagmati, Gandaki, and Lumbini have achieved electricity access rates comparable to the national average, exceeding 90%. Although Karnali province initially had the lowest electricity access, there have been notable improvements. The current electrification status for provinces Koshi, Madhesh, Bagmati, Gandaki, Lumbini, Karnali, and Sudurpashchim stands at 91.23%, 99.95%, 97.47%, 97.76%, 96.73%, 56.79%, and 78.85% respectively. These figures demonstrate the progress made in expanding electricity access across different provinces of Nepal. This analysis emphasizes the lower electrification status of the Karnali and Sudurpashchim provinces, pointing to their relatively lower level of development.

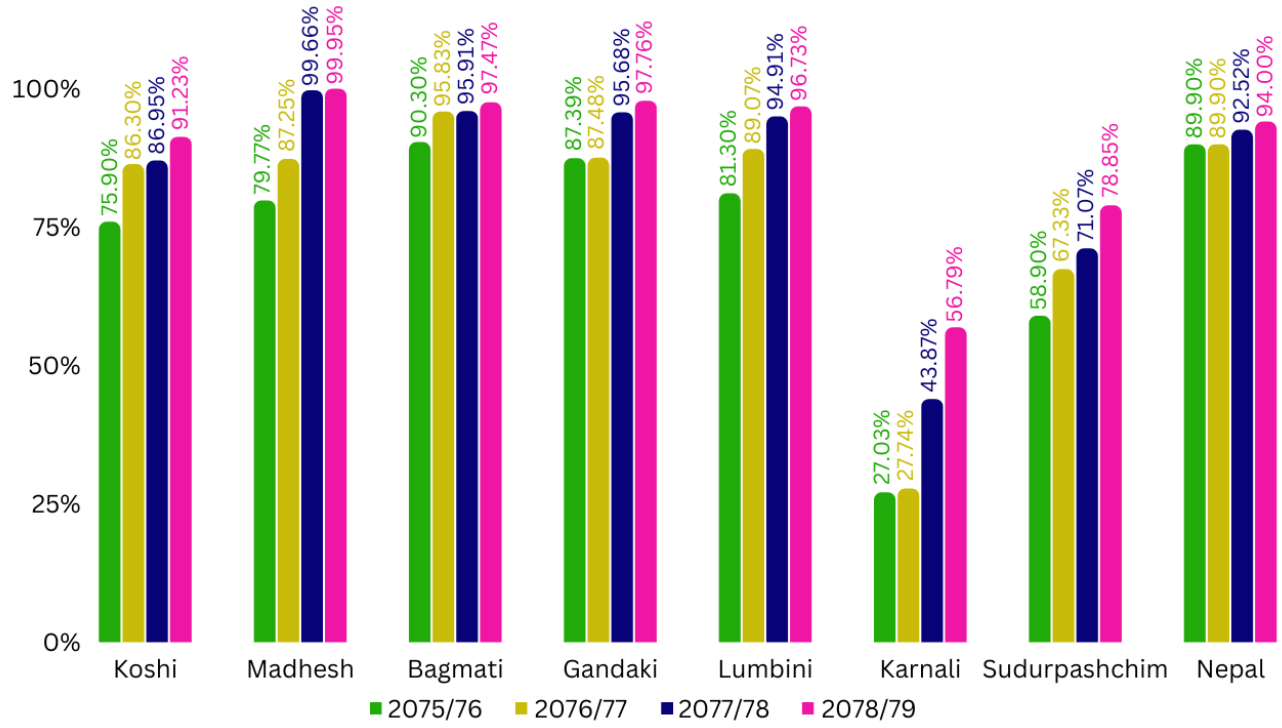


Figure 3-14: Provincial and National Electrification Status *(MoF, 2022)*

3.4 Modern Renewable and Alternative Energy Resources

3.4.1 Micro Hydro

Micro-hydro and pico hydro are small-scale hydroelectric power systems generating electric power below 100 kW and 1 kW capacity, respectively. Pico Hydro utilizes various technologies, such as Peltric Sets, Pelton Turbines (for low discharge and high head), Cross Flow Turbines, and other technologies (for high discharge and low head), depending on available water flow and elevation. These systems primarily serve nearby households through local, decentralized, isolated mini-grids. Micro/pico hydro plants are practical and cost-effective solutions for providing electricity in rural and remote areas where extending the national grid is challenging. The majority of these plants are concentrated in mountainous and hilly regions where water sources are abundant, while districts in the Terai region have fewer installations due to insufficient water flow and elevation for micro-hydro installations.

The installation of mini/micro hydro systems demonstrates a positive trend, indicating a growing utilization of these technologies. In 2076/77 the rate of installation increased to 34,870 kW by 8.09% from the previous year's value of 32,159 kW. This value continued to increase by 3.15% in 2077/78 and by 4.74% in 2078/79 to 37,734 kW.

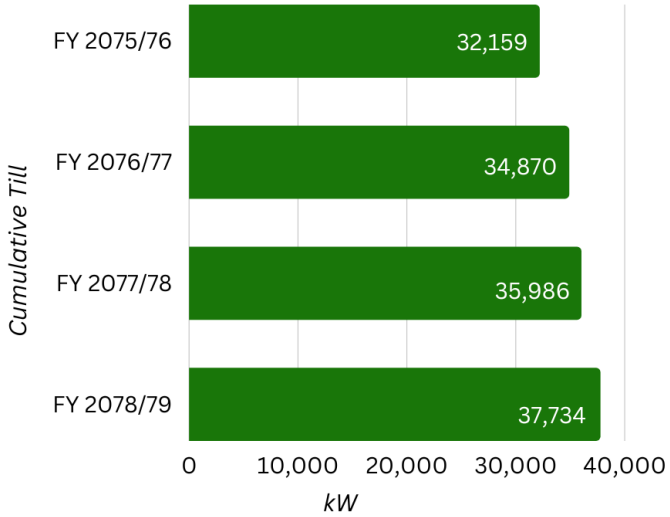


Figure 3-15: Cumulative Installation of Mini/Micro Hydro Systems (up to 2078/79)

3.4.2 Solar PV

The solar energy potential in Nepal is substantial with an average of 300 days per year and approximately 6.8 hours of sunshine per day (Poudyal et al., 2019). These climatic conditions actively favor the generation of solar energy in the country.

In terms of solar energy potential, the northwest region of Nepal receives high levels of global horizontal irradiation (GHI), reaching 5.5 kWh/m^2/day. The southern regions have an average GHI ranging between 4.4 kWh/m^2/day and 4.9 kWh/m^2/day. Nepal has a specific solar photovoltaic (PV) electricity output capacity ranging from 1400 kWh/kWp to 1600 kWh/kWp. This translates to average daily totals of 3.8 kWh/kWp to 4.4 kWh/kWp. The mountainous areas exhibit a greater potential for PV energy yield due to their higher elevation and lower air temperature. Therefore the hills and lower-elevation mountains with favorable GHI and lower temperatures are considered prime locations for solar PV systems in Nepal.

Based on the Solar and Wind Energy Resource Assessment (SWERA) conducted by the Alternative Energy Promotion Centre (AEPC), Nepal has an estimated commercial potential of approximately 2,100 MW for on-grid solar PV systems. AEPC is the central government body responsible for promoting solar technologies in Nepal.

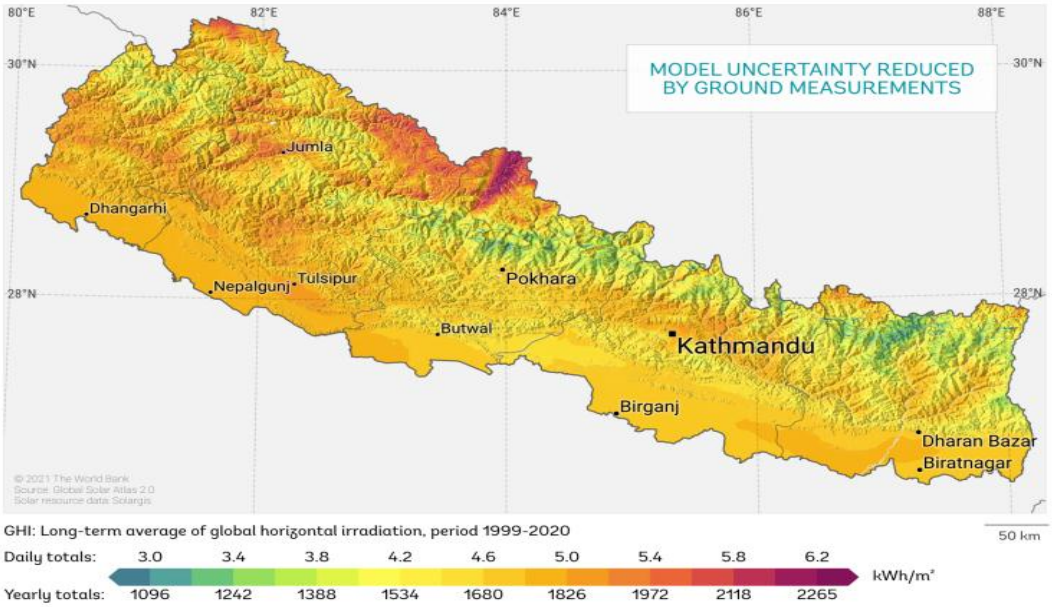


Figure 3-16: Global Horizontal Irradiation Levels Throughout Nepal

Solar home systems (SHS) represent the largest portion of installed PV systems fulfilling the energy needs of individual households through rooftop installations. As of FY 2078/79, a total of 974 thousand residential solar PV systems have been installed, primarily concentrated in remote districts of Western Nepal where access to grid electricity is limited. The installation of SHS faced significant challenges following the massive 2015 earthquake and subsequent trade issues. Additionally, the discontinuation of power cuts in 2017 temporarily decreased the demand for SHS, but it rebounded the following year. The impact of COVID-19 and related restrictions had a relatively minor influence on SHS installations.

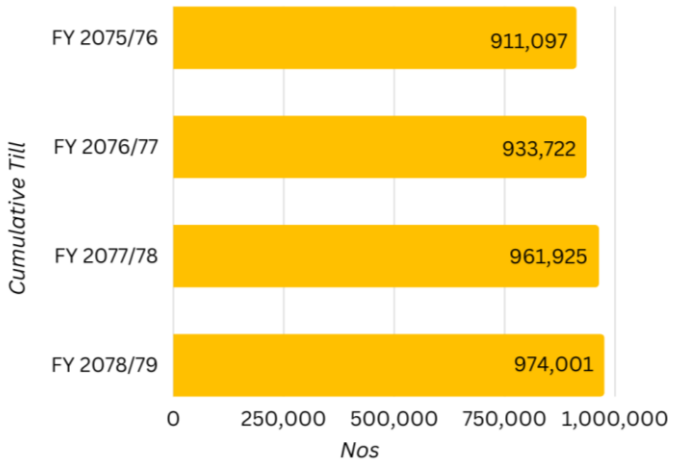


Figure 3-17: Cumulative Installations of Solar Home Systems

The installations of Integrated Solar Power Systems (ISPS) have been increasing steadily, indicating a growing adoption of comprehensive solar power systems. Until FY 2078/79, 3,817 systems have been installed, indicating an increase of about 30% from the previous year.

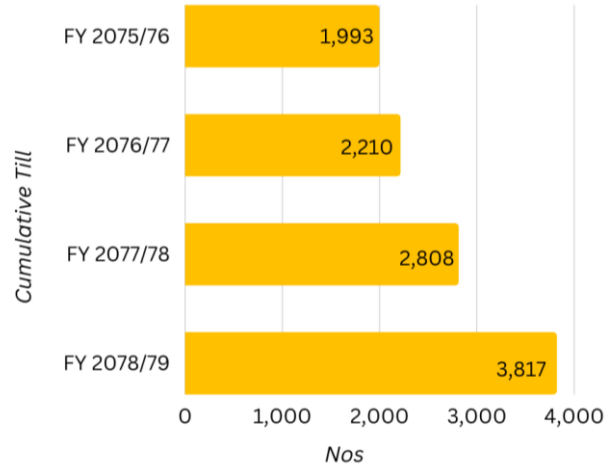


Figure 3-18: Cumulative Installations of Institutional Solar PV Systems

The installation of Photovoltaic Pumping Systems (PVPS) for drinking water-primarily targets communities residing in hilly regions, where accessing clean water requires traveling long distances. This system is least prevalent in the Terai region where shallow boring is sufficient for accessing water. However, PSVS for irrigation is prevalent in the Terai region as it encompasses the majority of agricultural areas.

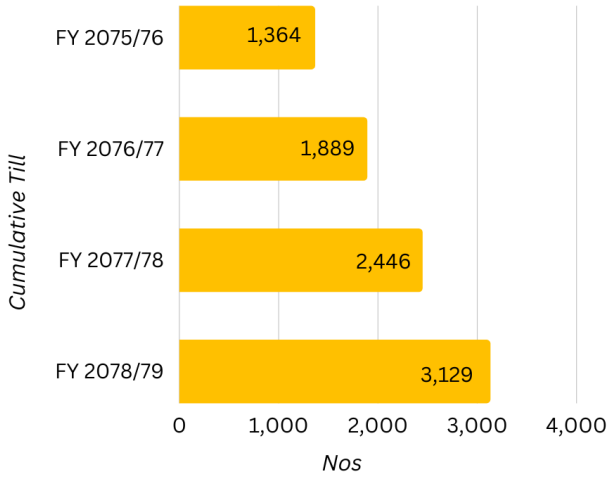


Figure 3-19: Cumulative Installations of Solar Drinking Water and Irrigation Pump

3.4.3 Biogas

Biogas is generated through the anaerobic digestion of organic matter, primarily from domestic animal manure and human waste. The resulting slurry serves as an environmentally friendly alternative to chemical fertilizers. This contributes to cost savings and maintaining a clean and sustainable environment. In Nepal, with its significant agricultural sector involving 60.4% of the population, the abundant biomass from livestock and farming activities makes biogas an ideal technology for cooking, with approximately 1.9 million households (42% of the total) having the potential for household biogas system installation, as highlighted in the recent study by Adhikari and Adhikari (2021) (Table 3-14).

Table 3-14: Annual Biogas Production and Fuelwood Saving Potential of Nepal

	Mountain	Hill	Low Land
Annual per capita fuelwood consumption (kg/year)	712	598	482
Annual per capita biogas requirement (m3/year)	155	130	106
Annual net weight of fresh dung (kg/household/year)	3,501	5,386	7,669
Average household size (number of people)	6	4	4
Annual potential biogas production (m3/household/year)	22	49	64
Weight of per capita saving of fuelwood (kg per capita)	101	224	292
Percentage share of saving of fuelwood (%)	14	37	60

1 m^3 biogas = 4.57 kg fuelwood

1 kg fresh dung = 0.036 m^3 biogas

The Government of Nepal has been actively promoting the implementation of biogas plants of various capacities, including 2 cubic meters, 4 cubic meters, 6 cubic meters, and 8 cubic meters, specifically for domestic use. These plants adhere to the GGC 2047 standard and the modified design based on GGC 2047.

Since FY 2075/76, there has been only a slight increase in biogas installations. As of 2078/79, there has been a cumulative of 439,547 installations.

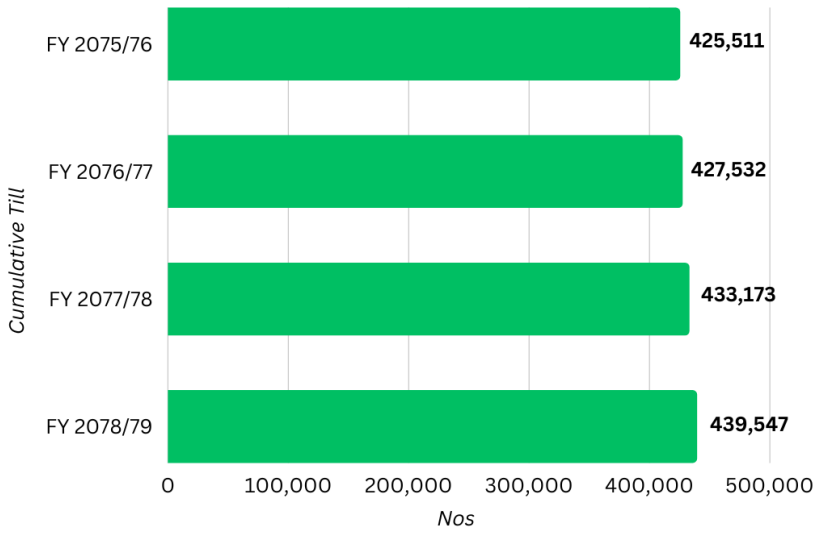


Figure 3-20: Cumulative Installation of Domestic Biogas

The development of large biogas plants with a capacity exceeding 12 cubic meters in Nepal is a significant achievement in biogas technology. This progress is the result of long-term practices based on the modified GGC 2047 model and valuable insights from international technological experiences. The large biogas plant category encompasses a wide range of systems, including institutional, community-level, and commercial installations. As of 2078/79, there have been a total of 355 large biogas installations.

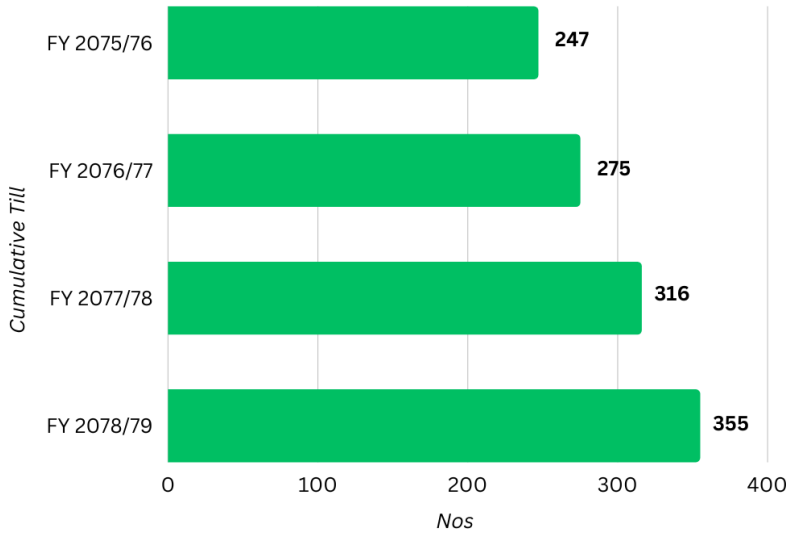


Figure 3-21: Cumulative Installation of Large Biogas Plants

While the majority of large biogas plants in Nepal are institutional, there are also notable examples of commercial-scale installations. These include 4,200 m^3 plants in Pokhara, 3,750 m^3 plants in Nawalparasi, and 3,500 m^3 plants in Syangja.

3.4.4 Wind Energy

Generation of electricity from wind involves converting wind energy into electricity through the use of wind turbines. In recent years there has been a rapid acceleration in the development of wind energy systems worldwide. According to the Global Electricity Review-2023, in 2022 wind power contributed 312 TWh of electricity generation indicating a significant increase of 17% from the previous year.

According to an assessment conducted by AEPC regarding the electricity generation from wind (at 50m above ground level (a.g.l.) with a resolution of 5 km), a wind power density of more than 300 W/m^2 was observed in Mustang and Solukhumbu. Similarly, the power density was observed to be between 200-250 W/m^2 in Humla and Sankhuwasava, between 150-200 W/m^2 in Myagdi and Manang, and between 100-150 W/m^2 in Bajhang, Darchula, Dolakha, Dolpa, Mugu, and Taplejung districts. The remaining districts have a wind power density of less than 100 W/m^2, which is generally not useful for wind energy harnessing. Wind power densities greater than 200 W/m2 are considered for non-grid-connected power generation, while greater than 300 W/m2 are considered for grid connectivity in developing countries. Considering 10% of Nepal's area with a wind power density of 300 W/m2, Nepal has the potential to produce 3000 MW of electricity from wind (UNEP/GEF, 2008).

In 2016, the World Bank conducted a wind resource mapping of Nepal by using the Weather Research and Forecasting (WRF) model, showing the distribution of mean annual generalized wind power density at 100m a.g.l. for the period 2004/08/04 to 2013/08/14. The mapping was done at 3 km x 3 km grid spacing.

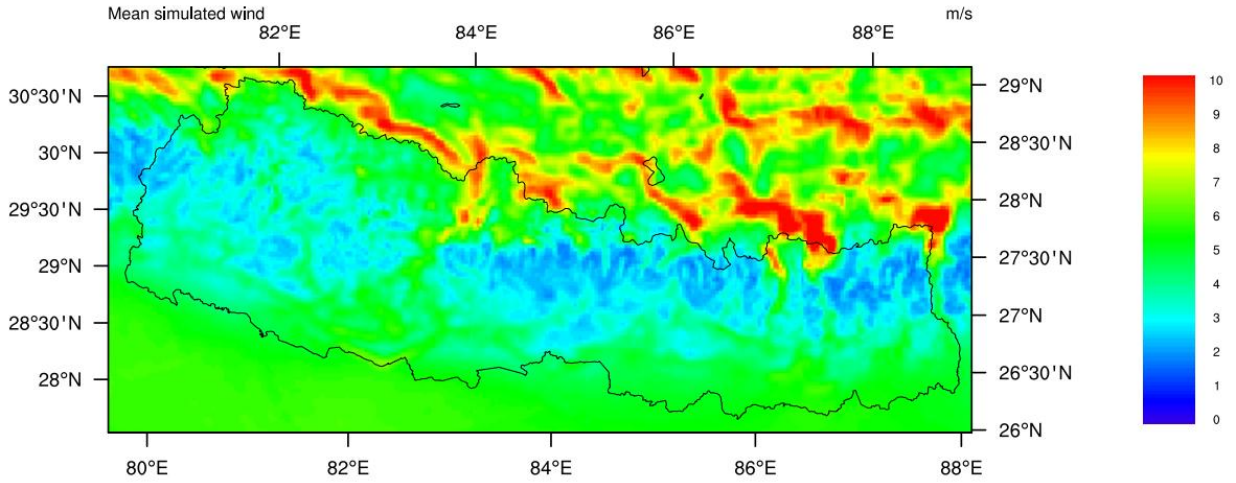


Figure 3-22: Mean Annual Simulated Wind Speed for Nepal at 100 m a.g.l.

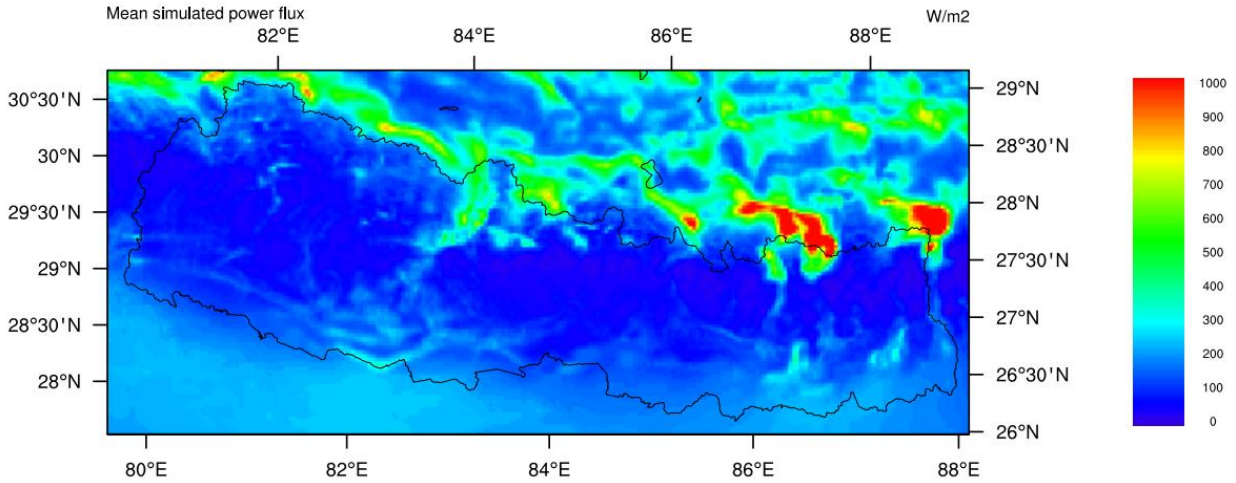


Figure 3-23: Mean Annual Simulated Wind Power Density for Nepal at 100 m a.g.l.

Despite its huge potential, there has been no significant development in the wind energy sector in Nepal. The two 10 kW wind turbines installed by the NEA in Kagbeni, Mustang in 1989 were destroyed within three months of project commencement (Ghimire & Poudel, 2010). As of 2018, the total installed wind turbine capacity was 113.6 kW, consisting of 65 kW wind turbines provided by the AEPC, 3.5 kW wind turbines provided by Practical Action, and 45.1 kW wind turbines provided by the private sector (Poudyal, et al., 2019). AEPC installed two 5 kW wind turbines with a 2 kW solar hybrid system in Nawalparasi, Dhaubadi VDC, with support from the Asian Development Bank. Additionally, they established wind-solar hybrid systems with 400 W and 150 W solar power projects in six different sites. These projects directly benefited more than 19 households of Dalits in Pyuthan, including a mosque and two secondary schools in Pyuthan and Palpa (AEPC, 2022).

In FY 2065/66, two more wind turbines were added to the Haibung VDC of Sindupalchowk, benefiting over 29 households. In 2017, AEPC collaborated with ADB to install a wind-solar hybrid system consisting of 20 kW wind turbines and 15 kW peak solar panels in Hariharpurgadi village of Sindhuli district. This project produced 110 kWh of energy per day for 83 rural

households (ADB, 2017). The total capacity of the solar-wind hybrid mini-grid system reached 1500 kW (SEMAN, 2022).

3.4.5 Other Resources

3.4.5.1 Waste-to-Energy

Energy can be generated from organic municipal waste through waste-to-energy technologies. These technologies involve processing waste to produce electricity and/or heat and thus can provide a renewable source of energy to meet increasing energy demands.

According to the Waste Management Baseline Survey report published by CBS in 2021, According to a 2020 report, approximately 6 million tons of waste are collected annually, with organic content compromising around 54%. Only a small percentage of the waste is used for manure and recycling, while a significant portion is dumped, burnt, or left untreated. The collected waste, particularly the organic fraction, holds the potential as a valuable feedstock for energy generation. In FY 2075/76, a total of 15,581.9 metric tons of organic waste was generated in metropolitan cities, sub-metropolitan cities, and municipalities of Nepal. Specific areas like Kathmandu, Lalitpur, and Pokhara show the potential to generate 1,745 MWh, 278 MWh, and 244 MWH of electricity, respectively from waste (Sodari & Nakarmi, 2018).

Another study (by Lohani, et al., 2021) suggests that utilizing 100% of the organic fraction of municipal solid waste (OFMSW) in Kathmandu can generate 130,294 cubic meters of biogas, equivalent to filling 21,045 LPG cylinders per day and saving NRs 515 million. A bio-methanization plant was established in Teku, with the support of the European Commission and the Nepalese government, which has the capacity to convert 3 tons of OFMSW into biogas per day. Additionally, a waste-to-energy plant in Pamara, Dharan sub-metropolitan, processes 30 tons of municipal waste daily, generating bio-CNG and organic fertilizers (AEPC, 2021).

3.4.5.2 Hydrogen Fuel

Hydrogen fuel refers to the use of hydrogen gas as a source of energy. Hydrogen reacts with oxygen to generate heat and electricity with water vapor as the sole byproduct. It is produced via processes like electrolysis or steam methane reforming, the latter method leading to carbon emissions that require carbon capture and storage technologies.

Approximately 50 units of electricity are required to produce 1kg of hydrogen fuel, which in turn allows a car to travel approximately 60-70 km, depending on driving conditions. The fuel can be utilized in the transportation sector where the hydrogen fuel cells can be used to power vehicles. Additionally, hydrogen cells can also be used to generate electricity and heat for buildings and industrial applications. Nepal has significant potential for hydrogen fuel generation, and studies are being carried out to further explore its capacity and utilization.

3.5 Energy Consumption of Nepal

3.5.1 Energy Consumption by Fuel Types

In FY 2078/79 (2022), the energy consumption reached 640 PJ, reflecting a slight increase compared to the previous year. Traditional energy types still dominate the energy mix, accounting for 66.14% of the total consumption, with a slight decrease from FY 2077/78 (66.26%).

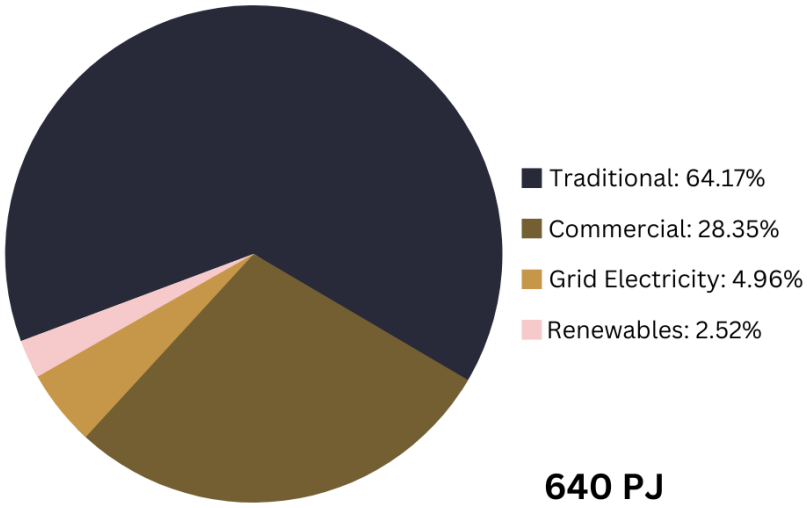


Figure 3-24: Overall Energy Consumption of Nepal in 2022

Fuelwood remains the leading fuel type consumed in 2022, representing 58.53% of the total fuel type consumption. However, there has been a decrease from the previous year's value of 60.38%. The use of agricultural residues has decreased from 3% in 2021 to 2.81%, while the consumption of animal wastes has decreased from 2.87% to 2.84%.

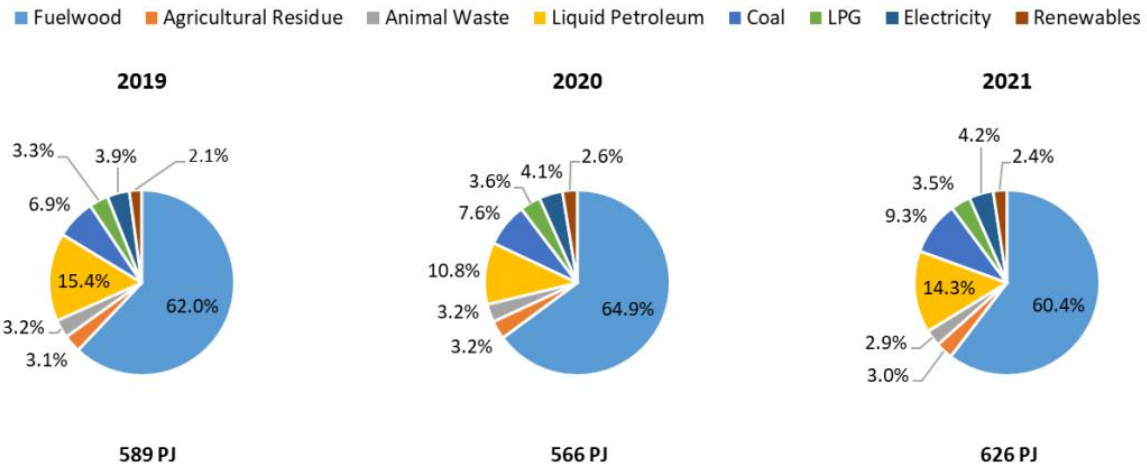


Figure 3-25: Energy consumption in 2019, 2020, and 2021

The consumption of commercial fuels has decreased to 28.35% compared to the previous year's 27.13%. On the other hand, electricity consumption has increased to 4.96%. The usage of renewable energy contributes only 2.52%.

Table 3-15: Overall Energy Consumption in Nepal in 2022

	FY 2078/79					Growth Rate from previous FY
Category	**Fuel Type**	**Energy (000 GJ)**	**000 TOE**	**GWh**	**% of National Total**	
Traditional	Firewood	374,562.95	8,946.28	104,877.63	58.53%	-0.85%
	Agricultural Residues	17,965.50	429.10	5,030.34	2.81%	-4.35%
	Animal Waste	18,150.14	433.51	5,082.04	2.84%	1.02%
	Total	410,678.59	9,808.89	114,990.01	64.17%	-0.93%
Commercial	Coal	58,148.22	1,388.85	16,281.50	9.09%	-0.51%
	Petrol	24,653.98	588.85	6,903.11	3.85%	26.04%
	Diesel	66,079.60	1,578.28	18,502.29	10.33%	4.12%
	Kerosene	640.68	15.30	179.39	0.10%	-22.91%
	LPG	24,657.27	588.93	6,904.04	3.85%	13.09%
	ATF	5,392.72	128.80	1,509.96	0.84%	143.10%
	Furnace Oil	1,834.45	43.82	513.65	0.29%	-46.03%
	Total	**181,406.91**	**4,332.83**	**50,793.94**	**28.35%**	**6.88%**
	Grid Electricity	**31,766.40**	**758.73**	**8,894.59**	**4.96%**	**20.45%**
Renewable	Biogas	10488.72	250.52	2,936.84	1.64%	7.50%
	Wind	1.87	0.04	0.52	0.0003%	0.00%
	Micro/Pico Hydro	539.97	12.90	151.19	0.08%	4.86%
	Solar	5083.32	121.41	1,423.33	0.79%	6.80%
	Total	***16113.88***	***384.87***	***4,511.89***	***2.52%***	***7.19%***
Total		**639,965.79**	**15,285.32**	**179,190.42**	**100%**	**2.28%**

The energy consumption trend throughout the years is shown in the Figure 3-26.

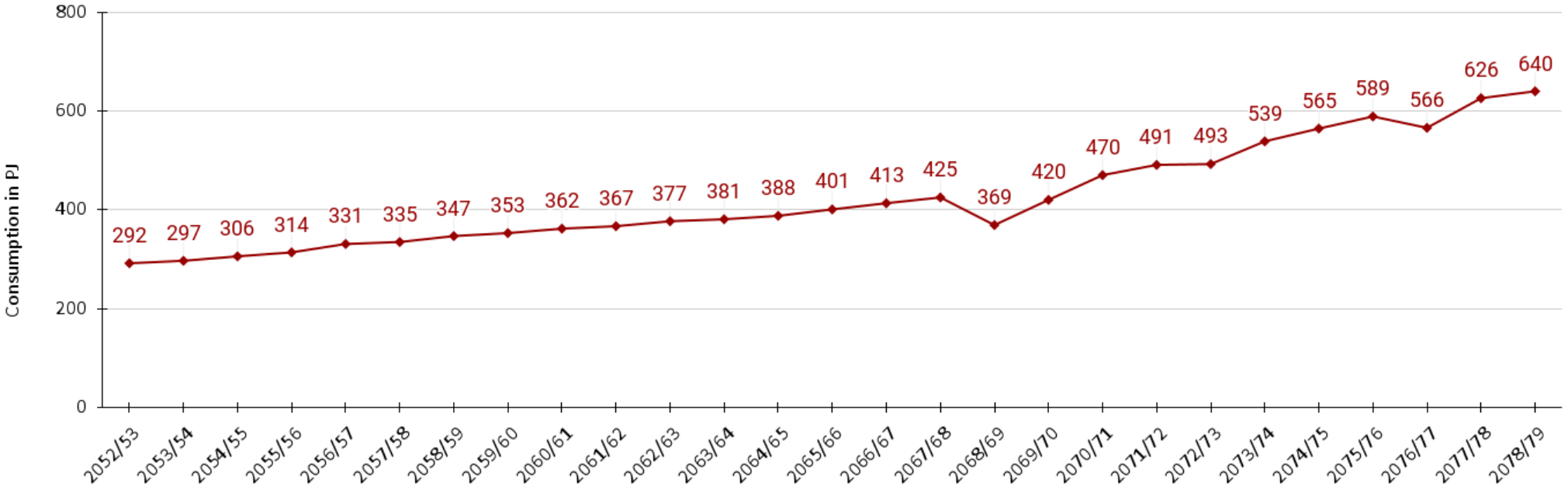


Figure 3-26: Total Energy Consumption throughout the Year

3.5.2 Sectoral Energy Consumption

The national consumption is dominated by the residential sector which accounts for 60.59% of the total consumption. Despite over 60% of the population engaging in agricultural activities, the traditional and less energy-intensive practices have led to the agriculture sector only accounting for 0.94% of the total consumption. The detailed analysis of each sector is discussed in further sections.

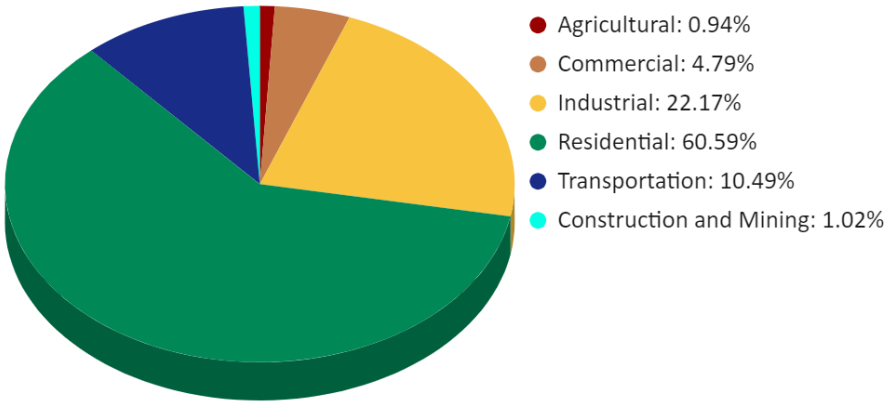


Figure 3-27: Sectoral Energy Consumption of Nepal in 2022

3.5.2.1 Residential Sector

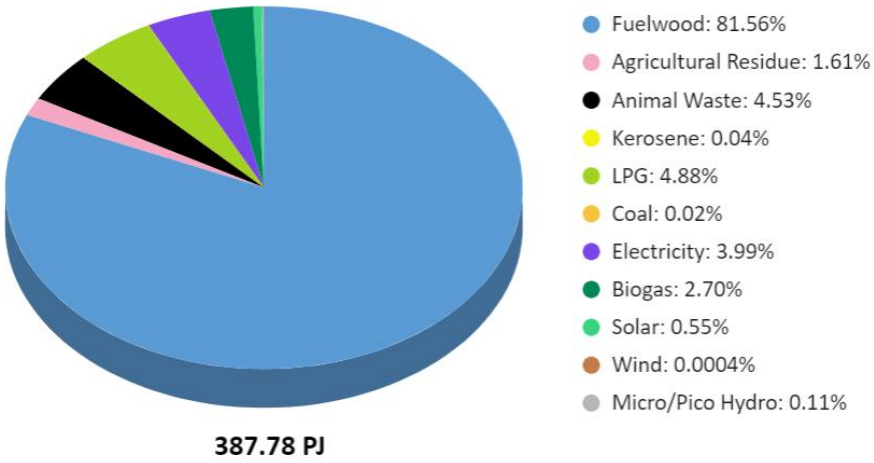


Figure 3-28: Energy Consumption by Fuel Types Residential Sector

The residential sector remains the highest energy-consuming sector (387.78 PJ), accounting for 60.59%. While fuelwood still dominates residential energy consumption at 81.56%, its share has decreased from 87% in 2009, primarily due to the adoption of more efficient technologies. However, the residential sector is still at risk in terms of energy security, with a growing dependence on imported LPG, which has more than doubled in consumption over the past decade. The promotion of alternative energy sources such as biogas and solar, along with an increase in electricity usage, is contributing to cleaner energy options. Although the residential sector was less impacted by pandemic restrictions compared to other sectors, the use of traditional fuel remained predominant. The growth of renewable energy was temporarily affected in 2020 but has resumed after the lifting of restrictions. Residential energy consumption

increased by 1.78% in 2020 and by 2.63% in 2021. In 2022, the consumption is observed to have decreased by 2.03%. This may be due to the calculations made on the basis of the recent census data and the increasing migration of people to other countries for work and other opportunities, and overestimation of data in the previous report.

3.5.2.2 Industrial Sector

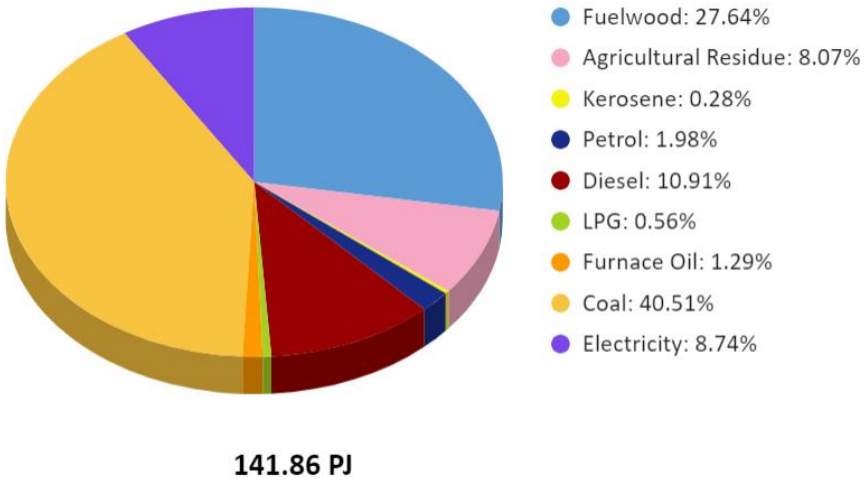


Figure 3-29: Energy Consumption by Fuel Types Industrial Sector

The industrial sector was also impacted by Covid-19 restrictions, resulting in a decrease in energy consumption by 5.99% in 2020. However, with the easing of restrictions, the sector experienced a growth rate of 25.36% from 2020 to 2021. This sector represents a highly energy-intensive segment of the economy, accounting for a total consumption of 141.86 PJ. This sector stands as the second-highest energy-consuming sector in the country, comprising 22.17% of the national total. Thermal energy usage predominates in the industry sector, with coal being the most widely used energy type at 40.51%, followed by fuelwood at 27.64%, primarily utilized in furnaces. Additionally, a significant amount of agricultural residue is employed in boilers. While there is an increase in the adoption of electricity for thermal purposes, the pace of replacing outdated technologies still needs to be increased. Diesel consumption is also notable in the industry sector, primarily for motive power, including running generators. Diesel as well as furnace oil is also utilized for thermal purposes in boilers.

3.5.2.3 Commercial Sector

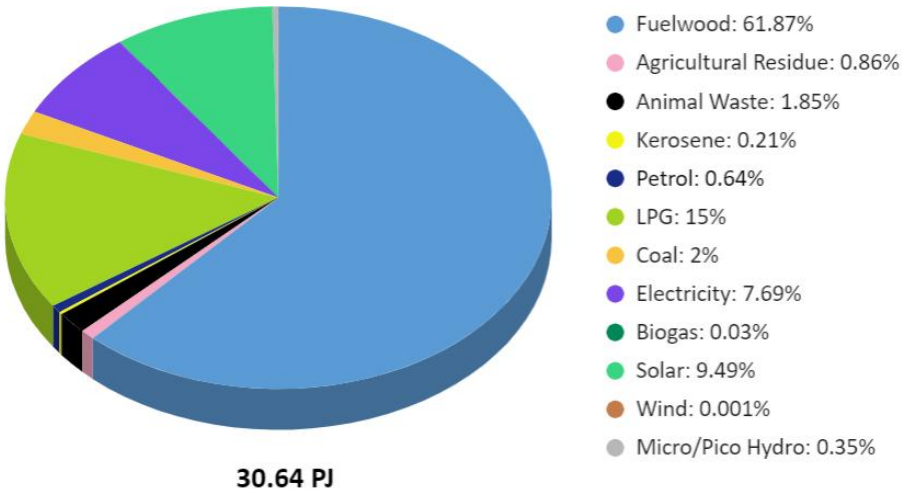


Figure 3-30: Energy Consumption by Fuel Types Commercial Sector

Although the commercial sector is experiencing rapid growth as an economic sector, it accounts for only 4.79% of the national consumption. Despite the sector's expansion, the rate of energy consumption is not increasing at the same pace. This is primarily because the commercial sector is less energy-intensive compared to other sectors, mainly relying on highly efficient electricity. Furthermore, the reduction in power outages has led to a decrease in the use of petroleum generator sets.

The largest portion of the energy consumed (30.64 PJ) in the commercial sector is in the form of thermal energy, primarily used for cooking in the food and accommodation subsector. Consequently, the dominant energy types in the commercial sector are fuelwood, electricity, and LPG. Conversely, the use of kerosene and diesel is minimal due to the availability of electricity, which has reduced the reliance on generators. Notably, there has been significant growth in the adoption of renewable energy sources, particularly solar power (both photovoltaic and thermal).

The energy consumption in the commercial sector was impacted by the restrictions imposed during the pandemic. As a result, there was a drop in energy consumption in 2020. However, the impact of the pandemic on the industrial and transport sectors was not as significant. Energy consumption in the commercial sector decreased by 1.4% in 2020 but rebounded with a growth rate of 8.78% from 2020 to 2021. This rate has, however, been observed to decrease by 35.27% in 2022. This higher reduction rate may be due to the increasing migration of people to other countries for work and other opportunities, and overestimation of data in the previous report.

3.5.2.4 Agricultural Sector

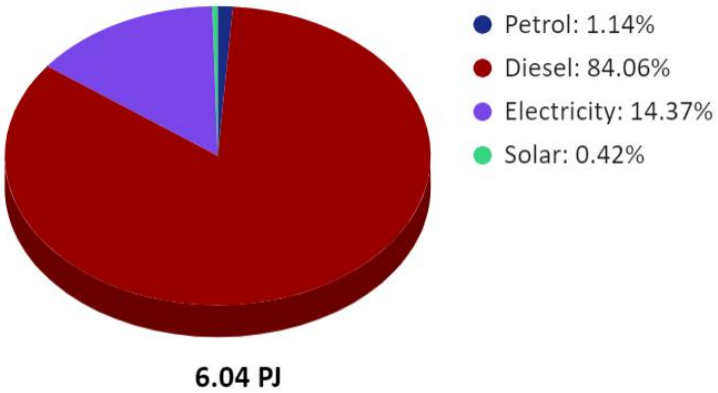


Figure 3-31: Energy Consumption by Fuel Types Agriculture Sector

Energy consumption in the agricultural sector of Nepal is primarily driven by various farming activities such as water pumping, tilling, threshing, and harvesting. Among these activities, water pumping, particularly in the Terai region, accounts for the highest energy usage. In hilly regions, irrigation is often gravity-fed or reliant on rainwater. While a few large farming areas utilize modern machinery, small holdings still rely on draught animals for agricultural tasks.

This sector consumes 6.04 PJ of energy, with diesel comprising 84.06% of the energy source. Farm machineries like water pumps and irrigation systems operate on electricity, while most machinery like tillers and harvesters operate on petroleum products mainly due to the mobility requirements of machinery like. Furthermore, diesel-powered water pumps are commonly used. However, there has been a growing trend in recent years toward adopting solar pumping systems for irrigation. As a result, solar energy contributes 0.42% to the agricultural sector's energy consumption, and this share is expected to increase in the future.

It is worth noting that the COVID-19 pandemic had a relatively minimal impact on the agricultural sector in Nepal due to its subsistence-based nature deeply embedded in the livelihoods of the Nepalese people. Despite this resilience, energy consumption in the agricultural sector experienced a slight increase from 9.1 PJ in 2019 to 9.4 PJ in 2020, indicating a growth rate of 3.76%. However, in the following years, the consumption rate showed a declining trend, resulting in 9.18 PJ in 2021, with a growth rate of -2.98%, and further dropping to 6.04 PJ in 2022, reflecting a significant decrease of 41.35%.

3.5.2.5 Transportation Sector

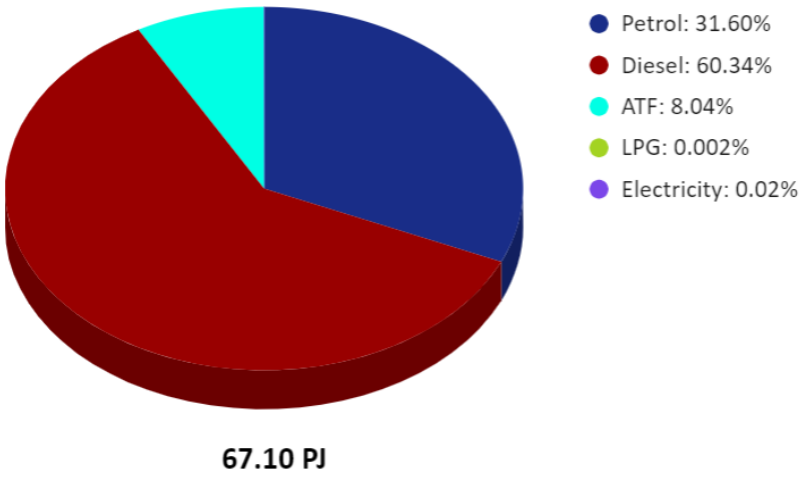


Figure 3-32: Energy Consumption by Fuel Types Transportation Sector

The transportation sector in Nepal ranks third in terms of energy consumption. It utilizes 67.1 PJ of energy, representing 10.49% of the national total, with petroleum products being the primary energy source. Electricity usage in this sector is just 0.02%. However, with the increasing availability of charging stations and dedicated EV charging infrastructure, the energy consumption of the private electric vehicle transport system is expected to become more noticeable in the database. Energy consumption in the transportation sector has been on the rise due to the sector's strong ties to both economic and demographic factors. Diesel fuel holds the largest share in this sector (60.34%), primarily used by freight and heavy passenger vehicles, while petrol is mainly consumed by small private vehicles (31.6%). Additionally, aviation fuel accounts for 8.04% of this sector. The transportation sector in Nepal, like other sectors, was significantly affected by the Covid-19 pandemic, leading to a halt in the transport system and a subsequent reduction in energy consumption by nearly 45.22% in 2020 compared to the previous year. As restrictions were gradually lifted, energy consumption in the transport sector increased by 38.48% in 2021 and by 16.99% in 2022.

3.5.2.6 Construction and Mining Sector

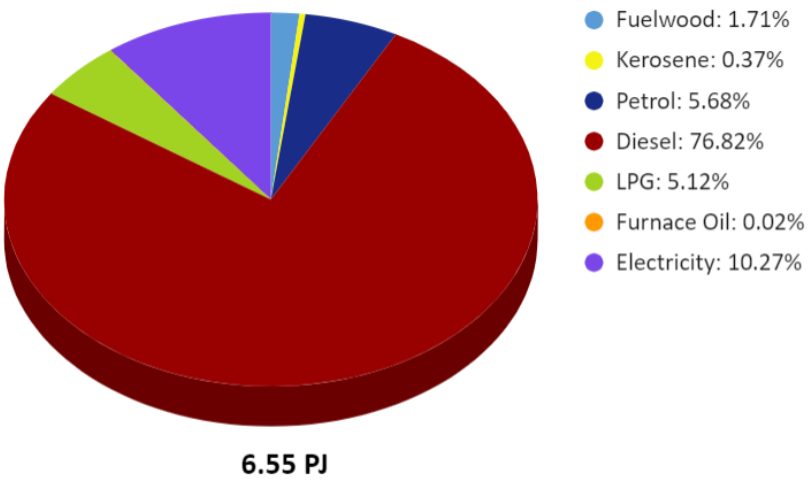


Figure 3-33: Energy Consumption by Fuel Types Construction and Mining Sector

The construction and mining sector in Nepal is an emerging and significant sector that consumed approximately 6.55 PJ of energy in 2022. Although it represents only 1.02% of the total national energy consumption, it has a considerable impact on both energy consumption and the economy. The primary energy consumption in this sector is attributed to the operation of large on-site equipment, predominantly diesel-operated generators. The use of fuelwood and kerosene for heating purposes is being replaced by LPG and diesel. The energy consumed for the transportation of construction and mining vehicles is accounted for in the transport sector.

The impact of Covid-19 restrictions on this sector is evident, with a notable decrease of 40.3% in consumption observed in 2020. However, the sector exhibited a significant rebound in 2021, experiencing a remarkable increase of 40.18% in consumption. Furthermore, the positive growth trend continued in 2022, with a notable increase of 22.28% in consumption.

Chapter 4: Energy Indicators

4.1 Energy Intensity

Energy intensities serve as indicators of both energy consumption rates and energy efficiency. Table 5-1 shows that Nepal's energy intensity is relatively high, nearly double the global average, and higher than India's average of 0.15 GJ per NRs. 1000. This not only reflects higher energy consumption in Nepal but also indicates lower energy efficiency compared to India. However, there have been improvements in energy intensity in the residential sector, with a decrease from 14 GJ per capita to 13.3 GJ per capita in 2019, attributed to improved energy access and the adoption of clean energy technologies. The increasing electricity intensity is a positive sign of efficiency improvement and access to clean energy. Moreover, the energy intensity per value addition provides insights into energy efficiency and technology usage. The agricultural sector has low energy intensity due to the reliance on human labor and draught animals, while the commercial sector benefits from efficient electric appliances. In contrast, the industrial sector's energy efficiency is higher than the national average, primarily due to petroleum products and coal dependence. Switching to electric and more efficient technologies in the industrial sector could help lower energy intensity. India's example demonstrates that expanding the economy while reducing economic energy intensity is achievable through increased electricity consumption. Nepal can follow a similar path by leveraging its indigenous electricity production.

Table 4-1: Final Energy Intensities

Parameter	Unit	2075/76	2076/77	2077/78	2078/79
Final Energy Intensity	GJ per 1000 NRs Value Addition	0.28	0.27	0.29	0.28
	GJ per capita	20.62	19.82	21.92	21.94
Agriculture	GJ per 1000 NRs	0.01	0.02	0.02	0.02
Commercial	GJ per 1000 NRs	0.03	0.04	0.04	0.04
Industry	GJ per 1000 NRs	0.76	0.78	0.97	0.91
Residential	GJ per capita	13.27	13.51	13.86	13.30
Electricity	kWh per 1000 NRs	3.08	3.2	3.52	3.63
	kWh per capita	228	232	265	305
Residential Electricity	kWh per HH	218	251	296	649

The average electricity price has been decreasing in recent years, while the consumption is increasing. It should be noted that the per capita consumption provided by NEA may differ from the values in Table 4-1, as NEA calculates its indices based on sales and there may be additional off-grid generation sources included in the table.

Table 4-2 Consumer Indices for Electricity for NEA Distributed Electricity

	2075/76	2076/77	2077/78	2078/79
Annual Unit sales per consumer	1420	1342	1425	1,606
Average price per kWh (Rs.)	10.48	11.57	9.76	9.72
Per capita sales	220	218	246.56	295.91
Distribution Loss	11.28%	10.28%	11.64%	10.68%

(WECS, 2022; NEA, 2021)

4.2 Energy Shares

Table 4-3 provides an overview of the energy types in the national total. The dominant share is occupied by biomass. The share of renewable energy, including hydroelectricity, is increasing, indicating progress in the right direction. However, the reliance on imported energy, such as petroleum, coal, and electricity, remains high, posing challenges to energy security. Nepal should prioritize reducing petroleum imports and effectively manage its electricity supply to avoid spillage during the wet season and the need for imports during dry seasons.

Table 4-3: Energy Share w.r.t. National Consumption

	Unit	2075/76	2076/77	2077/78	2078/79
Traditional biomass energy	Share in total	68.30%	71.26%	66.26%	65.63%
Total Renewable energy*	Share in total	5.04%	6.42%	5.89%	8.27%
Imported Energy	Share in total	27.5%	26.02%	28.71%	26.11%

**includes electricity from hydropower*

4.3 Nepal's Progress in Achieving Targets of NDC, 15th Five-Year Plan and SDG-7

The progress of some targets of NDC and the 15th five-year plan are shown in Figure 4-1.

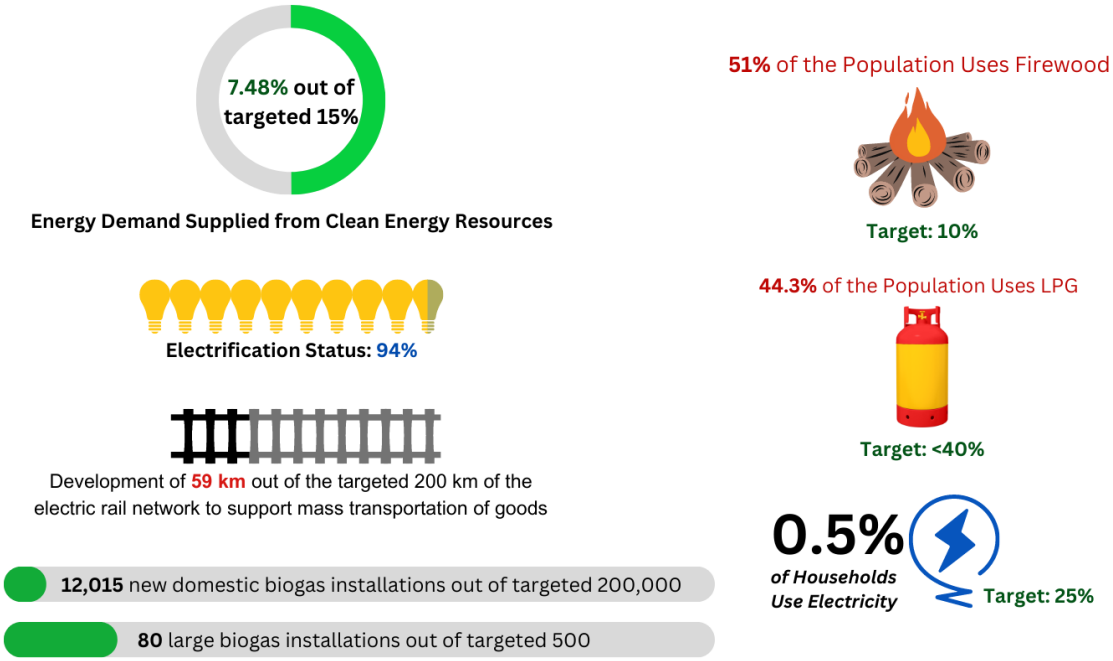


Figure 4-1: Nepal's Progress in Achieving Preset Targets

The following points are the summary of the progress in correspondence with SDG-7 in 2022:

- 94% of Nepal's population has access to electricity which is increasing at a significant pace. At this rate the entire population is assumed to be electrified by 2024.
- The percentages of population with access to electricity in each province are: Koshi - 91.23%, Madhesh - 99.95%, Bagmati - 97.47%, Gandaki - 97.76%, Lumbini - 96.73%, Karnali - 56.79%, and Sudurpashchim - 78.85%.
- 6.9% of the total national population has access to renewable energy.
- Renewable energy share in the total final energy consumption mix is 2.52% (16.11 PJ).
- 92.2% of households use electricity as the main source of lighting.

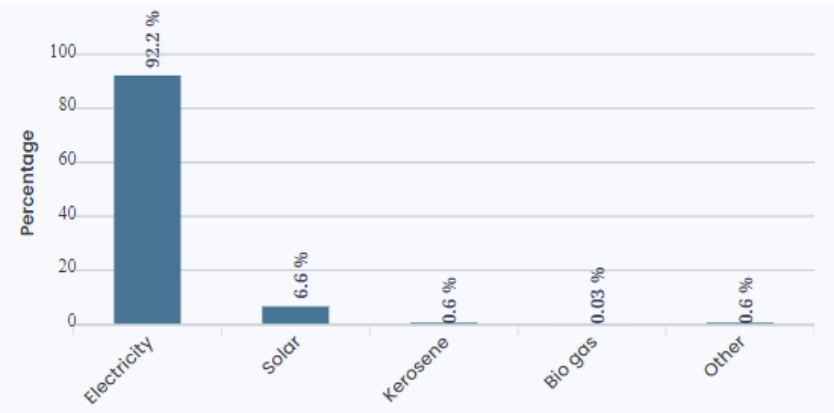


Figure 4-2: Households by Main Source of Lighting

Chapter 5: Energy Balance

An energy balance table is the presentation of data of supply and demand/consumption of energy and its resources. The supply and demand/consumption is represented by the same unit of energy.

An energy balance table has three components:

1. **Primary supply:** Lists incoming sources and resources, including primary energy production, imports, and exports.
2. **Transformation/Conversion side:** Involves conversion of energy from one form to another for final use, like hydro to electricity, and accounts for losses that occur during the process.
3. **Consumption side:** Indicates where and how much energy is being consumed.

Table 5 shows the energy balance of FY 2078/79.

Table 5: Energy Balance of FY 2078/79 (2022)

Energy Balance 2078/79																				
in TJ	Traditional				Commercial										Renewables					Grand Total
					Petroleum Products															
	Fuelwood	Agricultural Residue	Animal Waste	Total Traditional	Petrol	Diesel	Kerosene	LPG	ATF	Furnace Oil	Total Petroleum	Coal	Electricity	Total Commercial	Biogas	Wind	Micro/Pico Hydro	Solar	Total Renewables	
Primary Supply																				
Production	374,563	17,966	18,150	**410,679**	-	-	-	-	-	-	**-**	216	34,276	**34,492**	10,489	1.9	540	5,083	16,114	**461,284**
Imports	-	-	-	**-**	24,849	65,926	624	24,656	5,499	1,834	**123,390**	57,932	5,555	**186,877**	-	-	-	-	-	**186,877**
Exports	-	-	-	**-**	-	-	-	-	-	-	**-**	-	(1,777)	**(1,777)**	-	-	-	-	-	**(1,777)**
Stock Changes	-	-	-	**-**	(195)	154	16	-	(107)	0	**(132)**	-	-	**(132)**	-	-	-	-	-	**(132)**
Total Primary Supply	**374,563**	**17,966**	**18,150**	**410,679**	**24,654**	**66,080**	**641**	**24,656**	**5,393**	**1,834**	**123,258**	**58,148**	**38,053**	**219,459**	**10,489**	**1.9**	**540**	**5,083**	**16,114**	**646,252**
Transformation																				
Inputs	-	-	-	**-**	-	-	-	-	-	-	**-**	-	(38,053)	**(38,053)**	-	-	-	-	-	**(38,053)**
Electricity Generation	-	-	-	**-**	-	-	-	-	-	-	**-**	-	38,053	**38,053**	-	-	-	-	-	**38,053**
T&D Losses	-	-	-	**-**	-	-	-	-	-	-	**-**	-	(6,249)	**(6,249)**	-	-	-	-	-	**(6,249)**
Other Losses, Own-use etc.	-	-	-	**-**	-	-	-	-	-	-	**-**	-	(38)	**(38)**	-	-	-	-	-	**(38)**
Net Supply to Consumers	**374,563**	**17,966**	**18,150**	**410,679**	**24,654**	**66,080**	**641**	**24,656**	**5,393**	**1,834**	**123,258**	**58,148**	**31,766**	**213,172**	**10,489**	**1.9**	**540**	**5,083**	**16,114**	**639,965**
Final Consumption																				
Residential	316,281	6,247	17,584	**340,111**	-	-	151	18,927	-	-	**19,078**	60	15,458	**34,595**	10,480	1.6	432	2,150	13,064	**387,771**
Industrial	39,217	11,455	0	**50,672**	2,813	15,476	402	796	-	1,833	**21,320**	57,475	12,396	**91,191**	-	-	-	-	-	**141,863**
Commercial	18,953	264	566	**19,783**	197	-	64	4,596	-	-	**4,857**	613	2,357	**7,828**	8.39	0.3	108	2,908	3,024	**30,635**
Agriculture	-	-	-	**-**	69	5,075	-	-	-	-	**5,144**	-	868	**6,012**	-	-	-	25	25	**6,037**
Transportation	-	-	-	**-**	21,202	40,494	-	1.32	5,393	-	**67,090**	-	14	**67,104**	-	-	-	-	-	**67,104**
Construction and Mining	112	-	-	**112**	372	5,035	24	336	-	1.47	**5,769**	-	673	**6,442**	-	-	-	-	-	**6,554**
Total	**374,563**	**17,965**	**18,150**	**410,679**	**24,654**	**66,080**	**641**	**24,656**	**5,393**	**1,834**	**123,258**	**58,148**	**31,766**	**213,172**	**10,489**	**1.9**	**540**	**5,083**	**16,114**	**639,965**

Chapter 6: Energy Pricing

In Nepal, the majority of energy resources are not involved in trading activities, with the exception of fossil fuels that are imported from outside the country. The government plays a significant role in regulating the prices of electricity and petroleum. On the other hand, energy products such as coal, charcoal, and various petroleum products like candles and raw petroleum follow a free-market system, where their prices are determined by market forces. The government's pricing strategy aims to provide energy at lower costs, particularly for commercial energy resources like electricity, petroleum, and traded fuelwood, which is subsidized and distributed through different dealers and points.

The price of fuelwood is determined based on the provincial reports of Koshi and Madhesh Province, according to the WECS 2020. The prices of LPG, kerosene, diesel, and petrol are sourced from NOC, with the information accurate as of May 15, 2022. The assumed efficiencies of diesel and petrol generator sets are 50% under full load conditions. The price of electricity is in accordance with the 2021/22 Annual Report of NEA.

Table 6-1: Energy Pricing for Cooking

Fuel Type	Natural Unit	Market Price (Rs/unit)	Market Price (Rs./kWh)	Average Efficiency (%)	Effective Price of Useful Energy (Rs./kWh)
Fuelwood	*kg*	15	2.90	15%	19.33
LPG	*cylinder*	1800	9.92	55%	18.04
Electricity - Rice cooker	*Unit (kWh)*	9.72	9.72	70%	13.89
Electricity - Induction cooktop	*Unit (kWh)*	9.72	9.72	85%	11.44
Kerosene	*Liter*	165	16.50	50%	33
Diesel (generator + rice cooker)	*Liter*	165	15.53	28%	55.46
Petrol (generator + rice cooker)	*Liter*	175	18.67	28%	66.68

6.1 Electricity Pricing

The Electricity Tariff Fixation Commission regulates the price structure for electricity transmitted through the national grid and distributed. However, in isolated systems and micro-hydro-generated electricity, the prices are determined by the generator. Tariffs for electricity vary across different sectors of the economy. In the residential sector, the tariff is based on the amount of electricity consumed. The industrial sector enjoys lower electricity prices compared to other sectors. Additionally, the Nepal Electricity Authority (NEA) has implemented Time of the Day

meters to promote efficient utilization of generated energy. The tariff structures for domestic consumers are provided by NEA. Tables 6-2 show tariff rates for domestic single-phase low voltage (230 V). Tables 6-3 and 6-4 show tariff rates for three-phase low voltage (400 V), and three-phase medium voltage (33/11 kV), respectively.

Table 6-2: Single Phase Low Voltage (230 V)

kWh (Monthly)	5 Ampere		15 Ampere		30 Ampere		60 Ampere	
	Monthly Minimum Charge (NRs.)	Energy Charge (NRs.)/ kWh	Monthly Minimum Charge (NRs.)	Energy Charge (NRs.)/ kWh	Monthly Minimum Charge (NRs.)	Energy Charge (NRs.)/ kWh	Monthly Minimum Charge (NRs.)	Energy Charge (NRs.)/ kWh
0-20	30.00	0.00	50.00	4.00	75.00	5.00	125.00	6.00
21-30	50.00	6.50	75.00	6.50	100.00	6.50	125.00	6.50
31-50	50.00	8.00	75.00	8.00	100.00	8.00	125.00	8.00
51-100	75.00	9.50	100.00	9.50	125.00	9.50	150.00	9.50
101-250	100.00	9.50	125.00	9.50	150.00	9.50	200.00	9.50
Above 251	150.00	11.00	175.00	11.00	200.00	11.00	250.00	11.00

Table 6-3: Three Phase Low Voltage (400 V)

kWh (Monthly)	Up to 10 kVA			Above 10 kVA		
	Monthly Minimum Charge (NRs.)	Month	Energy Charge (NRs.)/kWh	Monthly Minimum Charge (NRs.)	Month	Energy Charge (NRs.)/kWh
All Consumers	1100.00	Ashad-Kartik	10.50	1800	Ashad-Kartik	10.50
		Marg-Jestha	11.5		Marg-Jestha	11.5

Table 6-4: Three Phase Medium Voltage (33/11 kV)

kWh (Monthly)	Monthly Minimum Charge (NRs.)	Month	Energy Charge (NRs.)/kWh
All Consumers	10000.00	Ashad-Kartik	10.50
		Marg-Jestha	11.00

6.2 Coal and Petroleum Pricing

Coal is sold at CIF price between Rs. 5,300/- and 5,700/- which is the same as the imported ones. The Government of Nepal approves the pricing policy for major petroleum products, including kerosene, HSD, petrol, ATF, and LPG. The NOC board has the authority to set the prices for other unregulated products. Currently, NOC applies the Auto Petroleum Pricing Mechanism,

which allows for instant adjustments to the selling price of petroleum. Table 6-5 shows the pricing trend of petroleum products in FY 2078/79 and 2079/80*.

Table 6-5: Pricing Trend of Petroleum Products

Fiscal Year	Effective Date	Effective Time	Price				
			Petrol (NRs/ltr)	Diesel/Kerosene (NRs/ltr)	ATF (DP) (NRs/ltr)	ATF (DF) (USD/kL)	LPG (NRs/cyld)
2078/79	2078.10.05	24 hrs	139	122	106	995	1575
	2078.10.18	24 hrs	142	125	116	1095	1575
	2078.11.07	24 hrs	145	128	116	1095	1575
	2078.11.08	24 hrs	145	128	126	1195	1575
	2078.11.19	24 hrs	150	133	136	1295	1575
	2078.12.02	24 hrs	155	138	151	1495	1575
	2078.12.22	24 hrs	160	143	156	1545	1600
	2079.01.31	24 hrs	170	153	156	1545	1600
	2079.02.08	24 hrs	180	163	166	1545	1800
	2079.02.19	24 hrs	170	153	166	1545	1800
	2079.02.23	24 hrs	170	153	166	1545	1800
	2079.02.26	24 hrs	178	165	166	1545	1800
	2079.03.05	24 hrs	199	192	185	1645	1800
	2079.03.11	24 hrs	179	163	185	1645	1800
	2079.03.20	24 hrs	181	172	190	1645	1800
2079/80*	2079.05.16	24 hrs	181	178	190	1645	1800
	2079.09.01	24 hrs	178	175	190	1645	1800
	2079.09.24	24 hrs	175	172	170	1420	1800
	2079.10.23	24 hrs	178	175	170	1420	1800
	2079.12.20	24 hrs	175	165	160	1350	1800

Chapter 7: Provincial Energy Analysis

7.1 Koshi Province

7.1.1 Energy Supply Situation

7.1.1.1 Fuelwood Supply

The expansion of agricultural activities and population growth in Nepal has led to a decrease in forest areas. Specifically, the forest area in the Terai region declined by 16,500 hectares between 2001 and 2010, and by 32,000 hectares over a period of 19 years from 1991 to 2010. The annual rate of forest cover decrease during the last nine years from 2001 to 2010 was 0.44%, and it was 0.40% during the last 19 years from 1991 to 2010/11. Across all 20 Terai districts, excluding protected areas, the annual rate of deforestation was 0.06% (FRA/DFRS, 2014).

Koshi also witnessed an increase in cultivated land at the expense of forested land. However, despite the rapid growth of the commercial energy sector in the Terai region, the demand for fuelwood has risen due to poverty. This is because fuelwood remains practically free for people if they can spare the time for collection. Local communities collect a significant amount of fuelwood from community-managed and government-managed forests.

Table 7-1: Forest Area and Actual Fuelwood Produced

District	Forest Area (ha)	Stem Volume (m^3)	Annual Firewood Production (m3)	Annual Firewood Production of Accessible Forest (m^3)
Terai: accessible forest (100%)				
Jhapa	17,568	2,941,235	50,008	50,008
Morang	44,075	7,379,037	125,461	125,461
Sunsari	21,653	3,625,145	61,636	61,636
Total	**83,296**	**13,945,416**	**237,106**	**237,106**
Middle Mountain: accessible forest (90%)				
Udayapur	148,411	18,441,551	112,598	101,338
Ilam	93,467	11,614,209	70,912	63,821
Dhankuta	36,724	4,563,324	27,862	25,076
Terhathum	32,821	4,078,337	24,901	22411
Bhojpur	73,037	9,075,578	55,412	49,871
Khotang	74,284	9,230,530	56,358	50,723
Okhaldhunga	52,286	6,497,058	39,669	35,702
Panchthar	71,774	8,918,637	54,454	49,009
Total	**582,804**	**72,419,225**	**442,166**	**397,950**
Higher Mountain: accessible forest (70%)				
Sakhuwasabha	**190,052**	**42,807,312**	**554,195**	**387,936**
Solukhumbu	110,043	24,786,085	320,887	224,621
Taplejung	155,931	35,121,898	454,697	318,288
Total	456,026	102,715,296	1,329,779	930,845
Grand Total	**1,122,126**	**189,079,938**	**2,009,051**	**1,565,901**

7.1.1.2 Petroleum Products

Nepal relies entirely on imports from India for its petroleum consumption. The Nepal Oil Corporation Ltd. (NOC) is the sole company responsible for importing and selling petroleum products, including diesel, petrol, kerosene, and LPG. Industries handle the importation of furnace oils and other oil residues themselves. The regional offices of NOC supply petroleum products to meet the demand. Sales units for petrol, diesel, and kerosene are measured in liters, while LPG is measured in metric tons (MT). The sales data provided represent the sales to depots in each district. However, it's important to note that these sales are not restricted to the district boundaries, and the supply in each district is not solely dependent on depot capacity. There are inter-country trades and transportation of petroleum fuels, leading to potential discrepancies between the supply of petroleum products and their actual consumption.

Table 7-2: Petroleum Sales in 2075/76 in Koshi Province

Districts	MS	Diesel	SKO	LPG
	kL	kL	kL	tons
Taplejung	234	1,980	-	-
Sankhuwasabha	948	4,441	-	-
Solukhumbu	288	1,576	282	-
Okhaldhunga	816	5,722	168	-
Khotang	306	1,904	-	-
Bhojpur	288	3,113	-	-
Dhankuta	1,371	7,399	39	-
Terhathum	192	1,032	-	-
Panchthar	929	7,109	-	-
Ilam	2,245	6,487	-	-
Jhapa	27,102	66,017	777	20,824
Morang	25,507	71,727	1,528	9,358
Sunsari	21,557	59,436	1,019	51,994
Udayapur	3,622	15,950	-	-
Total	**85,405**	**253,891**	**3,813**	**82,176**

7.1.1.3 Electricity

Koshi Province, characterized by its mountains and hills, possesses abundant water resources and multiple promising locations for hydropower development. The estimated average potential for hydropower plants in Koshi Province is approximately 20,500 MW (Kandel, 2018). Furthermore, there is a small hydropower potential of 66 MW across 84 sites, along with nearly 70 sites identified for 1 MWp solar PV systems for decentralized electricity generation (NPC, 2018). The province is home to 29 Independent Power Producer (IPP) hydropower projects, 4 major hydropower plants, and 5 small hydropower plants (NEA, 2019). Currently, the installed capacity in the province stands at 237.59 MW, with 226.796 MW generated by IPPs and 10.794 MW generated by NEA. The district-wise status of electricity supply in Koshi Province, as provided by the Nepal Electricity Authority, is presented below.

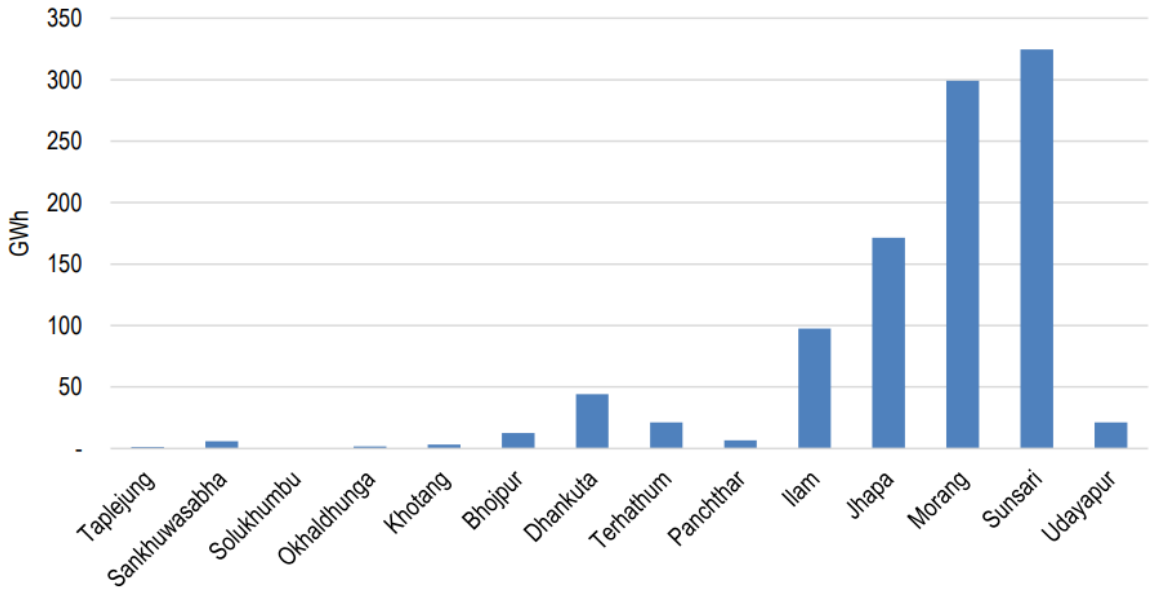


Figure 7-1: Electricity Sales in Koshi Province in 2075 (NEA, 2019)

Koshi Province recorded a total electricity consumption of 1,011 GWh across all economic sectors in 2020, according to the NEA database. Among the districts in the province, Jhapa, Morang, and Sunsari in the Terai region, known for their industrial activities, accounted for 79% of the total electricity consumption. Conversely, electricity consumption in the mountainous areas of Koshi Province was significantly lower, possibly due to limited access to electricity in remote regions. In comparison, the Hilly region had lower electricity consumption compared to the Terai region.

Based on NEA's domestic consumption data, the majority of households in Koshi Province have minimal ampere capacity connections, with over 90% having a 5A connection. Around 7% of households are connected with a 6-15A capacity, and less than 1% have a connection above 16A. In total, 76% of households in Koshi Province have access to electricity (NEA, 2019).

7.1.1.4 Renewable Energy Sources

In Koshi Province, as reported by AEPC, the number of installed plants for various renewable energy systems is provided in the table below. The province has seen the installation of approximately 1,440 kWp of solar home systems (SHS), 243 kWp of small solar home systems (SSHS), and 311 kWp of institutional solar PV systems (ISPS). Furthermore, solar photovoltaic pumping systems (SPVPS) have gained popularity among farmers. The average size of ISPS in the province is 2 kWp.

Most of the biogas plants in Koshi Province have a size of 4 cubic meters. Micro-hydro plants have not been installed in the province due to their lowland terrain. However, a solar mini-grid power plant with a capacity of 138 kW has recently been installed in the province, with 43 kW in Morang and 95 kW in Panchthar.

Table 7-3: Number of Modern Renewable Technologies Installed in Koshi (AEPC, 2019)

District	SHS	SSHS	ISPS	MUD ICS	Domestic Biogas
Bhojpur	12,348	321	2	163	225
Dhankuta	1,650	183	5	234	2,059
Illam	5,136	570	23	711	6,306
Jhapa	651	596	20	0	18,752
Khotang	12,833	865	23	137	100
Morang	1,365	776	32	8	10,800
Okhaldhunga	10,244	155	26	1,737	413
Panchthar	7,751	140	6	344	1,064
Sankhuwasabha	8,700	50	3	643	536
Solukhumbu	4,117	0	2	896	107
Sunsari	1,186	80	5	0	4,126
Taplejung	6,268	661	10	1,050	233
Terhathum	1,760	223	4	193	799
Udayapur	22,024	254	13	57	5,953
Total	**96,033**	**4,874**	**174**	**174**	**51,473**

7.1.2 Energy Consumption Situation

In Koshi Province, the total energy consumption in 2019 amounted to 74 PetaJoules (PJ). The industrial sector had the highest share of energy consumption in the province, followed by the residential sector. Solid fuels, including firewood, biomass, and coal, dominated the energy sources used in the region. The energy mix in Koshi Province has experienced a shift compared to previous studies conducted at national and regional levels. Approximately 45% of the total energy demand in Koshi Province is attributed to the industrial sector. Renewable energy sources account for 55% of the energy consumed, while non-renewable sources contribute around 45%. This contrast in the high usage of non-renewable energy is primarily driven by the presence of large industries and significant economic activities, which require more commercially available forms of energy.

In terms of sector-wise energy demand, the industrial sector holds the predominant position, accounting for nearly 45% of the total consumption. Due to the extensive industrial and commercial activities in Koshi Province, the energy share in the residential sector is lower than the national average. The reduction in energy consumption in the residential sector can also be attributed to energy transition and efficiency measures implemented, as discussed in a later section.

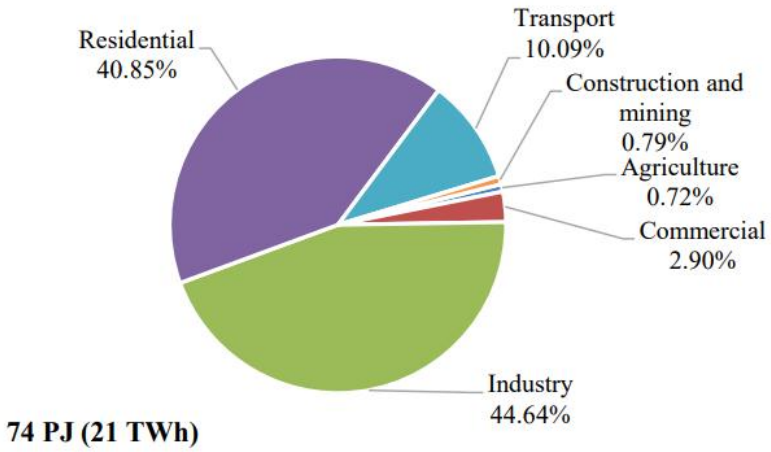


Figure 7-2: Energy Consumption Share in Koshi by Sectors

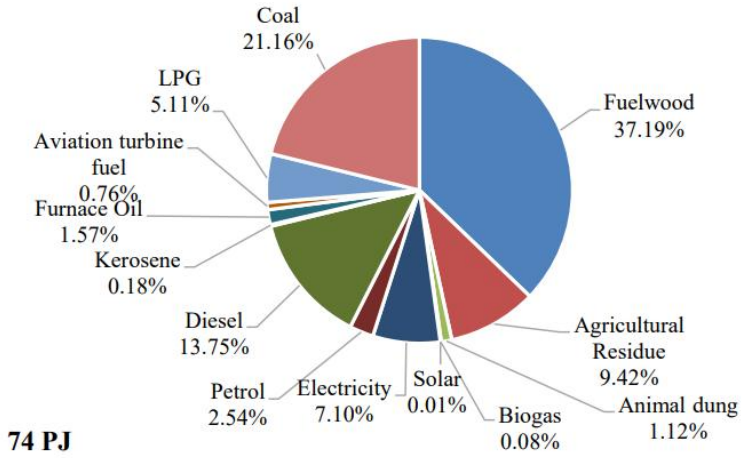


Figure 7-3: Energy Consumption Share in Koshi by Energy Types

Firewood remains the primary source of energy in the residential sector of Koshi Province. In contrast, the industrial sector relies heavily on coal and diesel for thermal energy and motive power. The commercial sector primarily depends on electricity and LPG. The transport and agricultural sectors still have a significant dependency on fossil fuels. There is a noticeable transition in the agricultural sector from petroleum-based water pumping systems to solar PV-powered systems, although the adoption is relatively lower in Koshi Province due to geographical constraints.

Table 7-4: Energy Consumption in Koshi by Sector and Fuel Type (TJ)

In TJ	Renewables							Non-Renewables							Total
	Conventional Renewables					New Renewables									
	Traditional Biomass			Modern Biomass											
	Firewood	Agricultural Residue	Animal Dung	Biogas	Bio Briquettes	Solar	Electricity	Petrol	Diesel	Kerosene	Furnace Oil	ATF	LPG	Coal	
Agriculture	-	-	-	-	-	0.09	0.08		534	-	-	-	-	-	**534**
Commercial	885	-	-	0.07	0.03	0	617	-	-	-	-	-	642	-	**2,144**
Industry	2,300	6,915	-	-	-	-	2,823	-	4,136	-	1,162	-	4	15,620	**32,961**
Residential	24,261	42	826	60.2	0.43	9.88	1,792	-	-	40	-	-	3,127	3.8	**30,163**
Transport	-	-	-	-	-	-	10	1,858	5,017	-	-	563	-	-	**7,448**
Construction and mining	13	-	-	-	-	-	2	16	462	89	-	-	2	-	**585**
Total	**27,458**	**6,957**	**826**	**60**	**0.47**	**10**	**5,245**	**1,874**	**10,150**	**129**	**1,162**	**563**	**3,776**	**15,624**	**73,835**

7.2 Madhesh Province

7.2.1 Energy Supply Situation

7.2.1.1 Fuelwood Supply

The Terai region experienced a decline in forest area, with a loss of 16,500 hectares between 2001 and 2010 and a further loss of 32,000 hectares over a period of 19 years from 1991 to 2010. The annual rate of forest cover decrease was 0.44% during the last nine years from 2001 to 2010 and 0.40% during the last 19 years from 1991 to 2010/11. In all 20 Terai districts, excluding protected areas, the annual rate of deforestation was 0.06% (FRA/DFRS, 2014).

Similarly, in Madhesh Province, the expansion of cultivated land came at the expense of forested areas. Despite the rapid growth of the commercial energy sector in the Terai region, the demand for fuelwood increased due to poverty. This is because fuelwood remains practically free for people if they can afford the time for collection. Local communities heavily rely on collecting a large quantity of fuelwood from community-managed and government-managed forests.

Table 7-5: Forest Area and Actual Fuelwood Produced

	Terai Area in ha	Churia Area (ha)	Total Area (ha)	Per ha Vol. in cubic m with branch	Growing stock in forests in m cum	Fuelwood produced in chatta
Saptari	3,584	30,595	34,179	96.42	1,949,899	85
Siraha	3,307	24,400	27,707	37.61	781,364	50
Dhanusa	27,218	380	27,598	29.2	805,861	8,803
Mahottari	12,009	10,050	22,059	37.61	829,639	102
Sarlahi	13,868	15,494	29,736	148	4,400,928	621
Rautahat	22,063	7,337	29,400	112.49	3,307,206	342
Bara	34,426	14,731	49,152	156.27	6,404,739	150
Parsa	77,124	0	77,124	220	2,227,630	383

7.2.1.2 Petroleum Products

All petroleum products consumed in Nepal are imported from India. The Nepal Oil Corporation Ltd. (NOC) is the sole company responsible for importing and selling petroleum products, including diesel, petrol, kerosene, and LPG. However, industries themselves import furnace oils and other oil residues. The regional offices of NOC serve as the source of petroleum product supply. The district-wise sales data for the year 2075-76 is presented in the table below. The sales units for petrol (Motor Spirit or MS), diesel, and super kerosene oil (SKO) are measured in kiloliters, while LPG is measured in metric tons (MT). It's important to note that these sales data represent the sales to depots within each district. However, the sales from these depots are not restricted to the respective districts, and the supply in each district is not limited by the capacity of the depots alone. There are inter boundary trades and transportation of petroleum fuels, which can result in discrepancies between the supply of petroleum products and their actual consumption.

Table 7-6: Petroleum sales in 2075/76 in Madhesh Province

Districts	MS	Diesel	SKO	LPG
	kL	kL	kL	tons
Bara	13,113	93,779	755	482
Dhanusha	15,832	44,541	1,982	152
Mahottari	7,588	19,094	84	
Parsa	14,077	46,702	864	181
Rautahat	9,480	23,829	287	
Saptari	8,654	19,477	567	
Sarlahi	10,644	28,708	239	
Siraha	11,565	26,392	332	
	90,956	**302,524**	**5,114**	**815**

7.2.1.3 Electricity

Madhesh Province has limited potential for hydropower generation, and therefore, it relies on importing electricity from other provinces through the national grid. The province lacks a significant indigenous source of electricity, with the exception of decentralized gensets used by industries. However, reliable data on the electricity produced by these gensets and their usage within the industries are not available. Consequently, the primary source of electricity in Madhesh Province is the national grid, distributed by the Nepal Electricity Authority (NEA). The district-wise electricity supply status, as obtained from NEA, is depicted in the figure below. It indicates that districts such as Bara and Parsa have comparatively high electricity consumption, primarily due to the presence of a larger number of industries in those areas.

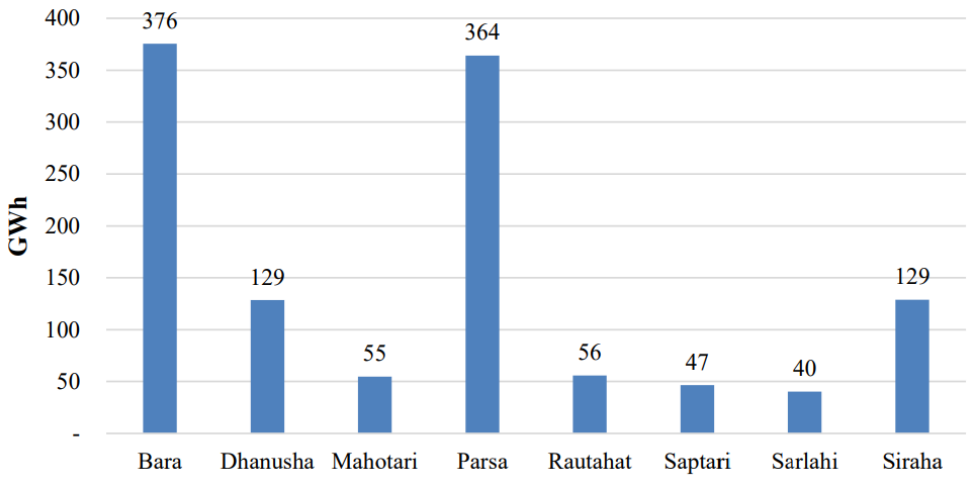


Figure 7-4: Electricity Consumption in Madhesh Province in 2075 (NEA, 2019)

As per NEA, 98% of the households lie within minimal amperage capacity of 5 A, and 1% relate to 6-15 A connection. Less than 1% have an electricity connection above 16 A. In Madhesh Province, 80% of households have access to electricity (NEA, 2019).

7.2.1.4 Renewable Energy Sources

In Madhesh Province, AEPC has installed various renewable energy systems, as indicated in the table below. The province has approximately 190 kWp from solar home systems (SHS), 123 kWp from small solar home systems (SSHS), and 184 kWp from institutional solar PV systems (ISPS). Solar photovoltaic pumping systems (SPVPS) have gained popularity among farmers, with a total of 498 units ranging from 500 Wp to 3.5 kWp in capacity. Most biogas plants in the province have a size of 4 cubic meters. Due to the geographical characteristics of the low-lying land, there are no micro-hydro plants installed in Madhesh Province.

Table 7-7: Number of Modern Renewable Technologies Installed in Madhesh Province (AEPC, 2019)

District	SHS	SSHS	SPVPS	MUD ICS	Domestic Biogas	ISPS
Bara	1,057	0	28	0	4,289	7
Dhanusha	147	21	15	9,501	820	30
Mahottari	463	679	6	3,424	1,803	9
Parsa	30	0	63	0	929	1
Rautahat	2,794	778	205	840	1,829	12
Saptari	1,176	187	44	2,008	688	5
Sarlahi	6,878	765	116	183	3,131	27
Siraha	140	44	21	4,556	626	12
Grand Total	**12,685**	**2,474**	**498**	**20,512**	**14,115**	**103**

7.2.2 Energy Consumption Situation

In Madhesh Province, the total energy consumption in 2019 amounted to 63 Petajoules (PJ). The residential sector continued to dominate energy consumption across sectors, with wood and biomass being the primary energy sources. There has been a noticeable shift in the energy mix compared to previous studies conducted at national and regional levels.

In terms of sector-wise energy consumption, the residential sector remained prominent, accounting for nearly 62% of the total final energy consumption. However, due to significant industrial and commercial activities in the province, the energy share in the residential sector was lower compared to the national average. When comparing these results to the national level sectoral share in 2011/12, it can be observed that the share of residential energy consumption in Madhesh Province was 20% lower, while the share of the industry was nearly three times higher. This discrepancy is primarily attributed to the presence of a large number of industries in the province. The impact of economic activity is also evident in the transport sector, which accounted for 9.2% of the provincial energy consumption, higher than the national level of 7%.

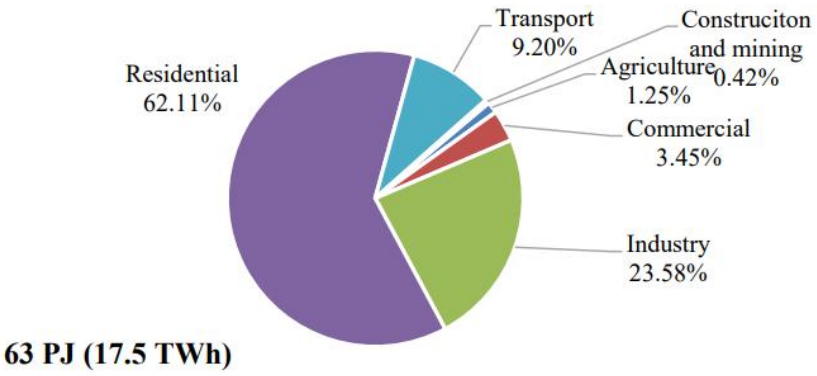


Figure 7-5: Energy Consumption Share in Madhesh Province by Sectors

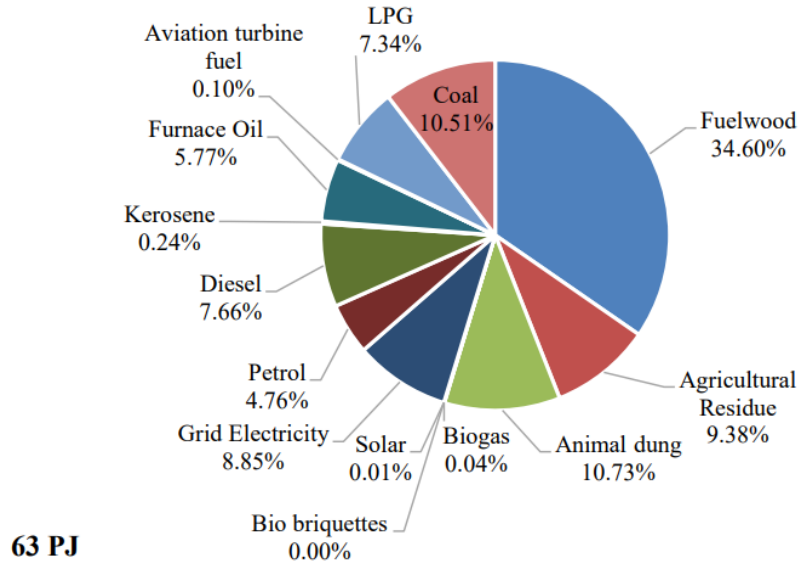


Figure 7-6: Energy Consumption Share in Madhesh Province by Energy Types

Fuelwood is still the main source of energy in the residential sector, while the commercial sector thrives on the use of electricity. The transport, industry, and agricultural sectors still show a huge dependency on fossil fuels. However, a shift from diesel power water pumping systems to solar-powered can be seen in the agricultural sector.

Table 7-8: Energy Consumption in Madhesh Province by Sector and Fuel Type (TJ)

In TJ	Renewables							Non-Renewables							Total
	Conventional Renewables					New Renewables									
	Traditional Biomass			Modern Biomass											
	Firewood	Agricultural Residue	Animal Dung	Biogas	Bio Briquettes	Solar	Electricity	Petrol	Diesel	Kerosene	Furnace Oil	ATF	LPG	Coal	
Agriculture	-	-	-	-		0.3	0.16	26	764	-	-	-	-	-	790
Commercial	3.59	-	-	0.22		-	1,869	-	-	-	-	-	305	-	2,178
Industry	975	824	-	-		-	1,511	-	1,254	-	3,645	-	59	6,632	14,900
Residential	20,880	5,101	6,777	27.99	20.84	7.45	2,057	-	-	151	-	-	4,220	5.56	39,248
Transport	-	-	-	-		-	129	2,984	2,638	-	-	62	-	-	5,812
Construction and mining	-	-	-	-		-	23	-	187	4	-	-	54	-	267
Total	21,859	5,925	6,777	28	20.84	8	5,588	3,009	4,842	155	3,645	62	4,638	6,638	63,174

7.3 Bagmati Province

7.3.1 Energy Supply Situation

7.3.1.1 Fuelwood Supply

In Bagmati province, 53.73% of the total land area is covered by forest and other wooded land equivalent to 1,090,876 hectares. There are five national parks and conservation areas with a majority of the total forest area of 608,541 hectares followed by community forests. A large quantity of fuelwood is being collected from the community-managed and government-managed forests by the local people. Traditional resources contribute as the primary energy source comprising 36.37% of the total energy consumption with 46.14% of households using fuelwood as a primary energy source.73.3% of the forest is located in rural municipalities where households use fuelwood for cooking and heating purposes.

Table 7-9: Forest area in Bagmati Province

District	Forest (km2)	Other Woodland (km2)	Total Forest land (km2)	Total area (km2)
Mountain (subtotal)	**260,715**	**17,766**	**278,481**	**614,020**
Rasuwa	49,821	4,935	54,756	150,123
Dolakha	97,091	10,751	107,842	214,871
Sindhupalchowk	113,803	2,080	115,883	249,026
Hill (subtotal)	**643,825**	**21,081**	**664,906**	**1,192,311**
Bhaktapur	2,459	15	2,474	12,311
Dhading	86,067	6,676	92,743	190,674
Kathmandu	15,129	150	15,279	41,361
Kavrepalanchowk	72,533	2,775	75,308	139,443
Lalitpur	23,924	536	24,460	39,683
Makawanpur	163,943	2,590	166,533	244,366
Nuwakot	49,423	2,616	52,039	119,317
Ramechhap	65,248	4,125	69,373	156,553
Sindhuli	165,099	1,598	166,697	248,603
Terai (Subtotal)	**141,668**	**5,821**	**147,489**	**223,970**
Chitwan	141,668	5,821	147,489	223,970
Total	***1,046,208***	***44,668***	***1,090,876***	***2,030,301***

7.3.1.2 Petroleum Products

Nepal relies on India for the import of all its petroleum products. The Nepal Oil Corporation is the exclusive importer of products like petrol, diesel, kerosene, and LPG, while industries and organizations directly import furnace oil, lubricants, and other related products. The Nepal Oil Corporation then distributes these petroleum products to private vendors such as petrol pumps and LPG suppliers, who in turn supply them to consumers.

7.3.1.3 Electricity

Based on the NEA 2020/21 report, Bagmati Province in Nepal has 60 local levels that have been fully electrified, 58 local levels that have been partially electrified, and 1 local level that has no electricity access. The total annual electricity consumption of the province is 2249.8 GWh. Within the province, there are 37 independent power producers (IPPs) hydropower plants with a combined capacity of 252.27 MW. These hydropower plants are spread across 8 districts. Among them, there are 10 hydropower plants with a capacity exceeding 10 MW, 20 plants with capacities ranging from 1 to 10 MW, and 6 plants with capacities below 1 MW.

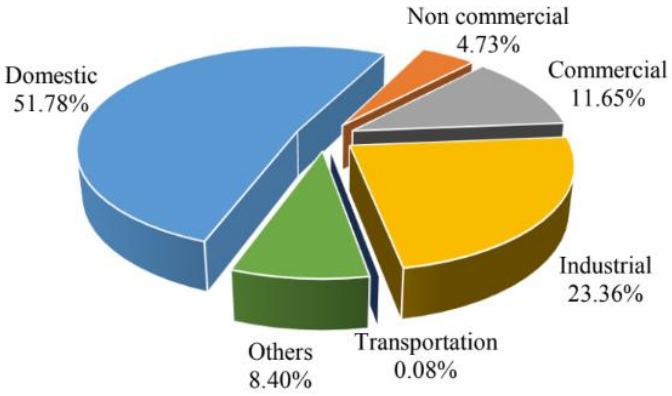


Figure 7-7: Sectoral Electricity Consumption

7.3.1.4 Renewable Energy Sources

The use of renewable energy sources, especially solar energy sources, has been growing in Bagmati province. According to AEPC, 234 kWh of power is generated from Independent Solar PV Systems (ISPS) and 177 kW of power has been generated from Institutional Biogas (IBG). Moreover, micro hydropower plants (MHP) and pico hydropower plants (PHP) have been generating 860 kW and 40 kW respectively. The following table shows the generation of power from different renewable energy sources in different districts of Bagmati province.

Table 7-10: Generation of Power from Renewable Energy in Bagmati Province

Districts	ISPS (kWh)	MHP (kW)	IBG (kW)	PHP (kW)
Bhaktapur	-	-	5.2	-
Chitwan	17.5	-	5.3	9
Dolakha	77	26.2	-	-
Dhading	-	464.5	2.7	-
Kathmandu	7	-	133.2	-
Kavrepalanchowk	42	20	5.1	-
Lalitpur	-	-	14.7	-
Makawanpur	24.5	16.5	11.2	-
Ramechhap	7	258.5	-	23
Sindhuli	59.5	75	-	8.5
Total	**234.5**	**860.7**	**177.4**	**40.5**

7.3.2 Energy Consumption Situation

Bagmati Province consumes a total of 83.53 PetaJoules (PJ) of energy. Fuelwood is the primary energy source, accounting for 32.73% of consumption, mainly in rural residential and industrial sectors. Commercially traded fuels, including diesel, gasoline, kerosene, LPG, coal, furnace oil, electricity, and aviation fuel, make up 52.11% of the energy consumption due to their accessibility. The use of electricity is increasing as the government aims to replace fossil fuels. Solar energy demand is rising, but still low. Aviation fuel consumption is higher due to the presence of an international airport. Traditional renewables are extensively used in rural areas, but there is a shift towards electricity and solar energy.

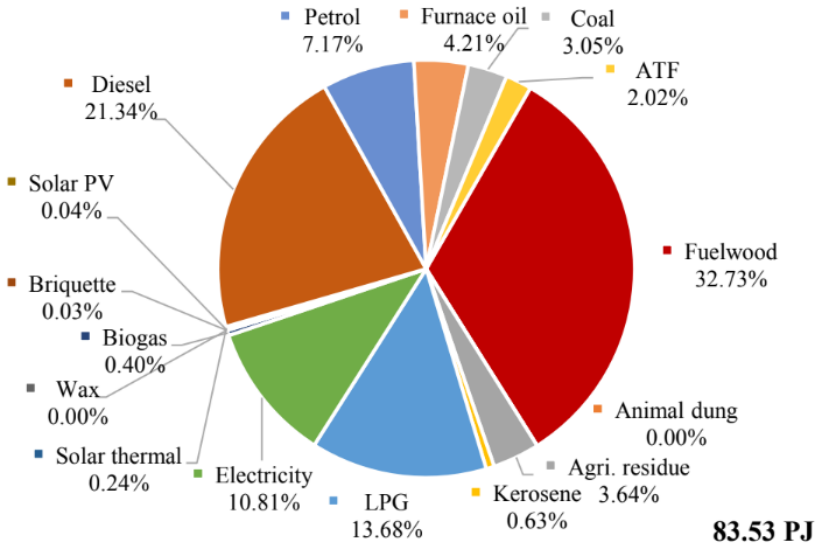


Figure 7-8: Energy Mix in Six Economic Sectors in Bagmati Province

The energy consumption in the residential sector is high in Bagmati province contributing 42.26% of total energy. The industrial sector consumes 33.34% of total energy followed by the transportation sector and the commercial sector. The energy consumption in agriculture, and construction and mining sectors is comparatively low.

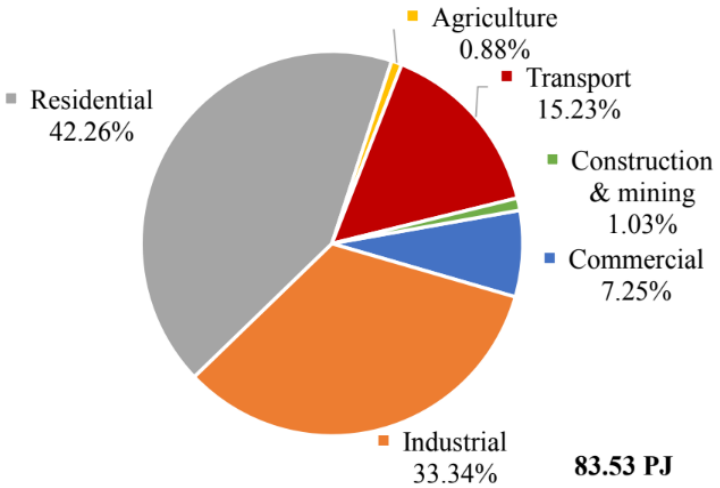


Figure 7-9: Energy Consumption in Six Different Economic Sectors

Table 7-11: Energy Consumption in Economic Sectors by Fuel Types in 2021 (TJ)

Fuel Type	Agriculture	Commercial	Industrial	Residential	Transportation	Construction & Mining	Total
Traditional fuels (Renewable)							
Fuelwood	-	114	6912	20302	-	11	**27340**
Animal Residue	-	-		3	-	-	**3**
Agriculture Residue	-	-	1039	2005	-	-	**3043**
Modern fuels (Renewable)							
Biogas	-	-	-	335	-	-	**335**
Briquette	-	15	0	7	-	-	**22**
New Renewables							
Electricity	55	2179	2139	4635	14	12	**9033**
Solar PV	6	-	-	25	-	-	**31**
Solar Thermal	-	10	-	189	-	-	**199**
Non-Renewables							
Coal	-	286	2261	0	-	-	**2547**
Kerosene	-	-	529	0.4	-	0	**529**
LPG	-	3455	93	7799	15	64	**11427**
Diesel	677	-	10257	-	6217	676	**17827**
Gasoline	1	-	1110	-	4791	89	**5990**
Furnace Oil	-	-	3508	-	-	9	**3518**
ATF	-	-	-	-	1689	-	**1689**
Total	**739**	**6059**	**27848**	**35300**	**12726**	**861**	**83535**

Chapter 8: Conclusion

The analysis of Nepal's energy supply and consumption reveals significant insights into the country's energy landscape. Nepal's energy sector, encompassing traditional, commercial, and alternative sources, plays a crucial role in the nation's economy.

Traditional energy sources, including fuelwood and agri-residue, have long been the primary energy sources for households in Nepal. The country's forest resources cover 40.36% of Nepal's total area. Community forests, which account for nearly half of the total forest area, play a significant role in fuelwood supply.

Agri-residue, derived from agricultural activities that involve over 60% of the population and contribute 40% to GDP, has emerged as another traditional energy source. The total potential supply of agri-residue has been increasing, generating an estimated energy of 457 million GJ. Similarly, energy from animal wastes is estimated to be 103.8 million GJ.

Commercial energy sources, including coal, electricity, and petroleum products, are driving factors in Nepal's economy. The production of coal in Nepal dropped to 6,927.04 tons in FY 2078/79.

The Nepal Oil Corporation (NOC) is responsible for importing and distributing petroleum products in Nepal. In 2078/79, petrol sales saw a nearly fourfold increase of 40.43%. Similarly, the sales values of diesel, LPG, and ATF increased by 32.24%, 11.5%, and 74.55%, respectively. However, the sales of kerosene declined by 4.99%.

Alternative energy sources, such as micro/pico hydro, biogas, solar, and wind, are gaining importance in Nepal's energy landscape. The installation of micro/pico hydro plants has shown a positive trend, reaching 37,734 kW in 2078/79. Biogas systems have been installed in a cumulative total of 439,547 households, including 355 large installations. The installation of residential solar PV systems has reached 974,000, primarily concentrated in remote districts with limited grid access. Wind energy development, although having significant potential, remains limited, with a total installed capacity of 113.6 kW in 2074/75.

Examining Nepal's energy consumption, traditional energy sources continue to dominate the energy mix, accounting for 64.17% of total consumption. Fuelwood remains the primary fuel, contributing 58.53% to total fuel consumption. The share of commercial fuels decreased to 28.35%, while electricity consumption increased to 4.96%. Renewable energy sources currently contribute only 2.52% to the overall energy consumption.

Nepal has made significant progress in expanding electricity access, with 94% of the population having access to electricity. The Madhesh region stands out with nearly universal access at 99.95%. Additionally, 92.2% of households rely on electricity as their primary source of lighting.

These advancements demonstrate Nepal's commitment to expanding electricity access and transitioning to sustainable energy sources. However, challenges remain, such as meeting the growing demand for electricity, reducing reliance on unsustainable traditional sources, improving

energy efficiency, and further developing renewable energy sectors. By implementing sustainable energy practices and effective energy management strategies, Nepal can achieve a reliable, affordable, and environmentally friendly energy system, supporting its economic growth and environmental sustainability.

Recommendations

- ***Establishment of a Collaborative Energy Database:*** It is crucial to establish a robust and accurate energy database by collaborating with relevant institutions and the National Energy Information System (NEIS). This will ensure the collection and representation of up-to-date and reliable energy data.
- ***Conduct Regular Energy Analysis:*** Regular energy analysis should be conducted for the nation and its seven provinces to obtain an accurate representation of energy supply and consumption patterns. This will enable informed decision-making and effective energy planning at various levels.
- ***Enhance Data Accuracy for Renewable and Traditional Energy:*** Detailed information should be collected to improve the accuracy of estimating renewable energy generation from isolated systems and traditional energy resources. This will contribute to better planning and utilization of these energy sources.
- ***Standardize Data Collection and Analysis Methods:*** It is recommended to define and implement standards for data collection and analysis in the energy sector. This will ensure consistency, reliability, and comparability of data, enabling effective monitoring, evaluation, and policy formulation.
- ***Introduce Distinct Codes for Energy-related Commodities:*** The Department of Customs should introduce specific codes for energy-related commodities to enhance transparency and accuracy in assessing energy flows. This will facilitate data collection and verification of energy supply sources.

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ANNEX

Annex I: GDP Structure

Gross Value Added by Industrial Division (at constant 2067/68 prices)

Rs. 000 millions

R = Revised/P = Preliminary

NSIC	Industrial Classification	2067/68	2068/69	2069/70	2070/71	2071/72	2072/73	2073/74	2074/75	2075/76	2076/77	2077/78	2078/79 R	2079/80 P
A	Agriculture, forestry and fishing	480	506	512	535	542	541	569	584	614	629	647	662	680
B	Mining and quarrying	9	9	9	10	11	10	12	13	15	15	15	17	17
C	Manufacturing	84	93	95	101	101	92	107	117	124	113	123	131	129
D	Electricity, gas, steam and air conditioning supply	14	17	17	17	17	16	20	22	24	28	29	45	54
E	Water supply; sewerage, waste management and remediation activities	9	10	11	12	13	14	15	15	16	16	16	16	17
F	Construction	93	93	95	104	107	107	127	142	153	146	156	167	163
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	221	227	233	247	258	251	278	326	352	312	333	358	347
H	Transportation and storage	77	83	89	95	101	101	105	118	128	113	118	123	125
I	Accommodation and food service activities	25	26	28	28	30	27	31	35	38	24	27	30	36
J	Information and communication	31	40	44	56	62	63	71	73	78	80	83	86	89
K	Financial and insurance activities	69	70	71	76	81	88	97	106	113	112	118	126	135
L	Real estate activities	143	145	148	151	153	153	160	162	168	172	177	179	183
M	Professional, scientific and technical activities	12	13	14	15	16	16	17	18	19	19	20	20	21
N	Administrative and support service activities	6	6	7	8	9	10	12	14	15	15	16	16	17
O	Public administration and defense; compulsory social security	64	66	70	73	79	81	87	91	96	102	105	110	115
P	Education	75	80	84	88	93	100	107	113	120	124	129	135	140
Q	Human health and social work activities	17	18	18	19	21	22	23	25	26	28	29	31	33
R, S, T, U	Arts, entertainment and recreation; Other service activities; and Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	7	7	7	7	8	8	9	9	10	10	10	11	11
	Gross Domestic Product (GDP) at basic prices	1436	1507	1554	1643	1700	1700	1847	1983	2109	2058	2150	2264	2312
	Taxes less subsidies on products	123	125	136	148	162	170	192	211	230	226	244	266	264
	Gross Domestic Product (GDP)	1559	1632	1690	1791	1862	1870	2038	2194	2340	2284	2395	2529	2576

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Annex I: Forest

Forest Distribution by Type

Province	Area (000ha)					
	Forest	Tree Cover 5-10%	Shrubs	OWL	OL	Total
Koshi	1,034.17	82.42	17.75	100.17	1,476.72	2,711.23
Madhesh	260.76	2.07	0.80	2.87	695.34	961.84
Bagmati	1,046.21	38.57	6.09	44.67	939.43	2,074.97
Gandaki	739.60	83.23	16.32	99.55	1,429.16	2,367.86
Lumbini	968.37	30.31	18.91	49.22	963.27	2,030.08
Karnali	902.82	168.02	47.50	215.52	1,828.31	3,162.17
Sudurpashchim	1,010.21	126.44	9.46	135.90	831.26	2,113.27
Total	**5,962.14**	**531.06**	**116.83**	**647.90**	**8,163.49**	**15,421.42**

Land Cover Area by Physiographic Region (ha)

Physiographic Region	Forest	OWL			OL	Total
		Tree Crown Cover 5-10%	Shrubs	Total OWL		
Terai	411,580	5,573	3,930	9,503	1,595,916	2,016,999
Churia	1,373,743	22,336	336	22,672	501,848	1,898,263
Middle Mountains	2,253,807	29,308	32,979	62,287	1,993,302	4,309,396
High Mountains	1,922,909	473,850	79,581	553,431	4,072,426	6,548,766
Total	**5,962,039**	**531,067**	**116,826**	**647,893**	**8,163,492**	**14,773,424**

Community Forest Coverage in Different Provinces

Province	Community Groups	Community Forest Area (ha)	Beneficiaries (Households)	Beneficiaries (Population)	Forest Area w.r.t. Province	Community Forest Coverage
Koshi	4,832	551,791	701,771	3,621,360	48.65%	17.35%
Madhesh	619	125,947	617,228	3,611,242	47.77%	3.96%
Bagmati	8,213	593,495	695,165	3,483,552	54.41%	18.66%
Gandaki	5,168	449,665	523,592	2,919,897	55.02%	14.14%
Lumbini	4,657	576,570	865,040	4,753,860	59.17%	18.13%
Karnali	3,532	375,918	333,858	1,846,745	31.77%	11.82%
Sudurpashchim	4,447	507,580	587,733	3,370,144	44.25%	15.96%
Total	**31,468**	**3,180,966**	**4,324,387**	**23,606,800**		

Sustainable Wood and Energy Supply in Different Provinces of Various Physiographic Regions

Province	Sustainable Wood Production (million Tons)												Total Energy (million GJ)
	Churia			Terai			Mid Hills			High Mountains			
	Forest	OWL	Total	Forest	OWL	Total	Forest	OWL	Total	Forest	OWL	Total	
Koshi	0.249	0.004	0.253	0.502	0.009	0.511	1.078	0.019	1.097	1.206	0.021	1.227	51.759
Madhesh	0.155	0	0.155	0.823	0.002	0.825	0	0	0	0	0	0	16.412
Bagmati	0.53	0.004	0.534	0	0	0	0.823	0.006	0.829	0.902	0.007	0.909	38.049
Gandaki	0.048	0.001	0.049	0.025	0.001	0.026	0.944	0.023	0.967	0	0	0	17.465
Lumbini	0.421	0.004	0.425	0.287	0.003	0.29	0.675	0.006	0.681	0	0	0	23.397
Karnali	0.065	0.003	0.068	0	0	0	0.505	0.022	0.527	0.721	0.032	0.753	22.557
Sudurpashchim	0.197	0.005	0.202	0.337	0.008	0.345	1.209	0.030	1.239	0.235	0.006	0.241	33.940
Total	**1.665**	**0.021**	**1.686**	**1.974**	**0.023**	**1.997**	**5.234**	**0.106**	**5.34**	**3.064**	**0.066**	**3.13**	**203.579**

Annex II: Agricultural Residue

Agricultural Residue Supply Potential – 2075/76

Province	Production in Tons				Total Residue in Tons	Total Potential Energy 000GJ
	Paddy	Maize	Wheat	Millet		
Koshi	1,237,954	831,379	192,249	97,180	2,358,762	89,914
Madhesh	1,495,045	161,764	582,565	1,663	2,241,037	85,276
Bagmati	521,446	598,000	159,444	69,465	1,348,355	51,819
Gandaki	427,689	423,308	93,433	99,740	1,044,170	39,369
Lumbini	1,188,675	369,898	496,117	10,869	2,065,559	79,184
Karnali	133,580	217,060	161,690	19,674	532,004	20,735
Sudurpashchim	605,626	112,225	320,170	15,632	1,053,653	40,179
Total	**5,610,015**	**2,713,634**	**2,005,668**	**314,223**	**10,643,540**	**406,476**

Agricultural Residue Supply Potential – 2076/77

Province	Production in Tons				Total Residue in Tons	Total Potential Energy 000GJ
	Paddy	Maize	Wheat	Millet		
Koshi	1,245,545	867,717	176,710	95,201	2,385,173	91,007
Madhesh	1,420,437	175,640	601,708	1,641	2,199,426	83,835
Bagmati	510,200	617,762	168,431	69,675	1,366,068	52,570
Gandaki	408,737	433,561	99,400	106,138	1,047,836	39,485
Lumbini	1,185,493	398,462	508,459	11,784	2,104,198	80,744
Karnali	134,407	225,238	196,296	20,404	576,345	22,495
Sudurpashchim	646,059	117,297	434,288	16,111	1,213,755	46,440
Total	**5,550,878**	**2,835,677**	**2,185,292**	**320,954**	**10,892,801**	**416,576**

Agricultural Residue Supply Potential – 2077/78

Province	Production in Tons				Total Residue in Tons	Total Potential Energy 000GJ
	Paddy	Maize	Wheat	Millet		
Koshi	1,327,718	921,281	187,153	96,629	2,532,781	96,689
Madhesh	1,514,149	186,482	637,269	1,666	2,339,566	89,169
Bagmati	543,860	655,896	178,385	70,720	1,448,861	55,795
Gandaki	435,703	460,325	105,274	107,730	1,109,032	41,850
Lumbini	1,263,705	423,059	538,509	11,961	2,237,234	85,848
Karnali	143,274	239,142	207,897	20,710	611,023	23,860
Sudurpashchim	688,682	124,538	459,954	16,353	1,289,527	49,344
Total	**5,917,091**	**3,010,723**	**2,314,441**	**325,769**	**11,568,024**	**442,555**

Agricultural Residue Supply Potential – 2078/79

Province	Production in Tons				Total Residue in Tons	Total Potential Energy 000GJ
	Paddy	Maize	Wheat	Millet		
Koshi	1,360,170	963,361	180,275	95,786	2,599,591	99,239
Madhesh	1,495,648	199,347	661,885	1,660	2,358,539	89,892
Bagmati	547,583	681,782	187,694	71,208	1,488,267	57,313
Gandaki	432,057	476,082	111,210	109,322	1,128,671	42,591
Lumbini	1,287,654	450,301	556,754	12,630	2,307,339	88,538
Karnali	146,781	249,229	234,835	21,299	652,143	25,466
Sudurpashchim	729,845	130,333	544,588	16,753	1,421,519	54,395
Total	**5,999,737**	**3,150,434**	**2,477,240**	**328,657**	**11,956,068**	**457,434**

Annex III: Animal Waste

Animal Waste Production and Corresponding Energy Potential in 2075/76

Province	Livestock Population		Total Annual Dry Dung Potential in Tons	Actual Dry Dung Production in Tons	Energy Potential in 000GJ
	Cattle	Buffalo			
Koshi	1,955,096	1,099,983	1,930,654	1,351,458	20,164
Madhesh	1,111,055	1,088,366	1,689,926	1,182,948	17,650
Bagmati	1,045,119	1,158,202	1,453,222	1,017,255	15,177
Gandaki	551,162	892,222	1,065,422	745,795	11,127
Lumbini	1,141,280	1,513,009	1,985,353	1,389,747	20,735
Karnali	550,981	441,135	599,498	419,649	6,261
Sudurpashchim	1,030,344	676,331	1,013,467	709,427	10,585
Total	**7,385,037**	**6,869,248**	**9,737,542**	**6,816,279**	**101,699**

Animal Waste Production and Corresponding Energy Potential in 2076/77

Province	Livestock Population		Total Annual Dry Dung Potential in Tons	Actual Dry Dung Production in Tons	Energy Potential in 000GJ
	Cattle	Buffalo			
Koshi	1,981,755	1,108,914	1,962,605	1,373,824	20,497
Madhesh	1,247,124	1,085,427	1,775,510	1,242,857	18,543
Bagmati	1,064,349	1,177,093	1,474,284	1,031,999	15,397
Gandaki	481,865	886,109	1,018,662	713,063	10,639
Lumbini	1,162,262	1,560,072	2,039,490	1,427,643	21,300
Karnali	504,184	396,145	521,985	365,390	5,452
Sudurpashchim	1,017,346	623,824	978,965	685,276	10,224
Total	**7,458,885**	**6,837,584**	**9,771,501**	**6,840,051**	**102,054**

Animal Waste Production and Corresponding Energy Potential in 2077/78

Province	Livestock Population		Total Annual Dry Dung Potential in Tons	Actual Dry Dung Production in Tons	Energy Potential in 000GJ
	Cattle	Buffalo			
Koshi	1,992,260	1,124,990	1,981,956	1,387,369	20,700
Madhesh	1,253,735	1,101,389	1,794,017	1,255,812	18,737
Bagmati	1,069,991	1,194,479	1,491,846	1,044,292	15,581
Gandaki	484,419	899,031	1,031,602	722,121	10,774
Lumbini	1,168,423	1,583,134	2,063,833	1,444,683	21,555
Karnali	506,857	401,921	527,950	369,565	5,514
Sudurpashchim	1,022,739	633,478	989,587	692,711	10,335
Total	**7,498,424**	**6,938,422**	**9,880,791**	**6,916,554**	**103,195**

Animal Waste Production and Corresponding Energy Potential in 2078/79

Province	Livestock Population		Total Annual Dry Dung Potential in Tons	Actual Dry Dung Production in Tons	Energy Potential in 000GJ
	Cattle	Buffalo			
Koshi	2,013,534	1,136,303	2,009,707	1,406,795	20,989.4
Madhesh	1,346,651	1,104,750	1,857,242	1,300,069	19,397.0
Bagmati	1,084,692	1,212,868	1,511,741	1,058,219	15,788.6
Gandaki	439,072	899,263	1,004,742	703,319	10,493.5
Lumbini	1,184,465	1,622,197	2,108,039	1,475,627	22,016.4
Karnali	476,550	373,853	478,263	334,784	4,995.0
Sudurpashchim	1,015,871	601,691	970,126	679,088	10,132.0
Total	**7,560,836**	**6,950,925**	**9,939,860**	**6,957,902**	**103,811.9**

Annex IV: Locations of Coal Reserves in Nepal

Economic Coal Reserves

S.N.	Location	District	Latitude (°)	Longitude (°)	Status
1	Simaldi	Palpa	27.817	83.714	-
2	Tosh	Dang	28.004	82.517	Mining
3	Siuja	Dang	28.067	82.604	
4	Chhap	Dang	28.075	82.6	
5	Khara	Rolpa	28.142	82.492	
6	Dubring	Rolpa	28.171	82.475	
7	Sarpani	Rolpa	28.246	82.4	
8	Naulo Khola	Dang	28.21	82.275	
9	Ajimara	Dang	28.2	82.267	
10	Boksi Khola	Dang	28.217	82.225	
11	Loharpani	Dang	27.998	82.717	
12	Murkuti	Dang	28	82.704	
13	Phalide	Dang	28.05	82.583	
14	Chhipan	Dang	28.054	82.6	
15	Jumlipani	Dang	28.017	82.617	
16	Dabang	Dang	28.008	82.65	
17	Sibang	Dang	28.225	82.375	
18	Pakhapani	Dang	28.227	82.342	

Locations with Deposits of Coal

S.N.	Location	District	Latitude (°)	Longitude (°)	Status
1	Hariharpur V.D.C.	Dhanusha	27	86	-
2	Nigale (Kankari)	Doti	29.233	80.8	
3	Shakti Khola	Bara	27.25	85.1	
4	Dhukuchhap	Lalitpur	27.598	85.292	Old-working

Locations of Coal Occurrences

S.N.	Location	District	Latitude (°)	Longitude (°)	Status
1	Koilabas	Dang	27.7	82.517	-
2	Sisneri	Dang	28.083	82.606	
3	Madday Khajuri	Dang	28.033	82.608	
4	Uja	Bara	27.292	85.042	
5	Bijauri	Bara	27.258	85.108	
6	Chandi Khola	Makawanpur/Rautahat	27.217	85.35	
7	Barahakshetra	Sunsari	26.833	87.167	
8	Kokaha Khola	Sunsari	26.833	87.283	
9	Daran Bazar	Sunsari	26.817	87.283	
10	Doijhava Khola	Jhapa	26.708	87.933	
11	Sanka Maka Khola	Jhapa	26.683	87.95	
12	Barahakshetra	Udayapur	26.8	87.033	
13	Kagbeni (Chanche)	Mustang	28.842	83.758	
14	Dharmasthali	Kathmandu	27.775	85.3	
15	Tupek (Gokarna)	Kathmandu	27.75	85.367	
16	Asarkot Danda	Dang	28.2	82.292	
17	Mettaura Goan	Rolpa	28.2	82.433	
18	Chirtung Danda	Palpa	27.802	83.714	
19	Purwa Khola	Palpa	27.819	83.731	
20	Agha Khola	Palpa	27.838	83.689	
21	East of Tansen	Palpa	27.864	83.556	
22	Sisne Khola (East of Bartun)	Palpa	27.858	83.564	
23	Ripdikot Danda	Palpa	27.835	83.425	
24	Phek	Palpa	27.814	83.417	
25	Lummas	Palpa	27.832	83.4	
26	Ghat Khola	Palpa	27.846	83.408	
27	Lukundol	Lalitpur	27.6	85.3	
28	Chhampi	Lalitpur	27.596	85.317	Old-working

Annex V: Petroleum Data

Import of Petroleum Products in Different Provinces in Different FY

Province	Petroleum Products	Fiscal Year				Province	Petroleum Products	Fiscal Year			
		2075/76	2076/77	2077/78	2078/79			2075/76	2076/77	2077/78	2078/79
Koshi	Petrol	105,907	89,664	111,724	134,640	Lumbini	Petrol	94,648	88,724	109,652	128,252
	Diesel	298,545	130,088	89,024	92,388		Diesel	404,772	267,308	298,616	246,148
	Kerosene	4,780	2,760	4,168	3,796		Kerosene	5,660	2,900	5,860	4,204
	LPG	72,534	78,059	88,169	97,961		LPG	82,587	93,577	117,009	137,978
	ATF	7,740	6,588	5,584	11,244		ATF	10,992	8,004	7,656	13,968
Madhesh	Petrol	130,376	133,276	149,104	177,108	Karnali	Petrol	0	0	0	0
	Diesel	593,584	805,088	1,129,966	1,289,069		Diesel	0	0	0	0
	Kerosene	8,284	9,392	9,500	6,120		Kerosene	0	0	0	0
	LPG	265,060	267,522	259,376	284,575		LPG	0	0	0	0
	ATF	0	0	0	0		ATF	0	0	0	0
Bagmati	Petrol	184,624	153,620	165,308	226,360	Sudurpashchim	Petrol	20,632	20,484	26,232	30,176
	Diesel	260,496	144,688	52,580	0		Diesel	84,448	76,564	95,088	95,952
	Kerosene	4,620	2,940	3,400	2,840		Kerosene	660	592	656	380
	LPG	0	0	0	0		LPG	9,429	9,905	13,198	15,514
	ATF	175,056	118,264	56,060	125,008		ATF	2,440	1,748	1,664	3,668
Gandaki	Petrol	30,640	26,360	29,680	39,740						
	Diesel	73,060	49,800	30,928	0						
	Kerosene	1,000	340	0	0						
	LPG	0	0	0	0						
	ATF	3,880	2,820	1,300	3,240						

(LPG is in MT, remaining values are in KL)

Sale of Petroleum Products in Different Provinces in Different FY

Province	Petroleum Products	Fiscal Year				Province	Petroleum Products	Fiscal Year			
		2075/76	2076/77	2077/78	2078/79			2075/76	2076/77	2077/78	2078/79
Koshi	Petrol	79,822	76,937	89,780	134,612	Lumbini	Petrol	67,235	62,175	76,227	121,119
	Diesel	234,772	234,828	268,151	319,083		Diesel	264,490	225,086	289,773	395,867
	Kerosene	4,507	3,609	3,924	3,895		Kerosene	4,059	3,157	4,832	4,793
	LPG	60,008	57,770	65,592	97,961		LPG	48,103	56,624	76,777	137,978
	ATF	6,185	4,755	4,329	9,442		ATF	3,704	2,877	1,970	12,530
Madhesh	Petrol	125,427	46,178	41,942	173,271	Karnali	Petrol	31,192	27,439	30,892	7,937
	Diesel	589,913	141,169	114,219	554,743		Diesel	71,923	61,671	64,739	24,581
	Kerosene	8,069	1,999	1,865	4,083		Kerosene	986	745	1,472	333
	LPG	265,060	267,522	259,376	284,575		LPG	0	0	0	0
	ATF	0	698	717	1,743		ATF	3,854	2,822	1,326	946
Bagmati	Petrol	215,461	179,912	192,346	223,979	Sudurpashchim	Petrol	20,599	20,481	26,101	30,069
	Diesel	339,297	264,156	293,012	262,570		Diesel	84,378	77,446	95,176	95,702
	Kerosene	5,658	3,923	4,583	3,107		Kerosene	700	613	703	382
	LPG	12,525	20,289	22,577	0		LPG	9,429	9,905	13,198	15,514
	ATF	177,679	121,242	56,228	122,496		ATF	2,421	1,753	1,656	3,720
Gandaki	Petrol	23,129	21,708	27,515	39,501						
	Diesel	117,383	95,650	122,820	75,025						
	Kerosene	1,105	1,012	1,328	1,204						
	LPG	34,485	36,952	40,232	0						
	ATF	6,293	4,533	4,173	3,201						

(LPG is in MT, remaining values are in KL)

Annex VI: Electricity

NEA Hydropower Generation Statistics

S.N.	Power Stations		Total Installed Capacity (MW)	Actual Generation (In MWh)			
				FY 2075/76	FY 2076/77	FY 2077/78	FY 2078/79
1	Kaligandaki 'A'	KGA	144	871,914.00	871,466.00	817,712.86	974,831.97
2	Mid-Marsyangdi	MMHPS	70	471,322.51	446,624.75	398,846.30	468,270.00
3	Marsyandi	MHPS	69	475,176.00	443,852.10	398,920.10	464,271.50
4	Kulekhani I	KLI	60	91,184.00	162,972.00	195,157.00	172,753.00
5	Kulekhani II	KLII	32	44,676.70	81,483.40	95,228.87	82,691.46
6	Upper Trishuli 3A	UT3A	60	16,185.60	407,551.15	314,767.50	432,832.50
7	Chameliya	CHEPS	30	161,395.54	160,811.64	151,247.41	153,981.04
8	Trishuli	THPS	24	123,741.10	128,973.11	121,211.30	137,113.27
9	Gandak	GHPS	15	11,950.80	10,337.60	12,123.40	15,181.70
10	Modi	MKHPS	14.8	69,400.50	66,913.20	60,470.50	79,601.90
11	Devighat	DHPS	15	86,851.14	92,053.14	85,429.11	98,389.60
12	Kulekhani III	KLIII	14	-	20,365.20	35,565.40	36,243.80
13	Sunkoshi	SKHPS	10.05	62,156.70	62,245.94	55,916.73	63,524.08
14	Puwa	PKHPS	6.2	34,192.81	34,914.55	34,477.31	37,715.20
15	Chatara	CHPS	3.2	2,698.25	1,822.00	3,351.80	2,878.58
16	Panauti	PHPS	2.4	3,005.84	2,886.76	2,947.96	3,251.28
17	Seti	SHPS	1.5	10,030.00	11,158.29	11,682.18	10,954.65
18	Fewa	FHPS	1	1,531.68	2,126.54	1,850.94	1,863.37
19	Sundarijal	SJHPS	0.97	3,587.30	2,814.76	3,922.39	6,101.62
	Total (Hydro)		***573.12***	***2,541,000.47***	***3,011,372.13***	***2,800,829.06***	***3,242,450.52***
20	Multifuel	MFPS	39	0.00	2.52	0.00	0.00
21	Hetauda Diesel	HDPS	14.41	115.74	57.09	54.36	32.51
	Total (Thermal)		***53.41***	***115.74***	***59.61***	***54.36***	***32.51***
	Grand Total		**626.53**	**2,541,116.21**	**3,011,431.74**	**2,800,883.42**	**3,242,483.03**

Hydropower Plants under Construction by NEA

S.N.	Project	District	Capacity (MW)	Status
1	Upper Tamakoshi Hydropower Limited	Dolakha	456	Completed. Grid connected.
2	Tanahu Hydropower Limited	Tanahu	140	Excavation of the left and right bank of the dam and diversion tunnel in progress. Tower foundation and tower erection under transmission line package is going on.
3	Rahuganga Hydropower Limited	Myagdi	40	Construction of power house in progress
4	Upper Sanjen	Rasuwa	14.6	Under Construction
5	Sanjen	Rasuwa	42.5	Under Construction
6	Rasuwagadhi	Rasuwa	111	Under Construction
7	Madhya Bhotekoshi	Sindhupalchowk	102	Under Construction
8	Upper Trishuli 3B	Rasuwa/Nuwakot	37	Under Construction
		Total	***943.1***	

NEA Proposed and Planned Projects

S.N	Projects	Capacity (MW)	Province
1	Uttar Ganga Storage Hydro-electric Project	828	Gandaki
2	Andhikhola Storage Hydro-electric Project	180	Gandaki
3	Begnas Rupa Pump Storage Hydro-electric Project	150	Gandaki
4	Kulekhani-Sisneri Pump Storage Hydro-electric Project	100	Bagmati
5	Chainpur Seti Hydro-electric Project	210	Sudurpashchim
6	Lower Seti Hydropower Project	126	Gandaki
7	Upper Modi A Hydro-electric Project	42	Gandaki
8	Upper Modi Hydro-electric Project	18.2	Gandaki
9	Tamakoshi V Hydro-electric Project	99.8	Bagmati
10	Upper Arun Hydro -electric Project	1061	Koshi
11	Dudh Koshi Storage Hydro-electric Project	635	Koshi
	Total	***3450***	

Annex VII: Modern Renewables

Cumulative Achievements in Renewable Energy Technologies (till Poush 2079)

Program	Unit	Achievement till			
		2075/76	2076/77	2077/78	2078/79
Domestic Biogas	*Nos.*	425,511	427,532	433,173	439,547
Electric/Induction Cookstoves	*Nos.*	-	-	-	22,699
Improved Water Mill (IWM)	*Nos.*	11,018	11,018	11,022	11,104
Institutional Gasifier	*Nos.*	-	33	33	33
Institutional Solar PV System	*Nos.*	1,993	2,210	2,808	3,817
Institutional, Urban and Commercial Biogas Plant	*Nos.*	247	275	316	355
Metallic ICS	*Nos.*	85,805	94,919	103,387	18,068
Micro/Mini Hydro	*kW*	32,159	34,870	35,986	37,734
Mud Improved Cooking Stoves (ICS)	*Nos.*	1,423,242	1,423,242	1,423,242	1,423,242
Portable Metallic stoves	*Nos.*	-	10,465	16,015	106,287
Rooftop Solar	*kW*	-	-	-	10,080
Solar Drinking Water and Irrigation Pump	*Nos.*	1,364	1,889	2,446	3,129
Solar Dryer and Cooker	*Nos.*	-	2,450	2,457	2,464
Solar Home System	*Nos.*	911,097	933,722	961,925	974,001
Solar Installed at Religious Place and Home stay	*Nos.*	-	-	-	4,511
Solar Mini grid Solar/Wind Min-grid System	*kW*	563	741	1,262	2,929
Solar Street Lights	*Nos.*	-	-	-	3,309
Urban Solar Home System	*Nos.*	21,144	21,144	21,144	-

Annex VIII: Energy Consumption

(1 TOE = 41.868 GJ | 1000 GJ = 0.28 GWh)

FY 2075/76 (2019)

Category	Fuel Type	Energy (000 GJ)	000 TOE	GWh	% of National Total
Traditional	Fuelwood	365,088.96	8,720.00	102,224.91	62.03%
	Agricultural residues	18,045.11	431.00	5,052.63	3.07%
	Cow dung	18,840.60	450.00	5,275.37	3.20%
	Total	**401,974.67**	**9,601.00**	**112,552.91**	**68.30%**
Commercial	Coal	40,780.08	974.02	11,418.42	6.93%
	Petrol	18,735.01	447.48	5,245.80	2.93%
	Diesel	63,604.81	1,519.17	17,809.35	9.94%
	Kerosene	889.87	21.25	249.16	0.14%
	LPG	19,605.69	468.27	5,489.59	3.06%
	ATF	6,306.28	150.62	1,765.76	0.99%
	Furnace Oil	1,221.93	29.19	342.14	0.19%
	Total	**151,143.67**	**3,610.00**	**42,320.23**	**25.68%**
	Grid Electricity	**22,864.38**	**546.11**	**6,402.03**	**3.57%**
Renewable	Biogas	8,174.99	195.26	2,289.00	1.28%
	Wind	1.04	0.02	0.29	0.0002%
	Micro/Pico Hydro	325.94	7.78	91.26	0.05%
	Solar	4,080.09	97.45	1,142.43	0.64%
	Total	**12,582.06**	**300.52**	**3,522.98**	**2.14%**
Total		***588,564.78***	***14,057.63***	***164,798.14***	***100%***

FY 2076/77 (2020)

Category	Fuel Type	Energy (000 GJ)	000 TOE	GWh	% of National Total
Traditional	Fuelwood	366,847.42	8,762.00	102,717.28	64.87%
	Agricultural residues	18,254.45	436.00	5,111.25	3.23%
	Cow dung	17,877.64	427.00	5,005.74	3.16%
	Total	**402,979.51**	**9,625.00**	**112,834.26**	**71.26%**
Commercial	Coal	43,203.07	1,031.89	12,096.86	7.64%
	Petrol	14,473.37	345.69	4,052.54	2.26%
	Diesel	41,104.14	981.76	11,509.16	6.42%
	Kerosene	681.51	16.28	190.82	0.11%
	LPG	20,493.49	489.48	5,738.18	3.20%
	ATF	4,369.79	104.37	1,223.54	0.68%
	Furnace Oil	373.99	8.93	104.72	0.06%
	Total	**124,699.36**	**2,978.39**	**34,915.82**	**22.05%**
	Grid Electricity	**23,200.05**	**554.12**	**6,496.01**	**3.63%**
Renewable	Biogas	10,140.70	242.21	2,839.40	1.58%
	Wind	1.42	0.03	0.40	0.0002%
	Micro/Pico Hydro	435.89	10.41	122.05	0.07%
	Solar	4,080.09	97.45	1,142.43	0.64%
	Total	**14,658.10**	**350.10**	**4,104.27**	**2.59%**
Total		***565,537.02***	***13,507.62***	***158,350.37***	***100%***

FY 2077/78 (2021)

Category	Fuel Type	Energy (000 GJ)	000 TOE	GWh	% of National Total
Traditional	Fuelwood	377,790.36	9,023.37	105,781.30	60.38%
	Agricultural residues	18,782.36	448.61	5,259.06	3.00%
	Cow dung	17,967.02	429.13	5,030.77	2.87%
	Total	**414,539.74**	**9,901.11**	**116,071.13**	**66.26%**
Commercial	Coal	58,445.58	1,395.95	16,364.76	9.34%
	Petrol	19,560.86	467.20	5,477.04	3.06%
	Diesel	63,465.44	1,515.85	17,770.32	9.92%
	Kerosene	831.03	19.85	232.69	0.13%
	LPG	21,802.75	520.75	6,104.77	3.41%
	ATF	2,218.29	52.98	621.12	0.35%
	Furnace Oil	3,399.09	81.19	951.75	0.53%
	Total	**169,723.04**	**4,053.77**	**47,522.45**	**27.13%**
	Grid Electricity	**26,373.39**	**629.92**	**7,384.55**	**4.12%**
Renewable	Biogas	9,756.95	233.04	2,731.95	1.52%
	Wind	1.87	0.04	0.52	0.0003%
	Micro/Pico Hydro	514.96	12.30	144.19	0.08%
	Solar	4,759.67	113.68	1,332.71	0.74%
	Total	**15,033.45**	**359.07**	**4,209.37**	**2.40%**
Total		***625,669.62***	***14,943.86***	***175,187.49***	***100%***

Annex IX: Sectoral Energy Consumption

(Energy in TJ)

Residential Sector

Fuel Type	FY 2075/76	FY 2076/77	FY 2077/78	FY 2078/79
Fuelwood	322,597.14	326,862.63	335,420.90	316,280.95
Agricultural Residue	7,208.31	7,278.95	7,350.28	6,246.60
Animal Waste	18,840.60	17,877.64	17,967.02	17,583.86
Kerosene	175.55	166.79	175.82	150.60
Petrol	0	0	0	0.00
Diesel	0	0	0	0.00
ATF	0	0	0	0.00
LPG	10,390.15	10,860.65	10,899.78	18,927.22
Furnace Oil	0	0	0	0.00
Coal	0	0	0	60.07
Electricity	9,075.49	9,977.37	11,668.28	15,457.53
Biogas	8,134.60	10,095.74	9,705.28	10,480.33
Solar	1,889.96	1,895.68	2,010.59	2,150.24
Wind	1.04	1.42	1.87	1.59
Micro/Pico Hydro	325.94	435.89	514.96	431.98
Total	**378,638.78**	**385,452.76**	**395,714.78**	**387,770.99**

Industrial Sector

Fuel Type	FY 2075/76	FY 2076/77	FY 2077/78	FY 2078/79
Fuelwood	19,906.96	18,262.79	19,273.78	39,216.74
Agricultural Residue	10,836.80	10,975.50	11,432.08	11,454.80
Animal Waste	0	0	0	0.00
Kerosene	303.16	218.45	278.07	402.24
Petrol	240.66	223.16	231.33	2,813.02
Diesel	14,448.78	9,453.95	14,597.05	15,475.84
ATF	0	0	0	0.00
LPG	1.71	1.79	2.03	795.97
Furnace Oil	1,221.93	373.99	3,399.09	1,832.98
Coal	37,514.18	40,049.61	55,150.22	57,474.73
Electricity	9,755.77	9,193.71	10,163.52	12,396.20
Biogas	0	0	0	0.00
Solar	0	0	0	0.00
Wind	0	0	0	0.00
Micro/Pico Hydro	0	0	0	0.00
Total	**94,229.95**	**88,752.95**	**114,527.17**	**141,862.52**

Commercial Sector

Fuel Type	FY 2075/76	FY 2076/77	FY 2077/78	FY 2078/79
Fuelwood	22,455.56	21,638.15	22,964.13	18,952.89
Agricultural Residue	0	0	0	264.09
Animal Waste	0	0	0	566.28
Kerosene	0	0	0	63.90
Petrol	34.98	34.07	35.51	197.23
Diesel	36.54	35.53	37.10	0.00
ATF	0	0	0	0.00
LPG	9,168.73	9,583.92	10,847.60	4,596.11
Furnace Oil	0	0	0	0.00
Coal	3,265.90	3,153.46	3,295.35	613.42
Electricity	3,452.97	3,417.84	3,799.61	2,357.07
Biogas	40.39	44.97	51.67	8.39
Solar	2,183.04	2,165.53	2,723.80	2,907.66
Wind	0	0	0	0.28
Micro/Pico Hydro	0	0	0	107.99
Total	**40,638.11**	**40,073.47**	**43,754.77**	**30,635.33**

Agricultural Sector

Fuel Type	FY 2075/76	FY 2076/77	FY 2077/78	FY 2078/79
Fuelwood	0.00	0.00	0.00	0.00
Agricultural Residue	0.00	0.00	0.00	0.00
Animal Waste	0.00	0.00	0.00	0.00
Kerosene	0.00	0.00	0.00	0.00
Petrol	128.35	133.08	136.34	69.03
Diesel	8,417.34	8,712.73	8,942.76	5,074.91
ATF	0	0	0	0.00
LPG	0	0	0	0.00
Furnace Oil	0	0	0	0.00
Coal	0	0	0	0.00
Electricity	560.06	596.94	79.70	867.70
Biogas	0	0	0	0.00
Solar	7.10	18.89	25.29	25.42
Wind	0	0	0	0.00
Micro/Pico Hydro	0	0	0	0.00
Total	**9,112.85**	**9,461.64**	**9,184.09**	**6,037.06**

Transportation Sector

Fuel Type	FY 2075/76	FY 2076/77	FY 2077/78	FY 2078/79
Fuelwood	0	0	0	0.00
Agricultural Residue	0	0	0	0.00
Animal Waste	0	0	0	0.00
Kerosene	0	0	0	0.00
Petrol	18,269.69	14,035.01	19,092.85	21,202.42
Diesel	36,140.77	19,917.37	35,280.34	40,493.58
ATF	6,306.28	4,369.79	2,218.29	5,392.72
LPG	0.09	0.10	0.11	1.32
Furnace Oil	0	0	0	0.00
Coal	0	0	0	0.00
Electricity	15.91	9.84	6.98	14.40
Biogas	0	0	0	0.00
Solar	0	0	0	0.00
Wind	0	0	0	0.00
Micro/Pico Hydro	0	0	0	0.00
Total	**60,732.74**	**38,332.11**	**56,598.57**	**67,104.44**

Construction and Mining Sector

Fuel Type	FY 2075/76	FY 2076/77	FY 2077/78	FY 2078/79
Fuelwood	129.30	83.84	131.55	112.37
Agricultural Residue	0	0	0	0.00
Animal Waste	0	0	0	0.00
Kerosene	411.16	296.27	377.14	23.94
Petrol	61.33	48.05	64.83	372.28
Diesel	4,561.38	2,984.55	4,608.19	5,035.27
ATF	0	0	0	0.00
LPG	44.99	47.03	53.23	335.82
Furnace Oil	0	0	0	1.47
Coal	0	0	0	0.00
Electricity	4.18	4.34	5.29	673.28
Biogas	0	0	0	0.00
Solar	0	0	0	0.00
Wind	0	0	0	0.00
Micro/Pico Hydro	0	0	0	0.00
Total	**5,212.34**	**3,464.08**	**5,240.23**	**6,554.41**