Government of Nepal

Water and Energy Commission Secretariat

Singha Durbar, Kathmandu, Nepal

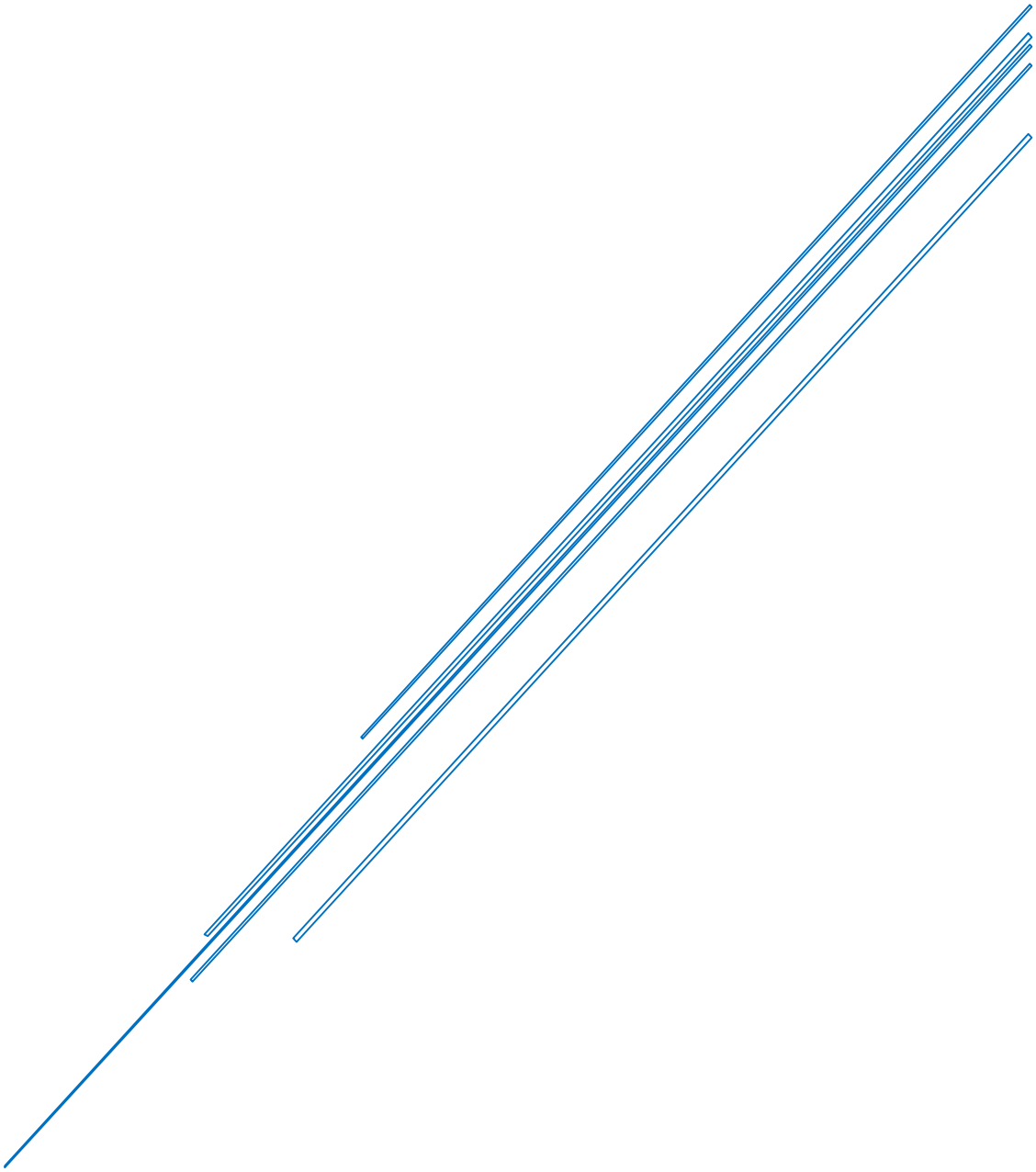
Energy Sector Synopsis Report 2021/2022

WECS 03/077/078

June 2022

NEPAL ENERGY SECTOR SYNOPSIS REPORT - 2022

Energy Resource and Consumption in Nepal in 2019, 2020, 2021



Water and Energy Commission Secretariat
Singhadurbar, Kathmandu, Nepal
2022

Contents

List of Figures

List of Tables

Abbreviations

AEPC	Alternative Energy Promotion Centre
CAGR	Cumulative Annual Growth Rate
CBS	Central Bureau Of Statistics
Cu.m	Cubic Meter
DOED	Department of Electricity Development
FY	Fiscal Year
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GJ	Giga Joule
GVA	Gross Value Added
GW	Gigawatt
HH	household
ICS	Improved Cooking Stove
IPP	Independent Power Producers
ISPS	Institutional Solar Photovoltaic Systems
IWM	Improved Water Mill
Kg	kilogram
kL	kiloliter
kW	Kilowatt
kWh	kilowatt hour
kWp	Kilowatt peak
LCEDS	Low Carbon Economic Development Strategies
LED	Light Emitting Diode
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MHP	Micro Hydro Project
MJ	Mega Joule
MoALD	Ministry of Agriculture and Livestock Development
MTOE	Million Tons of Oil Equivalent
MW	Megawatt
MW	Megawatt
NEA	Nepal Electricity Authority
NOC	Nepal Oil Corporation
O&M	Operation and Maintenance
PA	Protected Area
PJ	Petajoule
PVPS	Photovoltaic Pumping System
RETs	Renewable Energy Technologies
RPR	Residue-to-product ratio
SDG	Sustainable Development Goals
SHS	Solar Home System
TOE	Tons of Oil Equivalent
TWh	terawatt hour
WECS	Water and Energy Commission Secretariat
WPD	Wind Power Density

Executive summary

Energy consumption information is one of the significant indicators of the country's development status. The energy-related database provides crucial insights for developing specific starategies, provincial targets and integrating them to reach the national goal. Thus, a well-organized energy database is a basis for policy formulation and sustainable energy planning. In this context, this Energy Sector Synopsis Report provides status of energy sector in Nepal.

The overall energy consumption of Nepal is largely dominated by the use of biomass a non-commercial energy form in case of Nepal. Energy sources are still dominated by traditional sources (fuelwood, agri-residue, and animal waste). However, the shift to commercial energy (coal, petroleum products, and electricity) is evident and the renewable energy sources are also increasing. Consumption of electricity has also increased at good pace lately.

The supply and consumption situations of energy by fuel types and economic sectors were prepared for FY 2075/76, 2076/77, and 2077/78 along with the energy balance that gives a snapshot of the energy situation in Nepal. The six major energy-consuming economic sectors include residential, commercial, industry, transport, agriculture, and construction & mining. The energy types are classified under renewables and non-renewables. The renewables are further divided into conventional resources that include fuelwood, agri-residue, animal waste, and other biomass) and new renewables that include electricity generation systems from hydro, solar, and wind. Non-renewables include coal and petroleum products. The energy supply and consumption data were collected from different energy institutions such as the Ministry of Forest and Environment (MoFE), Ministry of Agriculture and Livestock Development (MoALD), Department of Forest and Soil Conservation (DoFSC), Department of Electricity Development (DoED), Department of Custom (DoC), Alternative Energy Promotion Centre (AEPC), Nepal Oil Corporation (NOC), Nepal Electricity Authority (NEA), etc.

Supply Situation

Traditional Resources

One of the primary energy resources used in Nepal is the forestry sector. According to the study, Forest covers 40.36% of the total area of Nepal. The Bagmati Province of the country has the highest total forest area (17.55%) while Madhesh Province has the lowest forest coverage area (4.37%). Similarly, out of the total forest, 37.80% lies in the Middle Mountain physiographic region, 32.25% in the High Mountains and High Himal, 23.04% in Churia, and 6.90% in the Terai indicating that majority of the forest areas are found in Middle Mountain and High Mountain. The annual energy potential of the sustainable fuelwood is estimated to be 203 PJ with Province 1 contributing the highest sustainable annual fuelwood yield (25.42%).

Based on the data and calculations, the country has a total of 2.98 million ha of accessible forest area which accounts for 50.05% of the country's forest. The sustainable fuelwood supply in the country is estimated to be 12.15 million tons in 2014 as per DFRS. The Province wise supply potential is as shown in Figure 1.

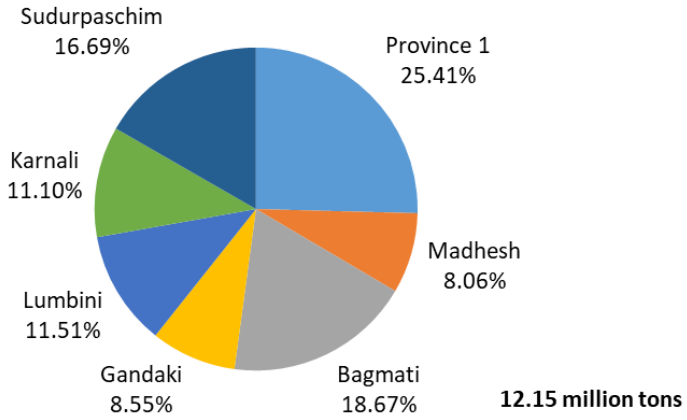


Figure 1: Proportion of Sustainable Annual Wood Yields in Provinces

Another traditional biomass used as an energy source is agri-residue. As more than 60% population is directly involved in agriculture, the agri-residue production mainly from cereal crops also forms one of the major sources of energy mostly in rural areas. Based on the crop production, the potential agri-residue for 2019 was estimated to be 23 million tons which grew at the rate of 4% to 26 million tons in 2021. The potential energy supply from agri-residue was estimated at 406 million GJ, 416 million GJ, and 442 million GJ in 2019, 2020, and 2021 respectively.

Dry dung is another traditional biomass used as an energy source mainly in rural areas. The dung yield from the livestock was estimated to be 6.8 million tons in 2019. This potential grew at only 0.35% in 2020 (6.84 million tons). However, in 2021, with the effect of the pandemic being lower, it is approximated to be about 6.9 million tons in the year 2021 at a cumulative growth rate of 1.12%. The energy potential from the dry dung was about 101.6 million GJ in the year 2019, which grew to 102 million GJ in 2020 and 103 million GJ in 2021.

Modern Renewables

According to the Solar and Wind Energy Resource Assessment(SWERA) by the Alternative Energy Promotion Centre (AEPC), the commercial potential on-grid solar PV system in Nepal is estimated to be 2,100MW. To date, there have been about 961 thousand residential Solar PV systems installed, most of which are installed in the hilly region, particularly in the Lumbini and Karnali provinces. In addition to small isolated systems, large utility-scale plants are also being installed. NEA operates about 1.35 MW plants while IPPs operate about 21 MW of solar plants.

As of 2018, the installed micro-hydropower plants have contributed up to 38 MW of power in total. More than 1,800 MHPs provide electricity to 344 thousand households in the remote areas of Nepal. MHPs have been providing service to the remote areas where the access to grid electricity is poor which. Biogas is another renewable resource with a high potential for energy production. The number of households with the potential for installation of a household biogas system is about 1.9 million, which represents about 42% of the total households in Nepal. The installation is dominated by Terai and Hilly belts due to the availability of a sufficient amount of feedstock and a favourable temperature. In the case of wind energy, the potential supply in Nepal is estimated to be 3000MW. But 113.6 kW has been harnessed to date and 5MW capacity is under construction in different parts of Nepal. The solar wind hybrid mini-grid system installed in Nepal reached 1500kW as of 2022.

Organic municipal waste is another source of modern renewables. According to research, Kathmandu has the potential of producing 1745 MWh of electricity from waste, Lalitpur Sub Metropolitan City has the potential of 278 MWh, and Pokhara has the potential of producing 244 MWh of electricity from

waste. As per the 2020 report on Waste Management baseline study by CBS, the average organic waste per municipality amounted to about 1,200 tons. According to a recent study, 130294 m^3 of biogas can be generated by utilizing 100% of the organic fraction of municipal solid waste(OFMSW) in Kathmandu. The biogas produced can be used to fill up 21,045 LPG cylinders per day which can save NRs 515 million.

Commercial Energy Resources

Nepal Electricity Authority is the sole organization responsible for the operation and distribution of electricity supply in the country. As per NEA 2021, the total installed capacity developed by NEA stands at 582 MW. NEA's hydropower plants including small power plants generated a total of 2,810.74 GWh of electricity in FY 2020/21, a slight decrease of 6.96 % over the generation of 3021.04 GWh in FY 2019/20. As of February 2022, The total installed capacity from hydropower plants is 2023 MW. In addition, there is 53.4 MW from thermal power plants and 49.76 MW from grid-connected solar power plants. The total installed capacity thus reached 2,205 MW by February 2022. As of June 2022, the peak demand is 1864 MW whereas the national demand is 1564 MW, and the remaining is exported to the neighboring country.

The primary production of coal is about 10.9 thousand tons whereas 2 million tons of coal are imported to meet the demand in the country, which are mainly used in brick manufacturing industries.

Nepal Oil Corporation is the only organization responsible for the import and distribution of petroleum products in Nepal. The NOC has current storage facilities of 68 thousand KL for all essential petroleum fuels except for LPG. The impact of COVID is visible in petroleum imports in 2020 which shows a more than 10% decrease in petrol, diesel, and kerosene and a significant reduction of 31% in ATF imports compared to 2019. On the contrary, there is an increase in LPG consumption of 5% as most of the activities are limited to the household.

Consumption Situation

Energy use is classified as traditional commercial and renewables forms. The energy consumption by fuel types in 2021 shows the dominance of traditional energy with 66% share and that of commercial and renewables share (excludes electricity) reached 31% and 2.4% respectively. Compared to 2009, the traditional energy shares however decreased from 87% whereas there is an increase in commercial and renewable shares. The total energy consumption in 2021 has increased to 626 PJ from 566PJ (163 TWh) in 2020 and 589 PJ (157 TWh) in 2019. The decrease in energy consumption in 2020 is mainly due to lower consumption of petroleum products as most of the economic activities which are the major consumer of petroleum products halted due to the nationwide lockdown during the COVID pandemic. The energy consumption decreased by 4% in 2020 compared to 2019 which regain its momentum to achieve a 11% growth rate in 2021 compared to 2020.

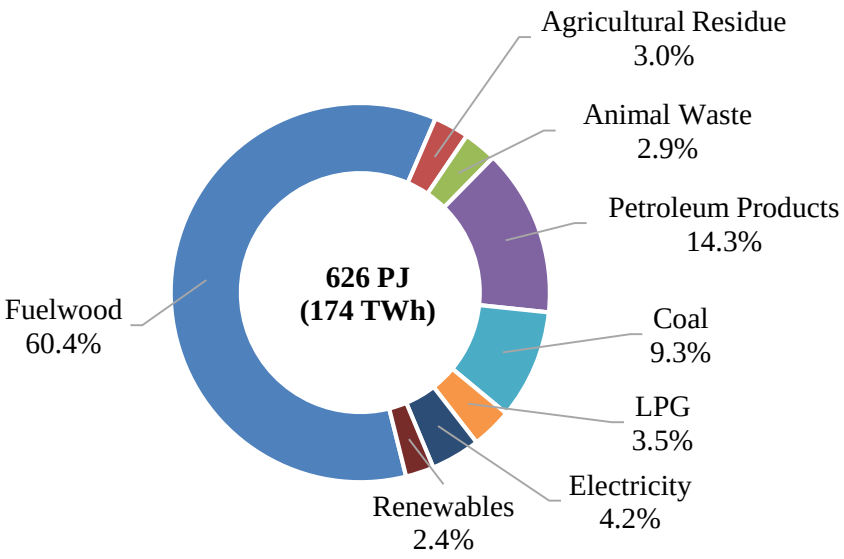


Figure 2: Energy consumption by fuel types in 2021

The energy consumption by fuel type in three consecutive years is shown in Figure 3. It shows the dominance of traditional biomass in overall consumption in all years. The increased share of traditional biomass in 2020 is due to a decrease in other commercial energy consumption as a result of reduced economic activities in the year.

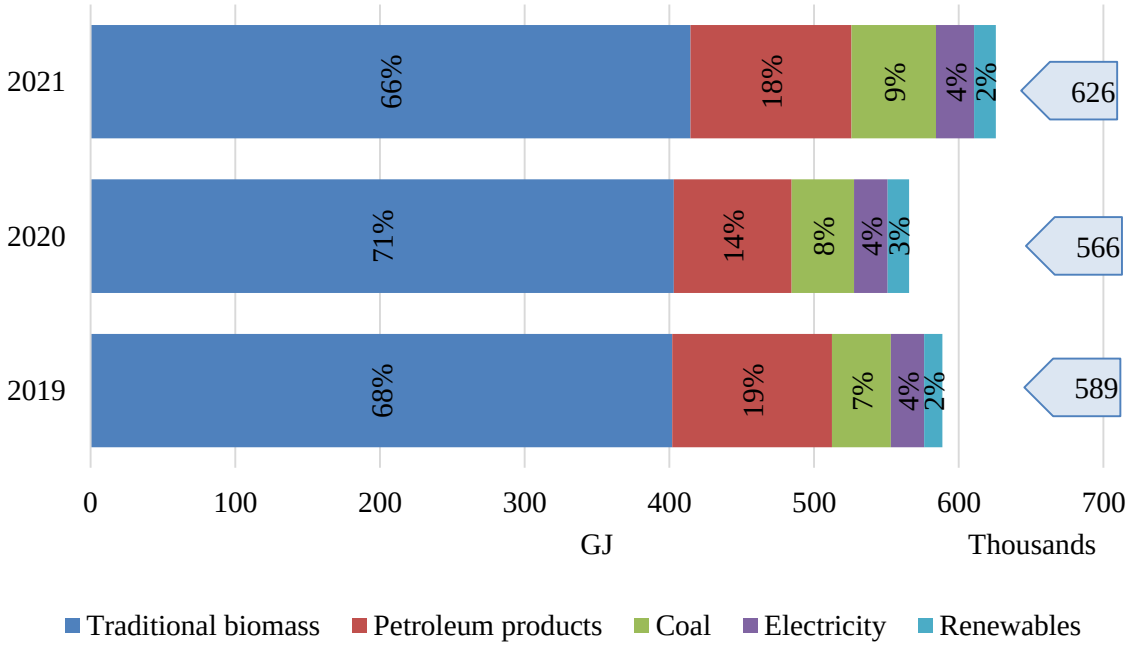


Figure 3: Energy consumption by fuel types in 2019, 2020, and 2021

The sectoral energy consumption has changed over the last decade. Residential sector consumption decreased from 89% in 2009 to 63% in 2021 due mainly to the growth in economic activities, use of modern technologies, and energy efficiency improvement. Industry sector consumption has increased significantly to 18% followed by the commercial sector (7%), transport (9%) agriculture (1.6%), and construction and mining (0.8%) in 2021. The effect of growing economic activities is seen mainly in– the industrial, commercial, transport, and agriculture sector. Apart from these, the share of energy

consumption is reaching 1% in the construction and mining sector – a significant sector in national development

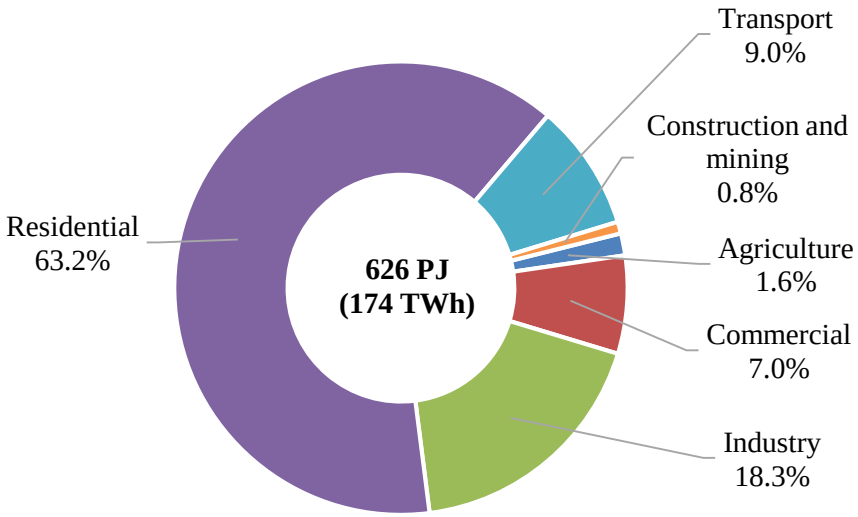


Figure 3: Energy consumption by sectors in 2021

The sectoral energy consumption in 2019, 2020, and 2021 is shown in Figure 4. There is a 4% decrease in energy consumption in 2020 as the COVID hit most of the economic activities to halt. In contrast, agriculture and residential sectors show 4% and 2% growth in 2020 being the former a subsistence activity of Nepalese livelihood. Wherein there is an 11% growth in energy consumption in 2021 compared to 2020 as the impact of COVID lessened and economic activities resumed. In industry, transport, and construction, and mining sectors energy consumption in 2021 increased by more than 30% compared to the previous year. At the same time GDP also grew at the rate of 5.8%.

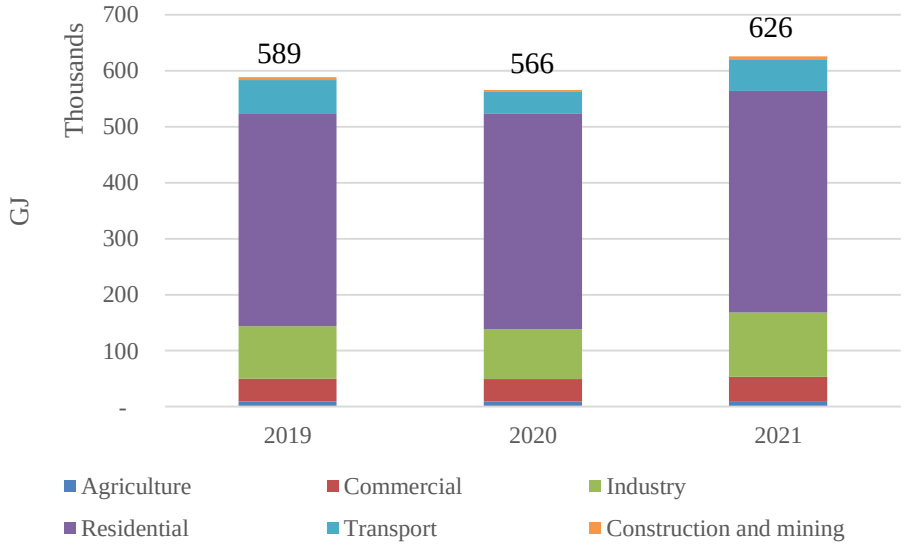


Figure 4: Energy consumption by sectors in 2019, 2020, and 2021

In 2021, the agricultural sector consumed 9.8 PJ energy, among which 91% is diesel, 1.4% petrol, 7.4% electricity, and 0.26% is solar. The agricultural sector's energy consumption in 2019 went up by 3.9%

during 2019-2021. However, in the commercial sector, consumption squeezed at the rate of 1.4% in 2020 compared to 2019 and accelerated at 9.2% in 2021 compared to the previous year. Similarly, in the industrial sector which is a highly energy-intensive economic sector, the energy consumption decreased at the rate of -5.8% in 2020 compared to 2019. With the especially loosened restriction in the industrial sector, consumption grew by 29% in 2021 compared to the previous year. The total consumption in this sector totals 114.5 PJ in 2021. Coal, traditional biomass, and petroleum products are the major source of energy used in this sector. The average growth rate stands at 10% during 2019-2020. On the other hand, the residential sector which is the most energy-consuming sector in Nepal with a 64% share in total consumption, energy consumption increased at a rate of 2.2% per annum in the last two years, higher than the population growth rate. Fuelwood is still the highest-energy type consumed, with an 85% share in this sector. The share of LPG consumption has increased to 2.8%, more than doubled in a decade. In addition, the renewables share mainly biogas has increased to 2.5% and solar to 0.5%. Similarly, the use of electricity increased to 3% from 1% in 2009. Meanwhile, the transport sector's energy consumption reduced by nearly 47% in 2020 compared to 2019. With loosened restrictions, it increased by one and a half folds in 2021 compared to 2020. The Construction and Mining sector energy consumption was also largely affected by pandemic restrictions during 2020.

Energy Indicators

Final energy intensity indicates the rate of energy consumption and energy efficiencies. The final energy intensity increased to 21.92 GJ per capita in 2021 which was 15 GJ per capita in 2009, indicating higher energy consumption. However, it is to be looked upon from the perspective of which energy and where it has been used. In that case, it can be seen that the consumption is highest for the residential sector, with increasing demand for commercial fuels. Yet the use of traditional biomass is still high. The energy intensity in the residential sector has decreased in the past decade from about 14 GJ per capita to 13.2 GJ per capita in 2019. This shows the impact of modern energy access as well as clean energy technology penetrations. The increasing trend of residential electricity per HH also indicated the gradual shift to clean energy with the use of more efficient electric technologies. The electricity per capita, including from alternative energy sources also have increased to 265 kWh in 2021. But this is still the least in the South Asian average. To meet the government targets to enhance the consumption of electricity to 700kWh per capita by 2022/23 more focus on electrification is needed.

The share of energy in national consumption shows a traditional energy share of 68%, imported energy share of 29%, and renewable energy share of 6% in 2021. On the other hand, the energy share shows that traditional biomass energy share is 66% of the total. The increasing commercial forms of energy particularly petroleum products and coal increased the imported energy share to 29% in 2021 whereas the renewable energy share including electricity reached 6% in 2021 showing the shift to clean energy.

Table 1: Final energy intensities

Parameter	Unit	2019	2020	2021
Final energy intensity	GJ per 1000 NRs Value Addition	0.28	0.27	0.29
	GJ per capita	20.62	19.82	21.92
Electricity	kWh per 1000 NRs	3.08	3.20	3.52
	kWh per capita	228	232	265
Residential Electricity	kWh per HH	218	251	296

The overall energy supply and demand situation of Nepal shows the dominance of traditional biomass in Nepal. However, there is a gradual shift to commercial and renewable energy sources. Indigenous sources mainly traditional biomass, modern renewable sources (solar wind, biogas, MHPs), and

hydropower potential are abundant in Nepal but very less has been harnessed. Most of the commercial energy sources are imported to fulfill the growing energy demand of the nation. The energy share shows that the imported fuel share is growing at the rate of 2% per annum which has a direct impact on the national economy. To reduce the dependence on imported fuels particularly petroleum products, electrification in all economic sectors is needed. Though the electricity consumption is increasing at the rate of 15% in the last few years the electricity share is still lower than 5% of the national energy share. The recently submitted Second Nationally Determined Contributions (NDC) and long-term strategy for Net-zero emissions by 2050 also strongly focused on electrification providing a sustainable pathway toward clean energy sources.

1 Introduction

Energy consumption is one of the significant indicators of the development status of the country. It indicates the current situation of economic activities as well as how well a country is progressing towards development. Data and information regarding energy can provide crucial insights for developing provincial targets and integrating them to reach the national target. Thus, a well-organized energy database is a basis for policy formulation and sustainable energy planning.

Water and Energy Commission Secretariat (WECS) completed Sectorial Energy Supply/Demand Profiles at the regional level and Residential Energy Supply/Demand Profiles at the district level during 1990-1995 and updated in 1995/96. Industrial Sector Energy Consumption Survey was completed in 1997/98 covering both traditional and modern sectors and commercial, transport, and agricultural energy consumption survey was conducted in 1998/99, 1999/2000, and 2000/01 respectively. WECS published Energy Synopsis Report in 2010 with the baseline information that provided the basic information about the available energy resources in the country and their distribution in different parts of the country by physiographic region and development region. It updated the energy supply and consumption pattern of the country and provided the basis for analyzing the energy scenario of the nation. WECS conducted a National Survey of Energy Consumption and Supply Situation in Nepal in 2011/2012 to determine the energy demand and supply situation of the country in all economic sectors by physiographic region and developmental region. The detailed survey updated the energy situation of the country and provided a new database for the integrated energy system planning of Nepal. National Energy Strategy and Vision 2050 was prepared in 2013 in which future energy demand was forecasted and scenario analysis was carried out to develop future energy planning for the country. The energy consumption and Supply situation in the Federal System of Nepal (Province No. 1 and Madhesh Province) was conducted in 2020. Energy consumption and Supply situations for the remaining provinces are also underway.

According to an Economic survey, the overall energy consumption of Nepal is largely dominated by the use of non-commercial forms. Energy consumption is growing at the rate of 4% over the last decade (MoF, 2021). There is a decline in traditional energy consumption from 84% in 2010 to 67% in 2020 with the increasing use of modern energy resources. There is a gradual shift to commercial energy sources (coal, petroleum products, and electricity) increasing the share from 15% in 2010 to 31% in 2020, an increase of 12% growth per annum. There is a steady growth in renewable energy sources as well increasing the share from 1% in 2010 to 2% in 2020. Consumption of electricity has lately increased to 4% from 2% a decade ago.

The national energy supply and consumption survey were carried out by WECS in 2011/12 which shows the residential sector as dominating the energy-consuming sector. According to the survey, residential accounts for the major share of energy consumption (80.4%) followed by industrial (7.9%), transport (7.1%), commercial (3.4%), and agriculture (1.2%) in 2011/12 (WECS, 2013). The recent provincial energy consumption and supply situation conducted for Province 1 and Madhesh Province by WECS in 2020 show a slight difference in energy consumption by sectors. The detailed energy survey shows that Province 1 consumed 74PJ with the industrial (45%) and residential sectors (41%) dominating the energy consumption. Solid fuels – firewood, biomass, and coal dominated the energy source type in Province 1 (WECS, 2021a). Similarly, Madhesh Province consumed 63PJ of energy with the residential sector consuming 62% of energy mainly from the traditional biomass (55%) and non-renewable (36%) (WECS, 2021b).

In Nepal, the major source of energy in the residential sector is fuelwood, agriculture residue, animal waste, biogas, and other biomass. Hydro and solar substitute traditional energy in an urban

residential area mainly for cooking and lighting. The industrial sector consumes coal, fuelwood, diesel, and electricity as major sources of energy. The National Survey of Energy Consumption and Supply Situation in Nepal, 2013 shows fuelwood, LPG, coal, and grid electricity as major fuel sources in the commercial sector with a 34% share of non-renewable energy consumption (WECS, 2013). The agriculture sector mainly uses fuel for water pumping and farm machinery that consume diesel as a major fuel source. Diesel, petrol, and ATF are major fuel sources in the transport sector with minimal contribution of electricity in this sector. 76% of imported petroleum products in the country are used in the transport sector. As Nepal moves towards the path of sustainable development, the roadmap to sustainable development goals emphasizes clean energy and energy efficiency. The Second Nationally Determined Contributions (NDC) intends to reduce GHG emissions from both energy and non-energysectors and the long-term strategy for Net-zero emissions by 2050 targets zero carbon emissions by 2050. For that to achieve, Nepal needs a paradigm shift from traditional energy sources to clean energy sources. The Ministry of Energy, Water Resources, and Irrigation (MOEWRI) plan to generate 10,000 MW by 2028 and 100% electricity access by 2023 to provice clean energy access to all. The National Planning Commission's 15th periodic plan also targets to achieve around 4000MW of generation from renewable energy resources by 2030 (NPC, 2020). In addition, the government plans to increase the share of solar energy generation through private sectors with a target of generating over 550MW by 2024. Furthermore, as part of the NDC target, Nepal plans to supply 15% of the total energy demand through clean energy sources, adding 2100MW of solar energy to the national grid by 2030 (GoN, 2020).

1.1 Country Profile

Nepal is a landlocked country in South Asia with a small land area of 147, 516 km^2, but with a large diversification in ecology as well as demography. Located between the two economic giants – China on the northern side and India on the other three, it stretches 800 km from 80° East to 89° East. Meanwhile, it ranges from an altitude of 60 meters to 8848 meters above mean sea level between, 26° North to 31° North starching about 145 km to 241 km. The country is divided into three main physiographical belts spanning East to West. In the south, the plains of the Terai Region cover approximately 23% of the country's total area and are both the main agricultural region and the most densely populated region. To the north, the Hilly Region covers approximately 42% of the total area and consists of mountains, hills, flatlands, and valleys with elevations ranging from 600 to 3,000 meters. Farther north, the Himalayan Region covers nearly 35% of the total area and contains 200 peaks more than 6,000 meters in elevation and 13 peaks more than 8,000 meters high, including Sagarmatha - the world's highest mountain. From these, the water resources of Nepal emerge. The country's three major river systems are—from east to west—the Koshi (513 kilometers), Narayani (332 kilometers), and Karnali (507 kilometers). All these rivers are major tributaries of the Ganga in northern India.

Administratively, the country is divided into 7 provinces which are further divided into 77 districts, and within those, there are 753 local units which include 6 metropolitan municipalities, 11 sub-metropolitan municipalities, and 276 municipalities. Climatically, Nepal lies within a subtropical monsoon climate zone. Climatic conditions and precipitation tend to vary with elevation, ranging from tropical in the Terai plains to alpine and tundra in the northern mountain areas. Temperatures range from 5° C to 47° C in the Terai Region, from 0° to 28° C in the Hill Region, and from below 0° C to 16° C in the Himalayas. Annual rainfall generally increases with elevation up to 3,000 meters, thereafter declining with elevation and latitude. Precipitation tends to be highest in the east and declines westward, but certain areas in central Nepal have consistently high rainfall. The

majority of precipitation nearly 80% occurs during the annual monsoon. The pre-monsoon season from March to May is hot and dry, the monsoon season (generally June to September) is hot, and the post-monsoon season typically lasts through mid-October. Mid-October through March is typically dry and cold.

Nepal has large biodiversity within a small land area. However, Nepal's natural resource base is widely regarded as insufficient for economic needs. Commercial fuel resources are especially scarce. Although some methane gas has been discovered, petroleum reserves have not materialized. Renewable resources, particularly arable land, are perhaps the most economically important resources, but hydropower is hugely underutilized. The most available metallic minerals are copper, gold, lead, and zinc, but only lead and zinc have been commercially viable. Nonmetallic minerals such as marble, talc, and particularly limestone have been commercially viable, and there are some deposits of dolomite and magnesite.

1.2 Demography

Demography is one of the major drivers of energy consumption, particularly in the residential and transport sector. As per the preliminary report of the Central Bureau of Statistics (CBS, 2021), the national population in 2021 was estimated to be 29,192,480 with a growth rate of 0.93 % during the 2011-2021 period. The province-wise population, household numbers and household size is as shown in Figure 1-1. The national household size stood at 4.32 in the 2021 census lower than the previous HH size of 4.88 in 2011. The urban and rural household status as per CBS shows that approximately 66% of the population resides in the urban area and remains in the rural areas of Nepal. Population status as per physiographic division shows more than half of the population inhabits in Terai region (54%), followed by hills (40%) and mountains (6%).

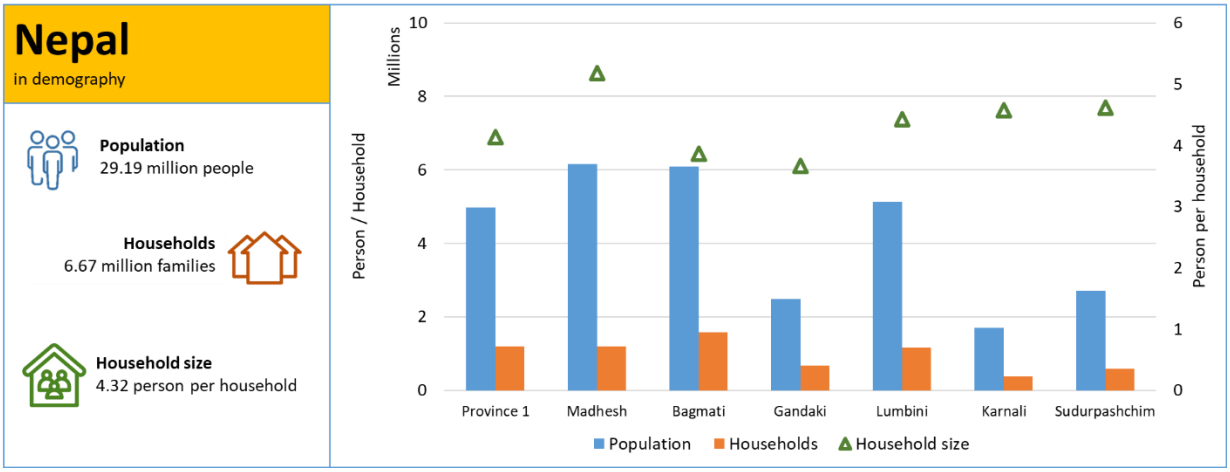


Figure 1-1 Provincial Population, Household number, and Household size in 2021

The provincial population share is as shown in Figure 1-1. It shows that the Bagmati and Madhesh provinces are inhabited by the highest population with 21% of the total population each, followed by Lumbini, Province 1, Sudurpashchim, Gandaki, and Karnali provinces.

1.3 Economy

The global economy was contracted by 3.3% in 2020 when most of the countries experienced negative economic growth along with the slowdown in global economic activities caused by the pandemic. The Nepalese economic growth become negative by 2.4% first time in the last two decades in the

fiscal year 2019/20 due to the impact of the Covid-19 pandemic. It however recovered and grew at a level of 4.3% in the current fiscal year (CBS, 2022). Although gradual improvement in the health crisis has been expected, the widely spread second wave of the Covid-19 during the third quarter of the last fiscal year has become challenging in achieving a higher growth rate.

Nepal has achieved good economic growth since 2014. This economic growth was mainly achieved by the expansion of the service and industry sectors. But the earthquake impact during 2015, and later the Covid impact in 2019 took a toll on the national economy. The GDP growth rate was 6.7% in 2019 which was shackled due to the global pandemic. The growth rate slowed down to -2.4% in 2020 which soon gained the momentum to achieve 4.4% in 2021 and 5.8% in 2022 as the economic activities resumed. Yet the growth rate is below the pre-Covid scenario. The provincial GDP growth rate is as shown in Figure 1-2. Province 1 shows no growth during the pandemic and Karnali and Sudurpaschim are least affected as the economic contribution from those provinces are the least whereas Bagmati province is much hit by the Pandemic with negative growth of 5.7% in the same year.

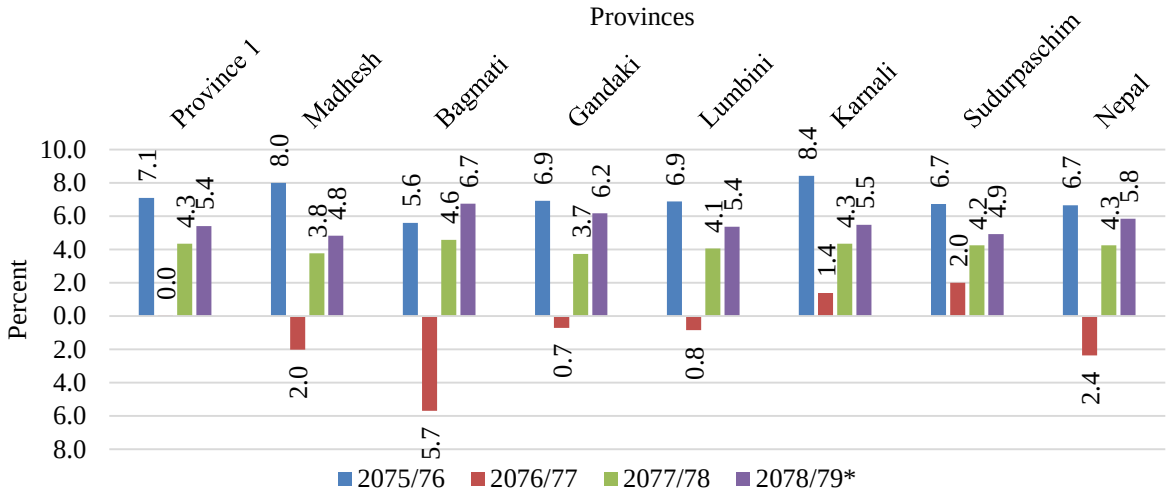


Figure 1-2 GDP growth rate (MoF 2022)

The value-added generated by the industry sector as the percentage of GDP grew slowly from 14.67% in 2012 to 15.56% in 2021. Meanwhile, the service sector increased to 54.16% from 51.78% and agricultural GVA decreased to 30.38% from 33.55% within the same period (Figure 1-3)

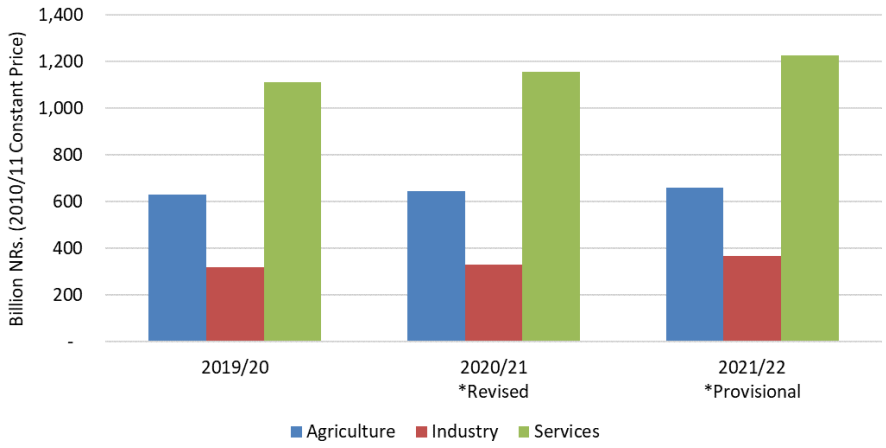


Figure 1-3 GVA structure by sectoral groups

The GVA in the agriculture, industry, and service sectors are expected to increase by 2.3%, 10.2%, and 5.9% respectively, in the current fiscal year 2021/22. The GVA growth rate that went negative during 2019/2020, recovered to 3.83% and is expected to reach 5.49% this fiscal year. Accordingly, the contribution of agriculture, industry, and service sectors in gross value added is estimated to be 29.37%, 16.25%, and 54.38%, respectively in the current fiscal year. See Annex I for more details.

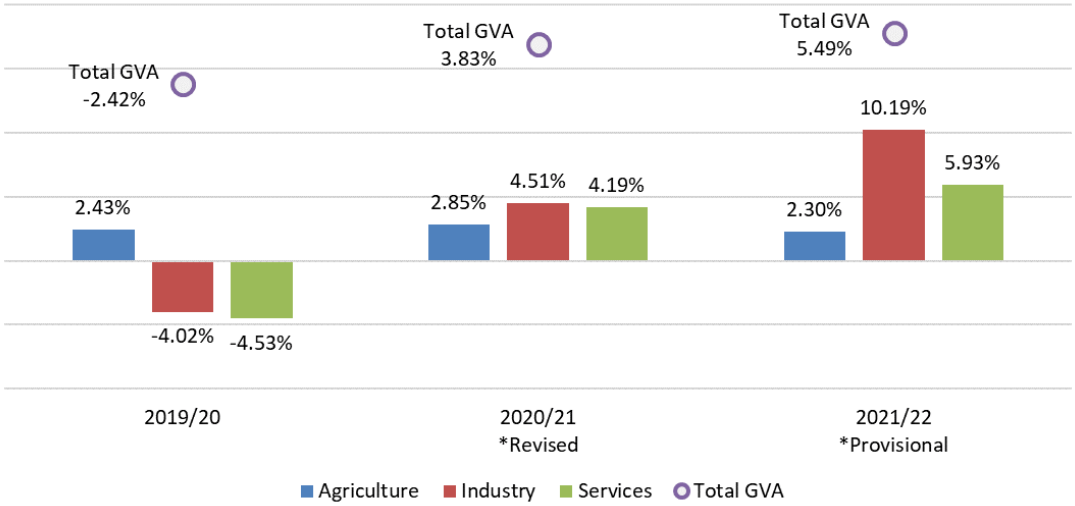


Figure 1-4 GVA growth rates by sectoral groups

Out of the total estimated GVA of Rs. 2,284 billion (basic price), in the fiscal year 2020/21, the share of Bagmati province is the highest at 36% and the Karnali province at the lowest at 4%. Figure 1-5 shows the province-wise GDP contribution in FY 2019/20, 2020/21, and provisional estimates for 2021/2022.

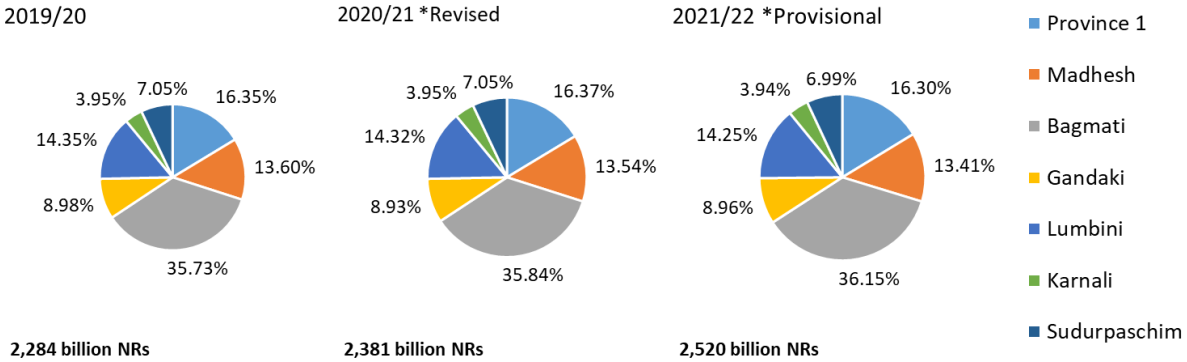


Figure 1-5 Province-wise contribution to GDP (CBS, 2022)

As per the National Economic Census 2018, there were nearly 923 thousand establishments, of which only 50% are registered (CBS, 2018). Meanwhile by the number of persons engaged, Accommodation and food service employees largest number while, education comes second, little shy to manufacturing. Province-wise, Bagmati had the largest number of establishments flowed by Province 1, Lumbini and Madhesh provinces. The establishments, as well as economic activities in Karnali and Sudrupaschim province overall, are very small in a national context (Figure 1-6).

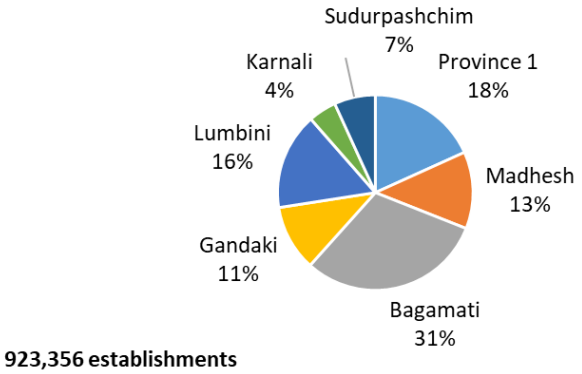


Figure 1-6 Provincial mixes of establishments in 2018

The wholesale and retail trade have the largest number of establishments followed by accommodation and food. Manufacturing establishments come third (Figure 1-7). But other than that, the other industry category is below 1% in establishments. However, the output of the manufacturing and other industry are substantial thus contributing more than 50% to the national GDP as discussed in the previous section. In terms of energy usage, apart from the residential sector, manufacturing and accommodation, and food service activities are the largest energy consumer in economic sectors as seen from provincial reports (WECS, 2021a; WECS, 2021b).

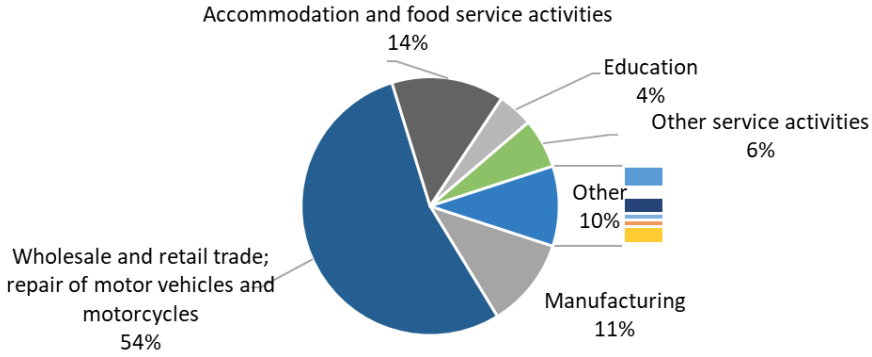


Figure 1-7 Share of Establishments by industrial divisions

1.4 Energy and related policies

The energy policy of Nepal has a clear policy of maximizing hydropower utilization to meet domestic electricity demand and accelerate the renewable energy service in the country. To provide access to energy and energy-efficient technologies, various subsidy mechanisms are in effect. National Rural Energy Programme (NREP) provided a framework for the implementation in local communities across the country. Under this policy, Nepal intends to expand its energy mix focusing on renewable energy by 20% by diversifying its energy consumption pattern to more industrial and commercial sectors.

Ministry for Electricity, Water Resources, and Irrigation (MOEWRI) - White Paper 2075

Ministry for Electricity, Water Resources, and Irrigation (MOEWRI) released a white paper 2075 in July 2018 with the objectives to elevate hydropower and renewable energy generation in the coming decade to take the country towards the path of sustainable development. It has set the target to improve per capita electricity consumption from the current 700kWh to 1500kWh in the coming ten years. It requires the penetration of electricity in all sectors, including electrification in

residential, commercial, transport, industry, and agriculture. It plans to generate 3000MW of hydropower by 2021 and upgrade the generation capacity by 5000 MW in the coming five years and by 15,000MW in 10 years. It also envisages that domestic demand will increase to 10,000MW in the coming ten years. Government plans to generate 200 MW of solar power from Madhesh Province, where the hydropower potential is minimal. The white paper focuses on optimum generation and utilization of clean energy resources, including efficiency improvement in the country.

Low Carbon Economic Development Strategy

Ministry of Population and Environment (MOPE) has prepared a Low Carbon Economic Development Strategy (LCEDS), with the vision of the strategy for enabling Nepal to become a developing nation through low carbon green economic development. It promotes the use of renewable energy in all economic sectors with the approach to reducing national GHG emissions. The strategy provides a framework for achieving sustainable development, prioritizing the sector-specific implementation plans for low GHG emissions. The strategic sectors included in the report are energy, agriculture and livestock, industry, transportation, and commercial.

Second Nationally Determined Contribution

The Government of Nepal submitted its enhanced Nationally Determined Contribution (NDC) in December 2020 under the Paris Agreement for the period 2021-2030, following Articles 4.2 and 4.11 of the Paris Agreement, and Decision 1/CP.21 paragraph 23 and 24, and other relevant provisions of the Paris Agreement. The major sectoral targets include energy generation from approximately 1,400 MW to 15,000 MW, of which 5-10 % will be generated from mini and micro-hydropower, the solar, wind, and bio-energy. Ensuring sales of e-vehicles to cover 90% of all private passenger vehicle sales in the transport sector. In the residential sector, it targets to increase the electric cookstoves usage to 25% of households by 2025, install improved cookstoves in rural areas and emphasize household as well as institutional biogas plants

Nepal: Sustainable Development Goals Status and Roadmaps 2016-2030

The National Planning Commission prepared the status and roadmaps to achieve sustainable development goals by 2030. It envisions Nepal graduating from the list of Least Developed Countries which requires the rapid economic growth of at least 7% over the decades. It highlights significant issues and challenges along the route to meeting SDGs. It emphasizes three sectors mainly clean energy, agriculture, and tourism for the sustainable prosperity of the nation. Sustainable Development Goals (SDGs) 7 targets include achieving (i) universal access to affordable, reliable, and modern energy services, (ii) increasing substantially the share of renewable energy in the global energy mix, and (iii) doubling the global rate of improvement in energy efficiency by 2030. The specific targets include increasing access to electricity in 99% of households and limiting the use of LPG to less than 40% such that people would shift to electric cooking. It would increase the per capita electricity consumption to 1500 kWh which would require the generation of 15,000 MW of installed capacity. The major intervention that would require to fulfill those targets are (i) the generation of power through large hydro projects, micro-hydro, off-grid, and grid-connected solar systems, (ii) transmission and distribution systems, (iii) improvement in energy efficiency, and (iv) O&M expenses to maintain a steady quality of power supply.

Nepal Electricity Regulatory Commission Act 2074

Nepal Electricity Regulatory Commission Bill was endorsed in 2017 to form a regulatory body for facilitating electricity production, transmission, distribution, trading, and management transparently. Its other objectives are to balance supply and demand, set electricity tariffs, develop

competition in the electricity market, and protect consumer rights. With the establishment of this regulatory body, the electricity market is expected to develop in a competitive environment where stakeholders' rights are protected, and electricity is made accessible, affordable, and acceptable

Nepal's Energy Sector Vision 2050 A.D.

Energy vision 2050 was formulated in 2013 with the vision to explore potential energy resources available in the country to meet energy demand sustainably. It envisions reducing the dependence on imported petroleum products by substituting them with indigenously available hydropower and other renewable energy resources. It identifies hydropower as the lead energy resource to meet the long-term energy demand of all sectors in the country. Electrification in all major sectors demands a power capacity of 4,100 MW, 11,500 MW, and 31,000 MW by 2020, 2030, and 2050 respectively. To achieve the target, GDP shares of the energy sector should approximately be 2.4%.

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

The renewable energy perspective plan was formulated to accelerate the development of renewable energy to meet Nepal's increasing energy needs. It attempts to quantify the contribution of renewable energy to the overall energy consumption in the country. The installed renewable capacity was 35 MW in 2015, and it targets to increase the installed capacity to 894MW by 2030. The share of renewable energy in total energy consumption was 2% in 2015 and the plan targets to increase the share to 15% by 2030. The contribution of small/micro hydropower was 1.7%, and 0.1% each from wind, solar, and biomass in 2015. The 20-year perspective plan targets to increase the share of small/micro hydropower to 9% and of wind, solar, and biomass to 2% in 2030. The target for domestic biogas plant installation is 1.5 million plants from 0.3 million in 2015. Similarly, the target for an improved cookstove is 2 million by 2030 from 0.6 million in 2015. The plan documents the institutional framework, policy & regulatory environment, capacity building, research & development, implementation mechanism, and prioritization of tasks to achieve this objective.

National Energy Strategy of Nepal, 2013

Nepal Energy Strategy of Nepal is a clear and comprehensive policy on the energy strategy developed by the WECS, with inputs from key stakeholders, and has adopted a set of objectives and policy principles that provide the framework for strategy formulation. Also, several mitigating issues related to the energy sector such as; poverty, access to electricity, clean and modern energy access, generating hydropower, conserving the environment, and reducing health impact due to indoor air pollution are identified. However, the topmost priority of the strategy is on the development and management of Integrated energy planning in the existing sub-sectoral energy planning process

under the guiding principles of socio-economic development and environmental sustainability. The strategy targets to replace the 30% demand capacity of diesel and petrol cars of the base case in the year 2030 with the electric and hybrid vehicles in equal share, improve efficiency, and discourage the use of traditional energy by replacing it with clean fuels.

Nepal's Long-term Strategy (LTS) for Net-zero Emissions, 2021

The Long-term Strategy for Net-zero emissions was formulated in 2021 by the Ministry of Forest and Environment and was recently submitted in the COP26 by Nepal Government. The major target is to reduce carbon emissions and achieve net-zero carbon emissions from both the energy and non-

energy sectors by 2045. To move towards the path of carbon-neutrality, it has taken stringent mitigation measures which would require bold policymaking, social transformation, and technological advancements. Its high ambition-related actions necessitate significant conditional financial resources, and its realization requires huge investments from domestic and international funding institutions. The sectoral targets include electrification in all potential end-use services.

15th five-year plan (2076/77-2080-81)

The current fifteenth five-year plan (2076/77-2080/81) has emphasized rapid hydropower production ensuring energy security. It has aimed to ensure clean energy availability through the increase in production of hydropower energy; to increase the consumption of electric energy in different sectors of life. It also intends to increase the regional trade of electric power reducing the import of petroleum products. Additionally, the plan aims to enhance renewable energy production and use ensuring access to energy for all.

Other supporting plans, policies, and programs are listed in Table 1-1

Table 1-1 Key Plans and Policies in Energy Sector

Key Plans, Policies, programs	Features
Hydropower Development Policy 1992, Hydropower Development Policy 2001, Water Resources Act 1992, and Electricity Act 1992	• Emphasize foreign private sector investment to develop hydropower to meet the existing demand • Provision for developing hydropower through a transparent procedure to attract foreign and domestic private sectors investment, • To create an independent regulatory body
Forest Act (1993)	• Provision to hand over any part of the National Forest to a user's group in the form of a community forest for developing, managing, and utilization of the forest.
Motor Vehicle and Transport Management Act (1993)	• Legal provision for vehicles to pass the roadworthiness test for registration and operation - the test includes pollution test and age of vehicles.
	• Provision of penalties for violating the regulations and the spot check and fines for vehicles that are not roadworthy • Clear roles and responsibilities, and institutional setup of Department and Transport Management Committee • Appointment of transport inspector.
Forest Sector Policy (2000)	• Promotion of community forestry by entrusting forest protection and management to user groups. • Development and promotion of alternative energy sources and adoption of energy-efficient ICS
Hydropower Development Policy (2001)	• Generation of electricity at low cost by utilizing the water resources available in the country mobilizing resources from the private sector, government, and bilateral and regional cooperation.
National Transport Policy (2002)	• Supporting policies and programs that address emission reductions from the transport sector. • Provisions to restrict polluting vehicles restrict the operation of vehicles in

Key Plans, Policies, programs	Features
	urban core areas and the development of cycle tracks. • Provision to exempt custom duty and tax on non-polluting vehicles • Formation of Road Transport Authority for road transport management • Formation of National Transport Board to coordinate authorities relating to transport, including civil aviation
Rural Energy Policy (2006)	• Support for renewable energy technologies in rural areas without grid power supply • Provision of institutional setup and a Rural Energy Fund • Provision to provide rural renewable energy subsidy, and mobilize the private sector, financial institutions, NGOs, and local organizations.
Nepal Rural And Renewable Energy Program	• Single program modality for the effectiveness of RE projects and activities. • Targets for various RETs
Industrial Policy (2011)	• Provisions for technical, and financial support and provide incentives to industries using environment-friendly and energy-efficient technologies. • No royalty or tax for self-dependent industries on electricity and provision to sell excess energy to the national grid • Ordinance for auditing and reporting of energy intensity of industries • Provision to build the capacity of the Department to monitor and control pollution.
Environment-friendly Vehicle and Transport Policy (2014)	• Promotion, development, and expansion of environment-friendly and electric vehicles and transportation. • Provision to allow conversion of technically feasible motor vehicles into electric vehicles. • Target to achieve more than 20% of vehicle fleets to be environment-friendly vehicles by 2020. • Development of cycle tracks and charging stations for electric vehicles. • Preparation of LCEDS inclusive of environment-friendly vehicles and transport modes • Tax exemption and the provision of loans for private consumers to purchase environment-friendly vehicles • Establishment of a separate division or section under the MOPIT, or its departments to oversee the registration, regulation, and monitoring of environment-friendly vehicles
Subsidy Policy for Renewable Energy (2015) Urban Solar Energy System Subsidy and Loan Guidelines (2015)	• Explicit subsidies and financial arrangement/guidelines • Provision of net metering policy for urban solar energy. • Provision for tax exemption for importing solar energy systems, net metering equipment, and LED lights
14th three-year plan 2073 -	• Establishment of pollution monitoring systems in major urban areas

Key Plans, Policies, programs	Features
76	• Revision of the standards for lifespan and emission level for vehicles • Establishment of waste processing centers in each municipality • Promote and develop clean, renewable energy • Priority for hydropower development includes storage power plants, rural electrification, and smart grid and smart metering. • Generation of 2,300 MW hydropower, 11 MW mini, and micro-hydro, 16 MW solar, 1 MW wind • Study and development of railway including metro • Establishment of 7 Vehicle fitness testing centers and old vehicle management
National Renewable Energy Framework, 2017	• Accelerate the transition from subsidy centered model to a credit-focused model along with a smart subsidy mechanism • Improve access to renewable energy
National Energy efficiency strategy, 2075 (2018)	• To double the average improvement rate of energy efficiency in Nepal from 0.84% per year during 2000- 2015 AD to 1.68% per year during 2015-2030 AD.

1.5 SAARC energy outlook

The SAARC countries comprising Nepal, India, Pakistan, Bangladesh, Sri Lanka, Afghanistan, Bhutan, and Maldives, have contrasting economic profiles, energy consumption patterns, and energy portfolios. While India is one of the fastest-growing nations in the world (~7% GDP growth during fiscals 2013-2018), Afghanistan is the poorest among all (SEC, 2018). The energy profile of each country is discussed below:

Afghanistan

Afghanistan is one of the least developed nations in the world with the vast majority of people living in poverty. The energy consumption pattern in the country shows the primary energy consumption of 4.3 Million Tons of Oil Equivalent (MTOE) in 2018 which is expected to grow at a CAGR of 7% to reach 9.3 MTOE in 2030. Currently, only 35% of the country is electrified with 90% of rural households without access to electricity. Fuelwood, charcoal, and agricultural and animal waste still dominate energy sources and are used for cooking and heating. A large%age of the population still uses kerosene, candles, and biogas for lighting. Biomass forms ~10% of the total primary energy consumption in the country (as of fiscal 2018). Fuel mix in 2018 showed 49% share of petroleum products, 29% coal, 10% biomass, 7% imported electricity,4% gas, and 2% hydro. Average per capita electricity consumption is between 100 kWh and 150 kWh per person per year which is among the lowest in the world. The Afghanistan National Renewable Energy Policy aims to mainstream renewable energy in the national energy sector planning through different projects in the country with the target to generate 350-450 MW of renewables capacity by 2032.

Bangladesh

The country has been growing strongly with GDP rising 6.0-7.2% from fiscal 2013 onwards, led by rapid urbanization and improvement in energy access. The energy consumption pattern in the country

shows the primary energy consumption of 37.6 Million Tons of Oil Equivalent (MTOE) in 2018 which is expected to grow at a CAGR of 7% to reach 85.3 MTOE in 2030. Gas accounts for about two-thirds of its primary energy consumption which is an indigenous production. However, with domestic production of gas depleting, consumption of coal and imported LNG is increasing. Fuel mix in 2018 showed 77% Gas, 18% oil, 4% coal, and remaining electricity. The per capita energy generation is 433 kWh in fiscal 2017.

Bhutan

Bhutan is one of the fastest-growing economies in the world with a GDP growth of around 7.5% in 2017. The energy consumption pattern in the country shows the primary energy consumption of 0.725 Million Tons of Oil Equivalent (MTOE) in 2017 which is expected to reach 1.5 MTOE in 2030. Biomass and electricity generated from hydel projects meet around 60% of the total primary energy requirement of the country. Petroleum and Coal meet the reaming requirements. Fuel mix in 2018 showed 33% biomass, 26% hydro, 23% petroleum products, 18% coal, and 1% others. Bhutan‘s electricity peak load has been estimated to reach 772 MW by 2030 from 362 MW in 2017.

India

India, the largest country among the SAARC nations by economy and size, has grown steadily at a CAGR of ~7% over the last five fiscals. The energy consumption pattern in the country shows the primary energy consumption of 817 Million Tons of Oil Equivalent (MTOE) in 2018 which is expected to grow at a CAGR of 4.5% to reach 1,392 MTOE in 2030. Coal is the major primary energy source in the country. Renewable energy usage is increasing with the country’s strong commitment to sustainable energy. However, the reliance on fossil fuels is still high with industrial and commercial growth. Fuel mix in 2018 showed 65% coal, 26% oil, 7% gas, 1% nuclear, 1% hydro, and remaining renewables. As of fiscal 2018, 45 GW of hydro projects has been set up in the country, contributing ~13% of the power generation mix. India had an installed solar capacity of ~22 GW as of fiscal 2018.

Maldives

The real GDP of Maldives witnessed a 6% CAGR over 2012-2017, primarily led by the construction sector, large public infrastructure projects, and a rise in tourism. The energy consumption pattern in the country shows the primary energy consumption of 0.543 Million Tons of Oil Equivalent (MTOE) in 2018 which is expected to grow at a CAGR of 5.7% to reach 1.116 MTOE in 2030. Owing to the lack of indigenous fossil fuel resources, the country completely depends on imports of petroleum products to meet its energy needs. Fuel mix in 2018 showed a 97% share of petroleum products, 3% gas, and 2% renewables. In 2017, Maldives had an installed power plant capacity of 87.7 MW.

Nepal

Nepal is a landlocked nation spread over 147,181 sq km and shares a border with China and India. Nepal‘s economy witnessed a softer 4.3% CAGR during fiscal 2013-2017. The energy consumption pattern in the country shows the primary energy consumption of 13.4 Million Tons of Oil Equivalent (MTOE) in 2018 which is expected to grow at a CAGR of 3.8% to reach 21.2 MTOE in 2030. Traditional fuel met 71% of demand in 2018. The country is rich in fuels such as fuelwood and hydro reserves but has very limited coal resources and no proven petroleum reserves. Fuel mix in 2018 showed 71% traditional fuels, 18% petroleum products, 5% coal, 4% electricity, and 2% renewables. The per capita electricity generation was 250 kWh in 2021 (CBS, 2021; NEA, 2021).

Pakistan

Pakistan, although has a strong growth in GDP at 8.5% during fiscals 2013-2018, the country has huge

power debt, poor financial position, imports of huge fossil fuels, and limited domestic production. The energy consumption pattern in the country shows the primary energy consumption of 75 Million Tons of Oil Equivalent (MTOE) in 2018 which is expected to grow at a CAGR of 5.8% to reach 147 MTOE in 2030. Oil and gas constitute the majority of primary energy usage in Pakistan. Fuel mix in 2018 showed 48% share of gas, 39% oil, 9% coal, 3% hydro, 1% nuclear, and remaining renewables.

Sri Lanka

Sri Lanka is a large consumer of bioenergy with ~12 million tons of biomass used in 2017, accounting for ~40% of its energy mix. The energy consumption pattern in the country shows the primary energy consumption of 11 Million Tons of Oil Equivalent (MTOE) in 2018 which is expected to grow at a CAGR of 3% to reach 16 MTOE in 2030. The country is 100% electrified however usage of coal is expected to increase as more coal-based power plants are installed. Fuel mix in 2018 showed 46% oil, 40% biomass, 10% coal, 4% hydro, and remaining renewables. The total installed capacity was 4,109 MW in 2017 with a peak demand of ~2600 MW, and the system reserve margin was maintained at 54.6%.

2 Methodology

The methodology to carry out the proposed work is shown in Figure 2-1. The work was carried out in three major phases. In the first phase, a review of published documents on energy supply and consumption was carried out and a detailed methodology for data collection was developed. Identifying the relevant institutions and preparing the questionnaire and format to collect relevant data were done in this phase. The inception report and workshop were carried out among the WECS officials.

In the second phase, data collection from the identified institutions was carried out. The collected data were analyzed by fuel type, and by economic sectors: residential, commercial, transport, industry, agriculture, and construction and mining sectors. The supply and consumption situations of energy by economic sectors were carried out for the Fiscal years 2075/76, 2076/77, and 2077/78. hereafter given as 2019, 2020, and 2021 in AD. The energy balance for the analysis period was prepared which gives a snapshot of energy supply and consumption for the period. Analysis was carried out for the energy pricing history of Nepal. Finally, a draft report was prepared.

In the final phase, the stakeholder's consultation workshop will be carried out to disseminate the results, and feedback from the stakeholders will be incorporated to prepare the final energy synopsis report.

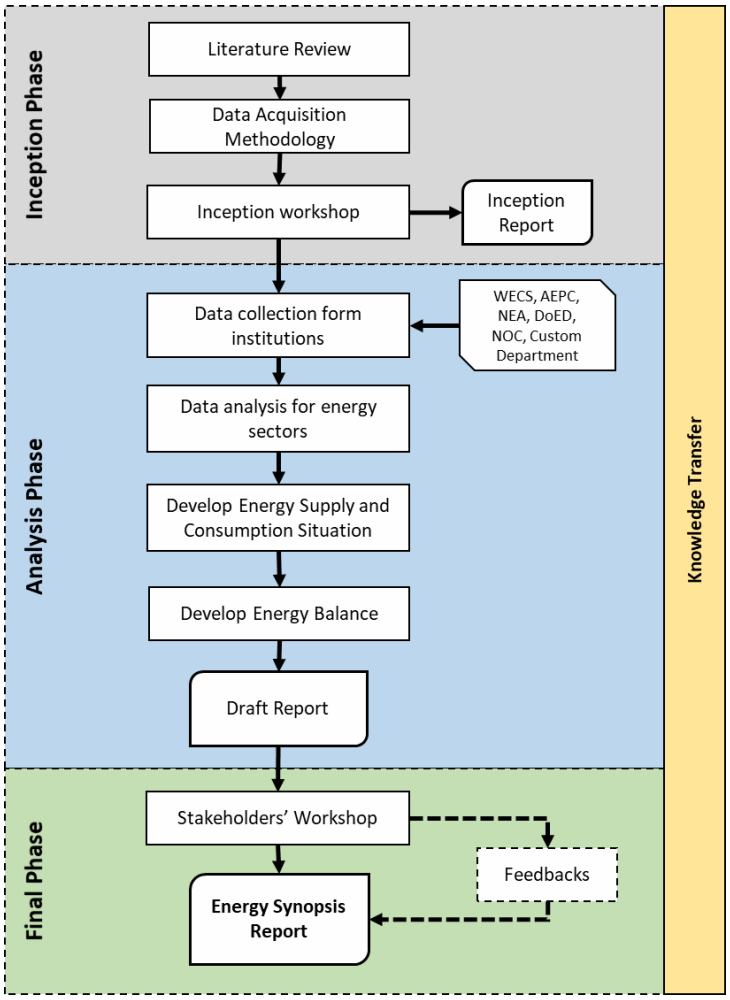


Figure 2-1 Methodological framework

2.1 Energy supply potential estimation

The primary energy resource used in Nepal is forest and hydropower. However, with the increasing demand for petroleum fuels, the import dependency has been ever- increasing. Although there is a large number of resources for renewable, the sustainable biomass and wood supply have always been an issue.

2.1.1 Traditional Energy

Traditional energy refers to the energy sources that had been used since early ages, that are used for thermal purposes, and are extracted from natural resources. There are organic matters that are replenished in a short period. The major traditional energy resources in Nepal are Fuelwood, agricultural residue, and animal wastes.

2.1.1.1 Fuelwood

Over 90 % of the biomass is predominantly and traditionally used for cooking and heating purposes in households. The main resource of the woody biomass is the forest. In addition to that, some private farmlands also contribute to the production of fuelwood. Recently, the Ministry of Forest and Soil Conservation published the National Forest Reference Level (FRL) of Nepal 2000-2010 in 2016 which provides detailed information on the activities such as deforestation, forest degradation due to fuelwood extraction, grazing, and forest enhancement (afforestation/reforestation) (MoFSC, 2016). It provides a detailed methodology for the estimation of sustainable fuelwood supply potential which uses the Dendroenergy Biomass (DEB) Mean Annual Increment (MAI) method for the estimation. The annual fuelwood harvesting in a given area is considered sustainable if it's less than, or equal to, the DEB MAI of such area, while the harvesting fraction that exceeds DEB MAI is considered unsustainable. The quantity of unsustainable harvesting corresponds to the annual forest biomass loss (or quantity of biomass that cannot be regenerated by normal re-growth capacity) and represents the degradation due to excessive fuelwood harvesting. The annual sustainable supply potential that is accessible and potentially available for energy uses is estimated to be 15.7 million tons DM. Such supply potential is significantly greater than the annual fuelwood demand, exceeding it by 5.6 million tons DM. But this apparent surplus is purely theoretical since demand and supply potential are not evenly distributed and there are areas where fuelwood harvestings exceed the sustainable increment and other areas where the supply potential remains untapped. The Dendroenergy Biomass (DEB) stock is estimated at 2010, the study was carried out between 2010 and 2014.

2.1.1.2 Agricultural Residues

Besides fuelwood, agricultural residues of crops such as paddy, wheat, millet, jute, etc. are also used as a source of energy particularly for cooking and heating. Many studies have evaluated the potential of the crop residues for energy generation on different levels ranging from local to global. WECS (2010) estimated the theoretical national energy potential of crop residues to be about 234 million GJ, which was around 61 % of the total energy consumption of the country in 2008/09. The potential production was estimated based on residue-to-product ratio (RPR) analysis. Actual values of RPR however vary widely depending on local conditions, crop species, and moisture content. The cereal crops are considered for the residue production in this study. The total production of cereal crops mainly paddy, wheat, millet, and maize were obtained from Statistical Information on Nepalese Agriculture published annually by the Ministry of Agricultural and Livestock Development (MoALD). The total production was thus multiplied by its respective RPR value obtained by the latest study carried out by Adhikari, 2017. The potential energy from the agri-residue is then estimated using the net calorific value The RPR value and the calorific value used in this study are shown in Table 2-1.

Table 2-1 Residue to Product ratio and Net calorific value

Crop residues	Residue to Product ratio	Net calorific value (MJ kg-1)
Paddy husks	0.36	16.57
Paddy straw	1.97	15.80
Wheat husks	0.82	17.46
Wheat straw	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 straw	1.89	12.56

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

2.1.1.3 Animal Waste

Animal waste is another source of traditional biomass energy largely used in rural areas for cooking and heating purposes. Animal waste is also used to produce biogas plants as a clean renewable energy source. However direct use in end-use is considered to be less efficient and traditional as the heat content of animal waste remains low. Existing cattle and buffalos are considered a major source of animal waste. For the estimation of potential animal waste supply, the total number of livestock was first obtained from Statistical Information on Nepalese Agriculture published by MoALD (2021). The dry waste production per unit of animal was based on the latest study carried out by Adhikari & Denich (2019) as shown in Table 2-2. The average accessibility and collection factor of 70% has been used to estimate the actual dry dung production in the country (Adhikari & Denich, 2019). The potential energy from the animal waste was thus estimated using the calorific value of dry dung estimated to be 14.92 MJ/kg. Animal waste is also used as the primary feedstock for biogas production. It has been assumed that 17% of animal waste is used for biogas production in Nepal as per the study conducted by Adhikari & Denich (2019).

Table 2-2 Dry dung yield from livestock by topographic region

Livestock	Region	kg of DM/day/livestock
Cattle	Terai	1.776
	Hill	1.130
	Mountain	0.462
Buffalo	Terai	2.441
	Hill	2.561
	Mountain	1.582

2.1.2 Commercial Fuels

Commercial fuels refer to commercially traded energy commodities. These fuels can be in the solid-state, liquid, or gaseous as well as converted energy types like electricity. These fuels are usually refined or converted from their original form except for coal.

2.1.2.1 Petroleum Products

All petroleum products are imported from India primarily and from China at nominal amounts. Nepal Oil Corporation is the sole authority for importing petroleum products in Nepal. The reliable import and sales data within the different levels of the federal government were taken from the respective regional offices of NOC (2021). Furnace oil is largely used by industries and is imported via the

Department of customs. Data from different custom offices were assimilated to account for furnace oil supply in the country. The Civil Aviation Authority of Nepal (CAAN) operates the aviation sector in Nepal. So the passenger, aircraft, and cargo movement details at different airports in Nepal were obtained from the CANN for the ATF fuel consumption in Nepal. Furthermore, data for the consumption pattern of petroleum were estimated from the literature review. Transport, industry, construction and mining, and agriculture are the three major petroleum-consuming sectors and nominal consumption in residential and commercial sectors.

2.1.2.2 Coal

Coal is almost exclusively consumed by the industrial sector, primarily for heating and boiling processes in brick, lime, and cement production as well as in steel processing. Apart from some minor coal reserves, all the coal for industrial needs is imported from India and other countries. Department of Mines and Geology is responsible for identifying the source, size, and current producing capacity of the coal. While the industries can import the required amount of coal themselves. Domestic data were obtained from the Department of Mines and Geology. The import data were taken from the department of customs and customs offices.

2.1.2.3 Electricity

The largest part of the electricity consumed in the country is generated from hydropower. Nepal has one of the largest hydropower potential owing to its mountainous geography, even though the country has a small land area. The 83 GW hydro potential as put upon by Shrestha in the 1960s has been updated in 2015 by Bajracharya, which indicated the potential is near 103 GW. During peak hours, the unmet demand is met by imports from India. In addition to these, a few large grid-connected Solar PV plants also have begun to generate electricity. NEA is responsible for the electricity supply through the national grid. Besides the national grid, thousands of small installations (diesel generator sets, solar home systems, winds, small island mini-grids, etc.) are installed in Nepal. DOED, AEPC, Ministry of Energy, Water Resources and Irrigation (MoEWRI) are involved in the licensing procedure for the different sizes and nature of the project depending upon the authority. Details of the hydropower and other types of electricity shall be taken from these governmental organizations furthermore consumption patterns were taken from the NEA and AEPC. Following data for electricity were collected:

- Theoretical and potential hydropower capacity of Nepal
- Hydropower capacity and generation by province
- NEA operated, under construction, and planned hydropower plants, and their capacity
- IPPs operated, under construction, and planned hydropower plants, and their capacity
- Total import and export of electricity
- Transmission and distribution loss, own use, and system loss

The consumption of electricity was estimated based on the first via NEA distribution centers which give electricity consumption status in each economic sector and the second via the energy usage pattern as per the recently published data.

2.1.3 Modern Renewables

Modern renewables include renewable energy resources that are abundant in nature and are replenished in a short period. These technologies have been in development for quite a while and yet

are still advancing.

2.1.3.1 Biogas

Biogas predominantly uses animal wastes and is concentrated in the rural population. However, in recent days, large institutional biogas plants are also being built. Moreover, the commercial production and sales of biogas have also begun. The data relating to the biogas were taken from the AEPC. The capacity and number of biogas installed and its operation factor was collected for residential, institutional, and community biogas. The potential biogas production was estimated based on the number of livestock, potential waste production, and, biogas yield per kg of the animal waste. The annual biogas yield was estimated at the provincial level.

2.1.3.2 Solar

Nepal is located in an advantageous location and high altitude topography, with slopes facing south, receives ample solar radiation and is advantageous to harness solar energy. The average solar radiation varies from 3.6–6.2 kWh/m2/day, and the sun shines for about 300 days a year. The development of solar energy technology thus seems promising in many parts of the country. As per the published report of AEPC, 2008 under Solar & Wind Energy Resource Assessment in Nepal (SWERA), the commercial potential of solar power for grid connection is 2,100 MW. Nepal has great potential for at least four types of solar energy technology: grid-connected PV, solar water heaters, solar lanterns, and solar home systems. NEA, AEPC, and the local government are the main sources of solar data. The grid-connected solar PV data have been based on NEA, while the off-grid solar home systems, institutional solar PV systems, solar pumping systems as well as solar/wind hybrid systems have been based on AEPC data. The solar thermal for water heating is based on the status report of solar water heaters for AEPC, UNDP country profile as well as the department of customs.

2.1.3.3 Wind

The wind is one of the clean energy sources abundantly available in Nepal but is yet to be harnessed. There is a potential area of 6074 sq. km with a wind power density greater than 300 watts/m^2. If 10% of the area is considered feasible for wind energy production, then Nepal has the potential of 3,000 MW of wind energy at the rate of 5MW per sq. km as per the published report of AEPC, 2008 under Solar & Wind Energy Resource Assessment in Nepal (SWERA). The study also shows that the most potential areas lie in areas of the high and middle mountains of the country. The commercially viable wind potential of the country is estimated to be only about 448 MW. Two wind turbines each of 5 kW capacities with 2 kW of the solar hybrid system have been implemented and supported by Asian Development Bank in Nawalparasi, Dhaubadi VDC apart from small wind-solar hybrid system pilot projects in various places of the country. Nepal's largest wind-solar hybrid power system with an installed capacity of 20kW was completed in December 2017 providing electricity to 90 rural households. The cumulative installation of solar and wind mini-grid systems by AEPC has been estimated to be 1262 kW till the fiscal year 2020/2021 (AEPC, 2021).

2.1.3.4 Mini/Micro and Pico Hydropower Plants

The hydropower stations for the generation of mechanical and electrical energy up to a capacity of 100 kW come under micro-hydro in Nepal. Till 2020/21, the total installed in various parts of the country by the mini, micro, and pico hydropower projects is about 35.9 MW (AEPC, 2021).

2.1.3.5 Others

Other energy resources include solid municipal wastes, industrial by-products like bagasse, secondary wood sources like logging residue, sawmilling, furniture, small plants, crops, bushes, and so on. Data related to the other mode of energy if available then the above stated shall be identified by the respective authority for secondary data.

2.2 Sectoral energy demand calculation

The six major energy-consuming economic sectors include residential, commercial, industry, transport, agriculture, and construction & mining. The sectoral energy consumption has been prepared based on the following assumptions:

- Traditional energy consumption is based on the economic survey, clean cooking assessment as well as urban and rural energy consumption patterns
- Renewable energy consumption is based on the number of installations and capacity
- Petroleum products and coal consumption is based on NOC sales, Department of Custom, Department of Mines and Geology
- Electricity consumption is based on sales units as per NEA
- Household traditional energy consumption is based on per capita energy consumption
- Fuel consumption in transport is based on the number of registered vehicles in the country, its operation factor, fuel economy, and annual vehicle kilometer travelled
- Commercial and agriculture energy consumption is based on gross value addition and energy intensity
- Industrial energy consumption is based on the number of industries established and manufacturing gross value addition and energy intensity

2.3 Preparation of data acquisition formats

The energy supply and consumption data were collected from different energy institutions. Different institutions such as the Water and Energy Commission Secretariat (WECS), Ministry of Forest and Environment (MoFE), Ministry of Agriculture and Livestock Development (MoALD), Department of Forest and Soil Conservation (DoFSC), Department of Electricity Development (DoED), Department of Custom (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), Federation of Nepalese Chamber of Commerce and Industry (FNCCI), Central Bureau of Statistics (CBS), Ministry of Finance (MoF), etc were visited and a series of interactions were conducted to collect the relevant information from those organizations. The appropriate checklists, questionnaires, and formats were developed before having discussions and interactions with these organizations.

2.4 Data collection

The data and information on each energy sector from different institutions and departments were collected before data analysis.

1 Fuelwood supply and consumption data were collected from the Department of Forests and Soil

Conservation (DoFSC), Timber Corporation of Nepal (TCN), User Groups (eg. Federation of Community Forests User Groups Nepal), Forest Product Development Boards, and others wherever applicable. Data were collected in a disaggregated form

2 Basic information and database of each renewable energy resource particularly the solar PV, wind, biogas, biomass, micro-hydropower, improved cookstove, and other technologies by years, number, capacity, and locations from related stakeholders such as the Alternative Energy Promotion Centre (APEC), Solar Energy Association, Renewable Energy Confederation of Nepal, etc. were collected

3 Data/ information on storage, import, and sale of petroleum products in Nepal for FY 2075/76, 2076/77, and 2077/78 were collected from Nepal Oil Corporation (NOC), Department of Custom, Civil Aviation Authority of Nepal (CAAN)

4 Data/ information on indigenous production and import of different types of coal, charcoal, and other energy forms in different years were collected from the Department of Mines and Geology and the Department of Customs.

5 Data/ information on electricity generation, sale, and consumption by years and sectors from relevant institutions such as the Department of Electricity Development (DoED), Nepal Electricity Authority (NEA), Independent Power Producers' Association of Nepal (IPPAN) were collected. Also, the list of existing hydropower projects, potential projects, and projects in the pipeline with capacity was obtained

6 Other supporting databases and information such as socio-economic, technical, and environmental facts were collected from the concerned institutions as well as available literature associated with the energy supply and consumption.

The data/information was collected in its original unit as developed by the concerned energy institutions. The original/ natural units were converted into Giga Joule (GJ) and Tonne of Oil Equivalent (TOE) units during the analysis of the data.

2.5 Data analysis

The collected data/information was analyzed to prepare the supply situation and consumption of energy in the country. The data are presented in tabulated and graphics forms. Data have been analysed for the following components:

1 Analysis of fuelwood supply and consumption by location and years

2 Estimation of the agricultural residues and animal waste based on the production information of the agriculture crops and livestock numbers by different years.

3 Analysis of the production and generation information of each Renewable Energy resource

4 Analysis of the individual energy consumption in economic sectors (i.e. Residential, Commercial, Industrial, Transportation, Agricultural, and Construction & Mining)

5 Analysis of energy consumption share of end-use by individual fuel type, and by economic sectors

6 Analysis of energy pricing history of Nepal

7 Preparation of energy balance for three fiscal years FY 2075/76, 2076/77, and 2077/78.

2.6 Reporting outline

The draft report has been prepared after analyzing and synthesizing the collected and compiled data from different sources and organizations involved in the field of energy development and conservation. The report has been prepared in the following outline form:

- Abbreviations
- Executive Summary
- Chapter 1: Introduction
- Chapter 2: Methodology
- Chapter 3: Energy Supply Situation in Nepal
- Chapter 4: Energy Consumption Situation in Nepal
- Chapter 5: Energy Indicators
- Chapter 6: Energy Pricing Structures
- Chapter 7: Energy Balance
- Chapter 8: Provincial Energy Synopsis
- Chapter 9: Conclusions
- References
- Annexes

3 Energy Supply in Nepal

3.1 Energy supply system

Nepal's energy supply system has broadly classified the energy types by form of recourses and forms. The resources that are replenished are categorized under Renewables while those that have limited supply from nature are categorized as Non-renewables. The renewables are further divined into conventional resources that are derived from organic matters and new renewables that includes electricity generation system from hydro, solar, and wind. In conventional resources, traditional energy resources include fuelwood from forests and tree resources, agricultural residues coming from crops, and animal dung in the dry form. Traditional energy resources can, of course, be termed biomass energy resources since it only covers the biomaterials for energy purpose. Energy resources coming under the commercial or business practices are grouped into commercial energy resources that particularly include coal, grid electricity, and petroleum products. Biogas, solar power, wind, and micro-level hydropower are categorized as the alternative energy resources in Nepal. Such resources are considered a supplement to conventional energy resources. This categorization has seen minor updates this WECS's reports. The latest WECS report on "Energy Consumption and Supply Situation in Federal System of Nepal (Province No. 1 and Madhesh Province) in 2020/21 has categorized the energy resources as given in Figure 3-1.

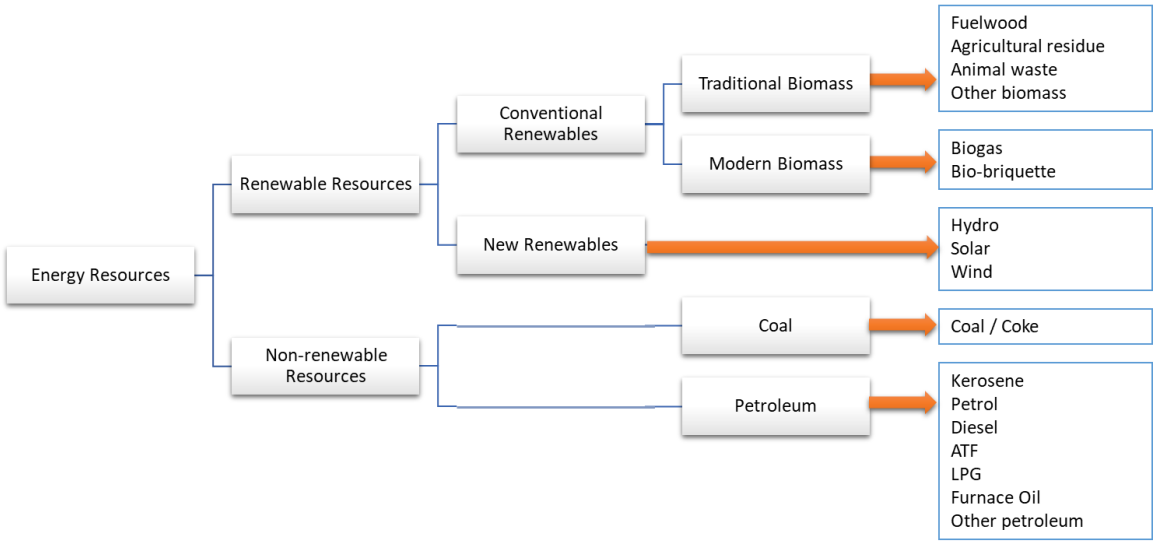


Figure 3-1 Energy resources system currently being adopted in Nepal

3.2 Conventional Energy Resources

3.2.1 Forest resources

By definition, the forest is all land with a forest cover, i.e. with trees whose crown cover is greater than 10%, not being used primarily for purposes other than forestry. The width of the stand must be more than 100 m and the stand can include non-forest patches narrower than 25 m or smaller than 1 ha. Also, temporarily clear-cut areas that will be planted are considered a forest. The definition of a shrub is similar to the definition of a forest except that a well-defined stem cannot be found. Globally, over 1.6 billion (25% of the total global population) people depend on forests for subsistence, livelihood, employment, and income generation (FAO, 2017). In Nepal over 65% population particularly from poor families depend on forests for timber, fuelwood, and fodder (FRTC, 2019).

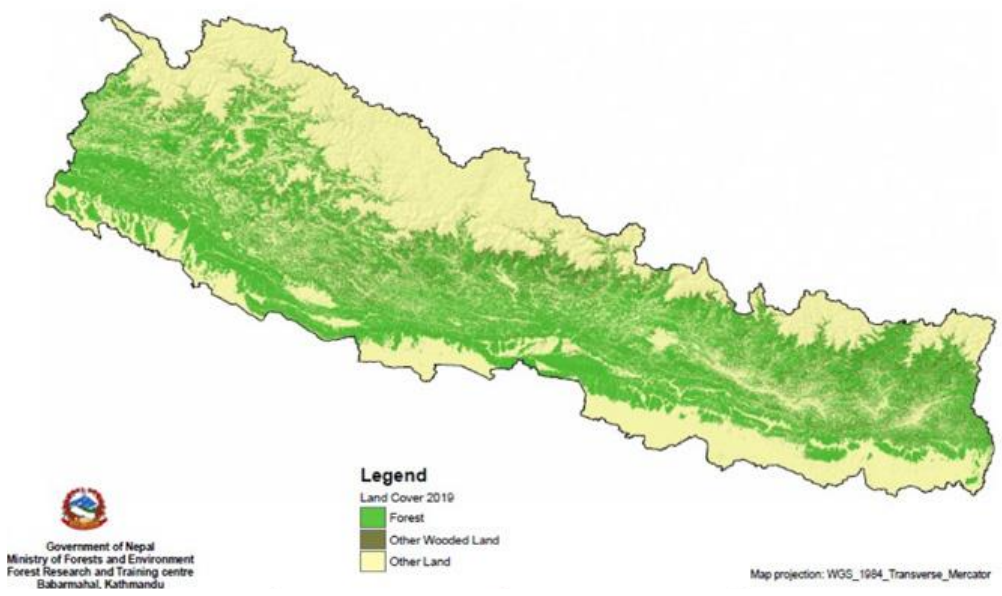
The first national-level forest inventory in Nepal was carried out in the 1960s. Since then, several forest resource assessments have been carried out, each different in terms of its purpose, scale, scope, design, and technology used. The second national-forest inventory was carried out in the 1990s. FRA Nepal (2010–2014) conducted by DFRS (2015) is the third and the most comprehensive national-level forest resource inventory. According to the study, Forest covers 5.96 million ha, i.e., 40.36% of the total area of Nepal. Similarly, Other Wooded Land (OWL) covers 0.65 million ha (4.38%) and Other Land covers 8.16 million ha (55.26%). Within OWL, shrub covers 0.12 million ha (0.79%), and areas with tree crown cover 5–10% cover 0.53 million ha (3.59% of the total area). Both Forest and OWL together cover 6.61 million ha, 44.74% of the total area of the country.

Table 3-1 Forest areas by province

	Total Area (ha)	Forest area (ha)	Districts included	Municipalities covered
Province 1	2,589,283	1,134,250	14	137
Madhesh	886,771	263,630	8	136
Bagmati	1,905,308	1,090,880	13	119
Gandaki	2,134,732	817,290	11	85
Lumbini	1,778,451	974,380	12	109
Karnali	3,061,752	1,183,400	10	79
Sudurpaschim	1,906,270	1,147,110	9	88
	14,262,567	**6,610,940**	**77**	**753**

(MOFE, 2020)

Figure 3-2 indicates the total land area distributed by land type in Nepal. It can be seen that the forest area is stretched along east to west, and is concentrated in hilly regions, also ranging in terai as well as high hill belts. According to DFRS (2015), the Bagmati Province of the country has the highest total forest area (17.55%) while Madhesh Province has the lowest forest coverage area (4.37%).



(DFRS, 2020)

Figure 3-2 Land cover map of Nepal

Out of the total forest, 37.80% lies in the Middle Mountain physiographic region, 32.25% in the High Mountains and High Himal, 23.04% in Churia, and 6.90% in the Terai indicating that majority of the forest areas are found in Middle Mountain and High Mountain. Out of the total OWL, Terai, Churia, Middle Mountains, High Mountains, and High Himal physiographic regions share 1.057%, 4.21%,

5.52%, and 89.23%, respectively.

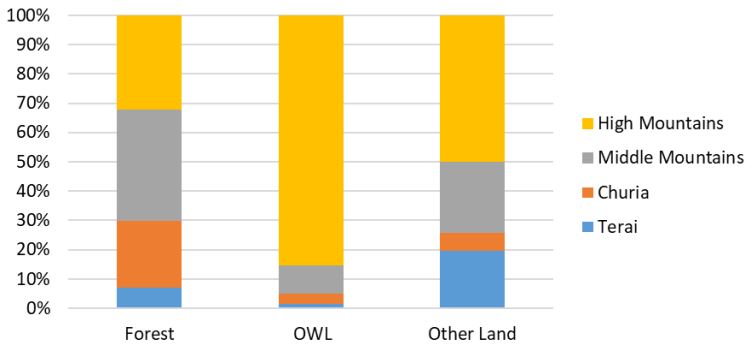


Figure 3-3 Proportion of Land Cover in each Physiographic Region

Out of the total forest of the country, 4.93 million ha (82.68%) lies outside the protected areas and 1.03 million ha (17.32%) inside the protected areas. Within the protected areas, the core areas have 0.79 million ha of forest and the buffer zones have 0.24 million ha of forest. Of the total forest inside the core areas, the high mountains and the high Himal regions together have the highest share (57.95%) and the middle mountains region has the lowest (2.10%).

Table 3-2 Forest Cover (ha) inside and outside the Protected Area by Physiographic Region

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 & High Himal	1,345,309	459,240	118,360	1,922,909
National total	4,929,436	792,506	240,098	5,962,040

3.2.1.1 Community Forest

Community forest has covered nearly half of the total national forests in Nepal (MOFE, 2020). It is the second-largest management regime after the government-managed forests. Figure 3-4 show the community forest land in different provinces of Nepal. The Bagmati has the highest area of community forest coverage (18.66) while Madhesh province has the least area of coverage (3.96%).

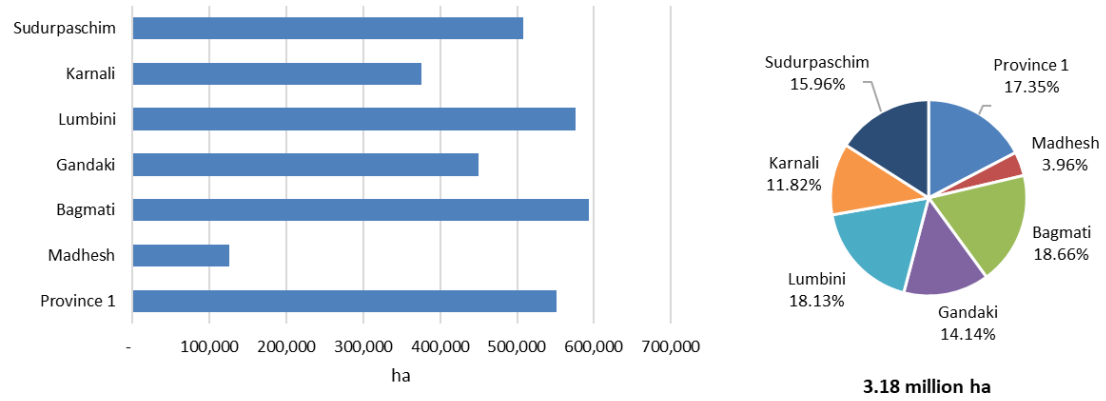


Figure 3-4 Community Forest Coverage in different Provinces

3.2.1.2 Forest Cover Change

Table 3-3 presents the time series forest and shrub land area coverage of the country. The data show the forest area in Nepal was in a decreasing trend from the 1960s up to the 2000s. A recent study by DFRS (2015) revealed an increase in forest land coverage. In the study, the forest area has been estimated to be about 40.36% of the total country area.

Table 3-3 Time Series Forest and Shrub Land Area of the Country

Year	Forest Area (000ha)	Shrub Area (000ha)	Forest % Area	Shrub % Area
1960s	6078.9	388	41.14%	2.63%
1970s	5612.5	694.1	38.10%	4.70%
1980s	5518	706	37.42%	4.79%
1990s	4268.8	1559.2	39.60%	10.59%
2000s	3900	1753	26.50%	11.90%
2005s	3636	1897	24.70%	12.90%
2010s	5962.126	647.892	40.36%	4.39%

Similarly, Table 3-3 shows that the shrub land area is in increasing trend except in the recent study of DFRS (2015). The shrub land area coverage increases from 2.63% in the 1960s to 12.90% in the 2005s has decreased to 4.39% in the 2010s.

3.2.1.3 Sustainable Wood and Fuel-wood Supply

According to DFRS (2015), Nepal has potential resources of about 1159.65 million tons of above-ground air-dried biomass which is equivalent to 1054.20 million tons of above-ground oven-dried biomass. High Mountain and High Himal physiographic regions contribute the highest amount of biomass comprising about 45% of the total national figures. High Mountain and High Himal physiographic regions are followed by Middle Mountain (27.84%), Siwalik (20.40%), and Terai (6.74%).

Table 3-4 Total above-ground air-dried and total above-ground oven-dried Biomass

(million tonnes)

Physiographic region	Total above-ground air-dried biomass	Total above-ground oven-dried biomass
Terai	78.21	71.10
Churia	236.57	215.06
Middle Mountains	322.88	293.52
High Mountains and High Himal	521.99	474.52
National total	**1159.65**	**1054.20**

(Source: DFRS (2015) and Calculation)

DFRS/FRISP (1999) has estimated that about 50.05% of the country's total forest area is reachable. The study further estimates the reachable (accessible) forest area for the then-different development regions as 78.29%, 57.45%, 36.69%, 38.11%, and 52.20% respectively for EDR, CDR, WDR, MWDR, and FWDR. Looking at the current political boundary, the values are adopted as 78.29%, 100%, 57.45%, 36.69%, 38.11%, 38.11%, and 52.20% respectively for Province 1, Madhesh Province, Bagmati Province, Gandaki Province, Province 5, Karnali Province and Sudurpaschim Province in the present analysis. Based on the data and calculations, the country has a total of 2.984 million ha of accessible forest area which accounts for 50.05% of the country's forest.

Table 3-5 Sustainable Fuelwood Supply and Energy in 2014

Province	Area in 000 ha						Sustainable Wood (million T) from Reachable			Energy (GJ)
	Forest		OWL		OL					
	Total	Reachable	Total	Reachable	Total	Reachable	Forest	OWL	Total	
Province 1	1,034.17	809.65	100.17	78.42	1,476.72	1476.723	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	939.425	2.25	0.02	2.27	38,048,744
Gandaki	739.60	271.36	99.55	36.52	1,429.16	1429.164	1.02	0.03	1.04	17,465,405
Lumbini	968.37	369.04	49.22	18.76	963.27	963.268	1.38	0.01	1.40	23,396,583
Karnali	902.82	344.06	215.52	82.13	1,828.31	1828.312	1.29	0.06	1.35	22,557,306
Sudurpaschim	1,010.21	527.33	135.90	70.94	831.26	831.262	1.98	0.05	2.03	33,939,709
Entire Country	**5,962.13**	**2,984.04**	**647.89**	**324.27**	**8,163.49**	**8163.494**	**11.94**	**0.22**	**12.15**	**203,578,923**

Similarly, DFRS/FRISP (1999) shows that about 12.15 million tons of fuelwood can be sustainably extracted from the existing forest resources. This figure comprises 11.94 million tons per year from forest areas and the remaining 0.22 million tons per year from other wooded lands. The results are comparable with WECS (2010) but slightly on the lower side which estimation was 12.51 million tons per year for the year 2008/2009. The annual energy potential of the sustainable fuelwood is estimated to be 203,578,923.85 GJ. Furthermore, Province 1 has the highest sustainable annual fuelwood yield (25.42%) while Madhesh province contributes the lowest sustainable annual fuelwood (8.06%) as shown in Figure 3-5.

Table 3-6 and Figure 3-5 depict sustainable fuelwood production for different provinces along with different physiographic regions. The results show that the Mid-Hills of all provinces (except Madhesh province) have a higher contribution of potential sustainable fuelwood supply from the forest area. Mid hill region of Sudurpaschim Province is expected to contribute about 10% of the country's total sustainable fuelwood supply. This is followed by the mid-hill of Province 1 (8.87%). On the other

hand, High Mountain of Province 1 has the highest contribution of sustainable fuelwood supply at the provincial level which is believed to contribute about 9.92% of the country's total potential.

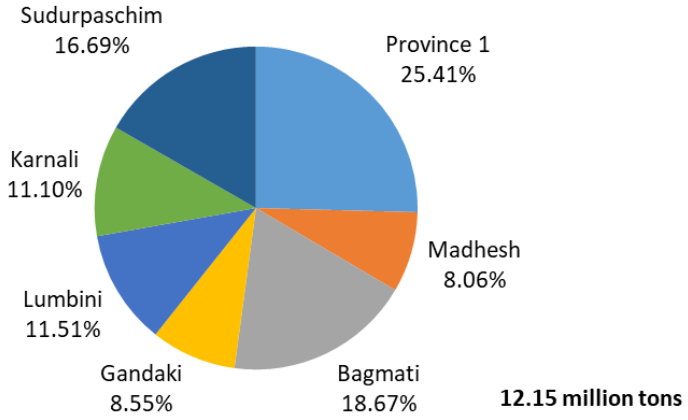


Figure 3-5 Proportion of Sustainable Annual Wood Yields in Provinces

Table 3-6 lists the sustainable fuelwood supply potential in different provinces along with their energy potential. It indicated that Province 1 has the highest energy potential from the sustainable supply of fuelwood while Madhesh Province has the least.

Table 3-6 Sustainable Wood and Energy Supply in different Provinces of various Physiographic Regions

Province	Sustainable Wood Production (million Ton)												Total Energy (million GJ)
	Churia			Terai			Mid Hills			High Mountain			
	Forest	OWL	Total	Forest	OWL	Total	Forest	OWL	Total	Forest	OWL	Total	
Province 1	0.249	0.004	0.254	0.502	0.009	0.511	1.078	0.019	1.098	1.206	0.021	1.228	51.759
Madhesh	0.155	0.000	0.155	0.823	0.002	0.824			-			-	16.412
Bagmati	0.530	0.004	0.534	-	-	-	0.823	0.006	0.829	0.902	0.007	0.909	38.049
Gandaki	0.048	0.001	0.050	0.025	0.001	0.025	0.944	0.023	0.968	-	-	-	17.465
Lumbini	0.421	0.004	0.425	0.287	0.003	0.290	0.675	0.006	0.682			-	23.397
Karnali	0.065	0.003	0.067	-	-	-	0.505	0.022	0.527	0.721	0.032	0.752	22.557
Sudurpaschim	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
Entire Country	1.665	0.022	1.686	1.974	0.022	1.996	5.235	0.107	5.342	3.064	0.066	3.130	203.579

Similarly, Figure 3-6 depicts that in Province 1, the largest amount of sustainable fuelwood can be supplied from the mid-hill forest and mid-hill OWL. Similar is the case for other provinces, except Madhesh Province, where there is no hilly region and more than 80% of fuelwood potential is from the forest and the rest from OWL.

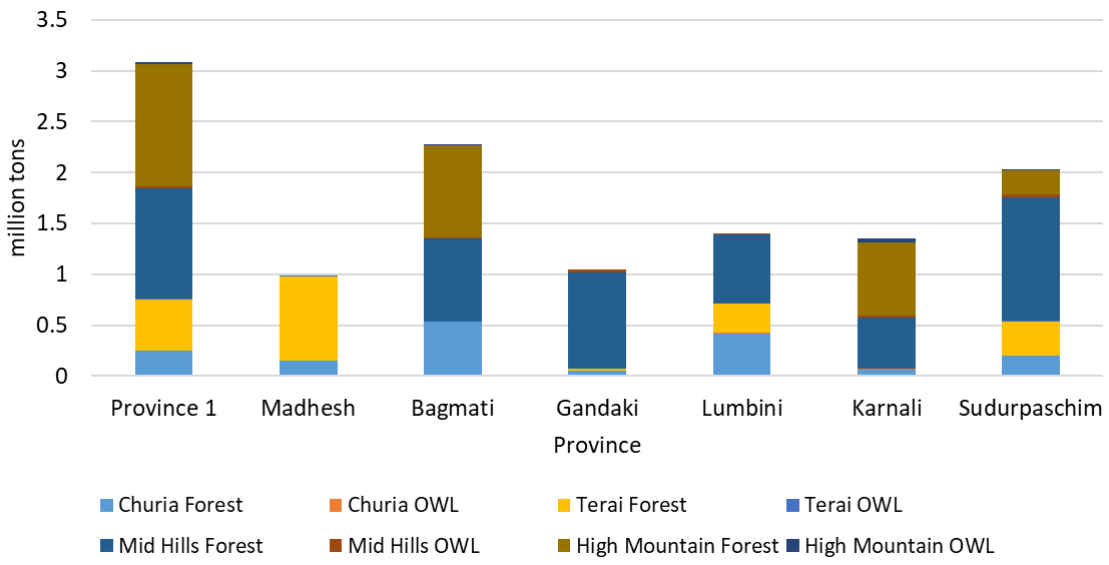


Figure 3-6 Proportion of different Provinces with different Physiographic Regions in Sustainable Annual Wood Yields

3.2.1.4 Community Forest Contribution to Sustainable Wood Supply in 2014

According to DFRS (2015), the annual sustainable fuelwood from community forests for the entire nation is 4.53 million tons. The highest value of annual sustainable fuelwood supply has been observed in Province 1 with the value of 1.58 million tons per year while the lowest value was observed in the Madhesh province (0.29 million tons).

Table 3-7 Annual Sustainable Fuelwood Supply and Energy by the Community Forest in 2014

Province	Area (000 ha)		Sustainable wood (million ton)	Energy (GJ)
	Forest	Reachable		
Province 1	536.68	420.17	1.58	26,391,873.88
Madhesh	77.64	77.64	0.29	4,876,954.71
Bagmati	374.80	215.32	0.81	13,524,931.69
Gandaki	233.59	85.70	0.32	5,383,219.72
Lumbini	394.88	150.49	0.56	9,452,519.01
Karnali	316.30	120.54	0.45	7,571,648.42
Sudurpaschim	265.09	138.38	0.52	8,691,877.17
Entire Country	2,198.99	1,100.59	4.53	75,893,024.59

At the national level contribution of the community forest to the annual sustainable wood, supply has been estimated to be about 37.28% of the total sustainable fuelwood supply. At the provincial level, Province 1 has the highest contribution of the CFs to the total sustainable wood supply of the province (51%). Similarly, Sudurpaschim province has the lowest contribution of CFs to the total sustainable wood supply of the province (25.61%).

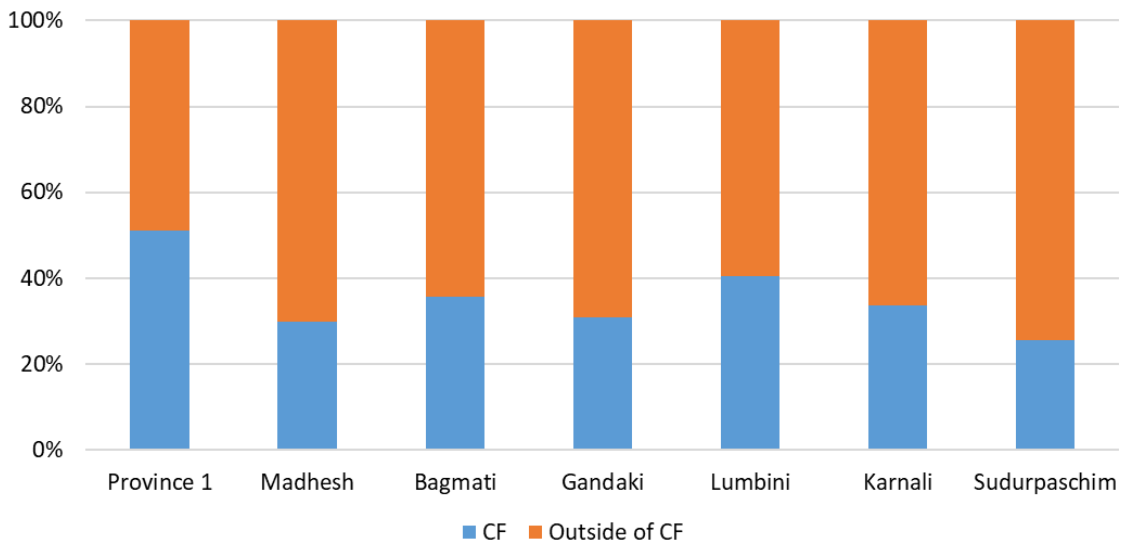
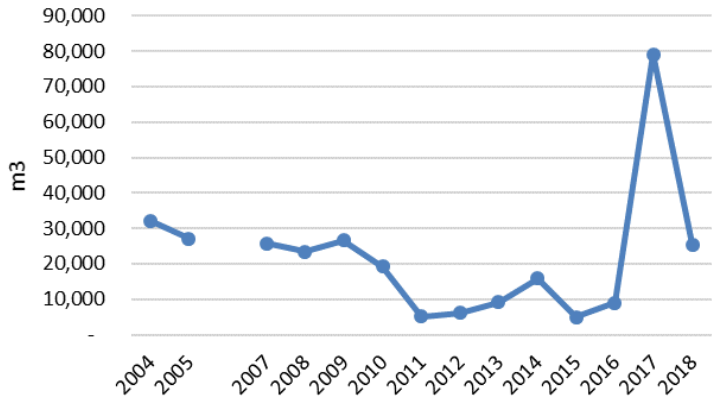


Figure 3-7 Community Forest Contribution to Sustainable Annual Wood Yields

The fuelwood sales trend remains nearly constant for over a decade, however, had taken a peak in 2017 (Figure 3-8).



(Bhatt, et al., 2021)

Figure 3-8 Fuelwood sales trend

Table 3-8 indicates that the sales of fuelwood supply are highest from Karnalu Province where the peaked in Bagmati province, specifically Makawanpur district, surpassing the old stock and production. Meanwhile, Karnali province neither has sales nor production.

Table 3-8 Supply of forest products by each Province in 2075/2076

(In chatta[1])

Province	Fuelwood (Except household-level private consumption)	Percent
Province 1	3580	7.67
Madhesh	6197.07	13.28
Bagmati	4429.05	9.49
Gandaki	2320.65	4.97
Lumbini	4964.23	10.64
Karnali	24374.00	52.22
Sudurpaschim	805.00	1.72
	46,672.00	100

(DoF, 2015)

It can be seen from Table 3-9 that TCN is not active in sales of fuelwood. In 2017, DFPSB is the largest seller of fuelwood. The production and sales are mainly from Terai and inner Terai districts

Table 3-9 Status of Fuelwood Productions and Sales in the Fiscal Year 2073/74 by authority

Authority	Old Stock (from 2072/073)	Production in 2073/74	Total	Sales
TCN	161	34	194	4
DFO	500	271	770	314
DFPSB	39	18	58	78,814
	700	**322**	**1,022**	**79,132**

In addition to TCN, DFO, and DFPSB, there are sales of fuelwood from community forests and private forests as well (Table 3-10). The largest amount of fuelwood came from the private forest. However, the demand for fuelwood seems to have dropped substantially in an adjacent year later.

Table 3-10 Sales of fuelwood from community forest and private forests

(In chatta)

	2016	2017
Community forest	705.16	394.59
Private forest	6460.33	2055.23

3.2.2 Agricultural Residue

The agriculture residue supply potential was estimated based on the methodology described in section 2.1.1. As per WECS 2010, the total potential supply in 2008/09 was 19 million tons of agri-residue and 243 million GJ of energy. The total potential supply of residue in 2021 was estimated to be 26 million tons. The total agricultural residue production in 2019 was 23 million tons, which grew slightly from 24 million tons in the previous, at the rate of 3%, This could be the result of the lower production rate during pandemics. Meanwhile, the after-effects of the pandemic went down, it rose at the rate of 6% from the previous year as seen in Figure 3-9. The 2021 production was estimated based on five-year production where paddy grew at 7% per annum and is the major agricultural product with more

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

than 50% share. It can be seen that the Terai region has the most potential for agri-residue production with the share of 48% of total supply potential followed by the hilly region (35%) and the lowest potential in the Mountainous region (18%).

The provincial agri-residue supply potential shows that Province 1, Madhesh, and Lumbini provinces have a high potential supply of agri-residue with a share of 22%, 19%, and 19% respectively. Bagmati province contributes 13% of the total supply potential followed by Gandaki and Sudupashchim with 10% and 11% share and Karnali province with the least supply potential of 6%.

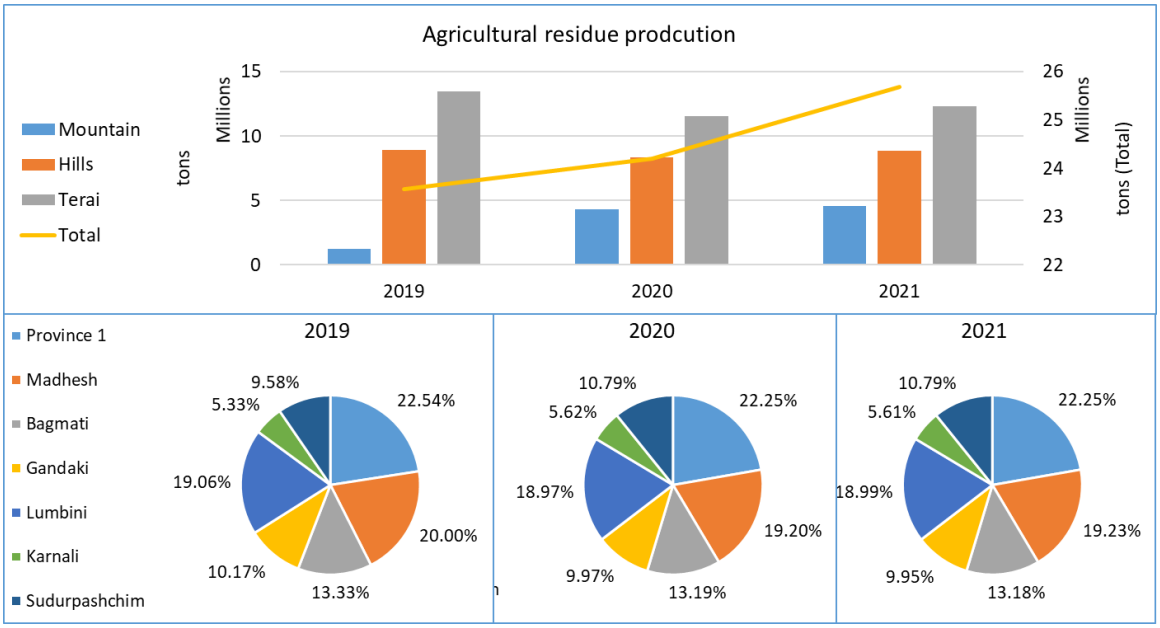


Figure 3-9 Status of agricultural residue production

It can is seen from Figure 3-10 that the energy potential from agricultural residue also grows similarly to the production. The equivalent potential energy from the agri-residue was 442 million GJ in 2021 which were 406 million GJ and 416 million GJ in 2019 and 2020 respectively (Figure 3-10). The growth rates of production and energy potentials are slightly different, primarily because of variation in the production of different crops and different regions. As a result, the energy potential share from agri-residue is a bit higher for the Terai region, while looking at the provincial level, the same share is higher in Madhesh Province as it fully lies in the Terai region. Karnali and Gandaki have the least amount of agri-residue energy potential due to lower production in the barren remote lands lying in the northern geography.

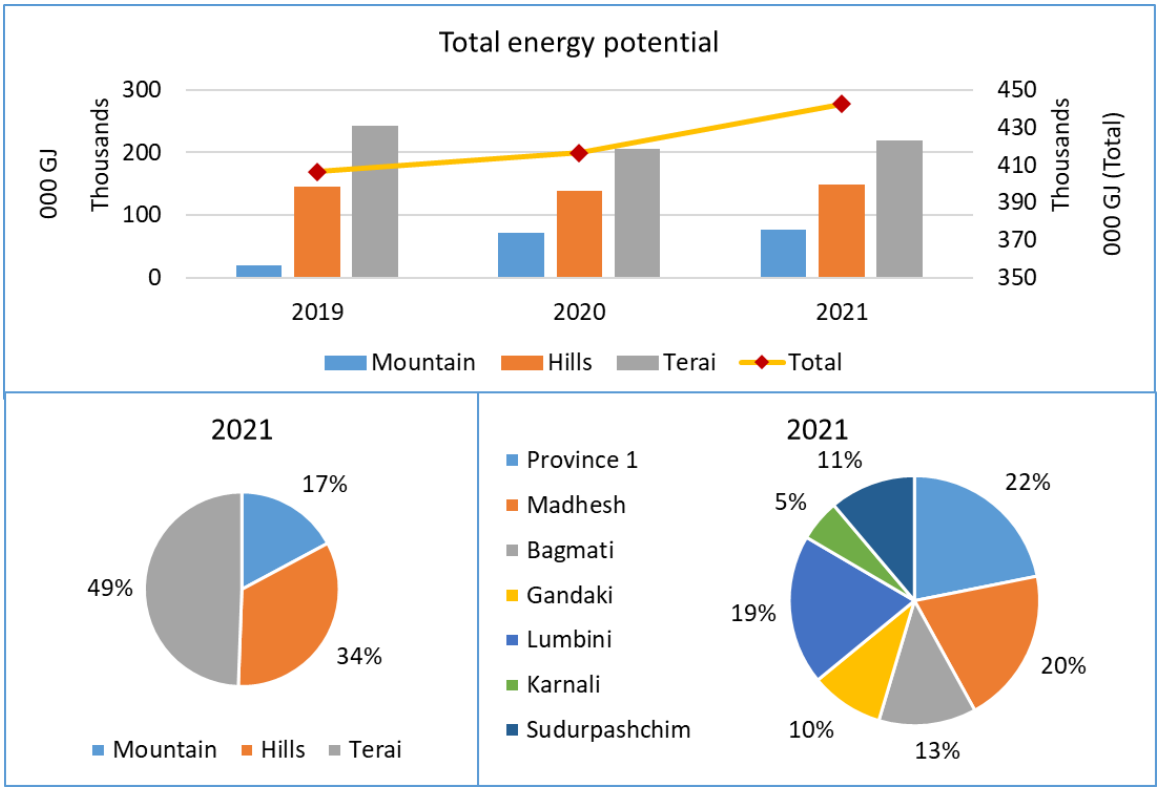


Figure 3-10 Energy potential from agricultural residue

The detailed data are given in Annex II

3.2.3 Animal waste

The animal waste supply potential was estimated based on the methodology described in section 2.1.1. As per WECS 2010, the total potential supply in 2008/09 was 15 million tons of dry dung. The livestock considered for animal waste production is cattle and buffalo. In 2019, there were 7.3 million cattle and 6.9 million buffalo (including milking buffalo). The dry dung yield from the livestock was estimated to be 6.8 million tons in 2019 considering the accessibility and collection efficiency of 70%. The lower value compared to 2010 is due to the difference in conversion units, the present value is based on the latest study in Nepal (Adhikari & Denich, 2019). This potential grew at only 0.35% in 2020 (6.84 million tons). However, in 2021, with the effect of the pandemic being lower, it is approximated to be about 6.9 million tons in 2021 at a cumulative growth rate of 1.12% (Figure 3-11).

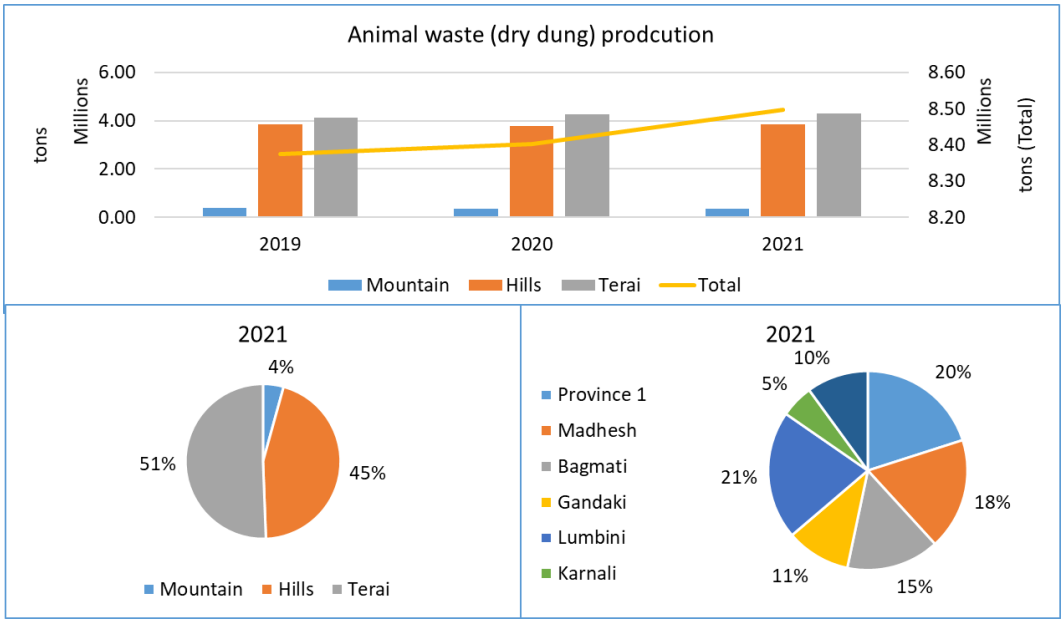


Figure 3-11 Status of animal waste production

Meanwhile, the energy potential from the dry dung was about 101.6 million GJ in the year 2019, which grew to 102 million GJ in 2020 and 103 million GJ in 2021. Region-wise, the Terai has the highest potential in animal dung production, indicating the highest potential for the intervention of biogas plants which are also favored by warmer days throughout the year than in the mountain region. The livestock farming pattern in mountain regions and its size already give lower potentiality for the intervention of biogas in the mountainous region. The installation and operation of a biogas plant in the mountain region are further challenged by the cold temperatures as well as the remoteness of the area.

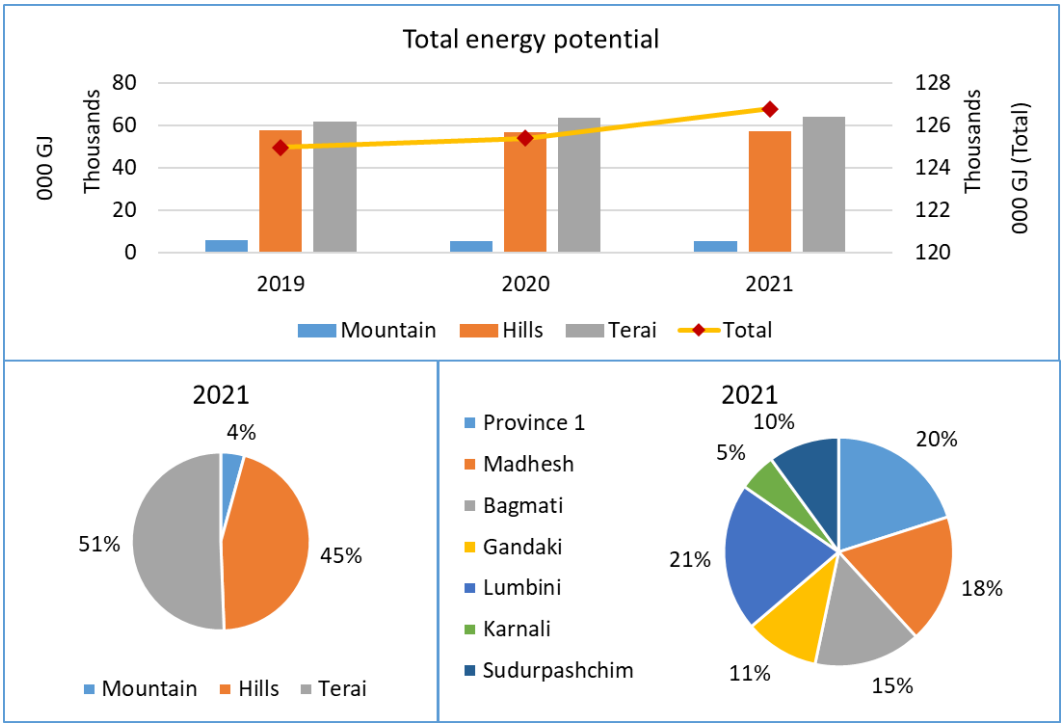


Figure 3-12 Energy potential from animal waste (dry dung)

The detailed data are given in Annex IV.

3.2.4 Other Energy Sources

There are other potential energy sources other than the above-mentioned resources. These are either non-conventional or are not easily traceable. Some of these types of sources are logging residue, wood mills, carpentry, crafting industries, and some food manufacturing industries, like sugarcane processing as well. The logging residue depends highly upon the size of the log, quality, type of sawing process, and product required. Similarly, the wood mills and crafting industry also cannot be traced and accounted to a standard baseline. WECS (2010) reported 50% residue generation with 60% recovery factor. Thus for a ton of log produced 300 kg of logging residue can be collected.

Bagasse could be another energy source. It is a waste product of sugarcane processing. However, it has the potential to be used for energy co-generation as heat and electricity with high efficiency in sugar mills. The yearly production of sugarcane on average has been around 3 million tons in the past decade. In the last three years, it can be seen that the production has slightly reduced, which could be the impact of Covid lockdowns. However, it can be expected to grow again this year reaching around 3.6 million tons (Figure 3-13). It is also evident that Madhesh province, with the largest Terai plain land, has the largest production followed by Sudruapschim and Lumbini provinces, while Karnali and Bagmati provinces have the least. Taking 34% of bagasse production from sugarcane, approximately 1.2 million tons of bagasse can be extracted in 2021 (Pokharel et al, 2014).

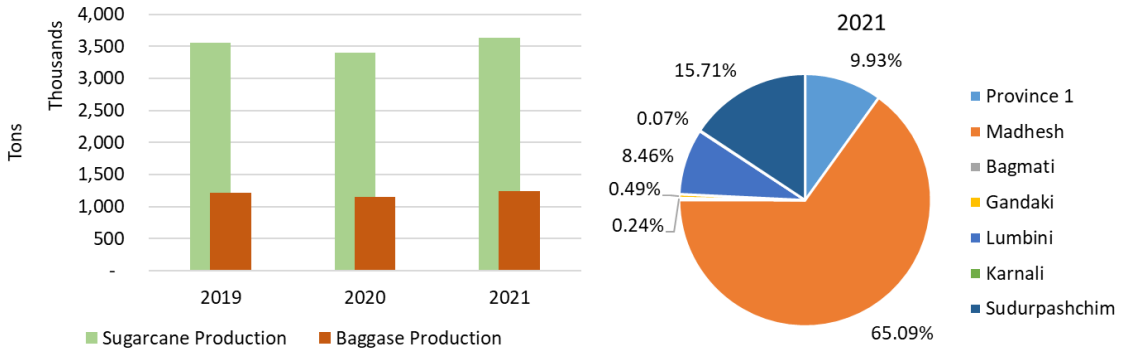
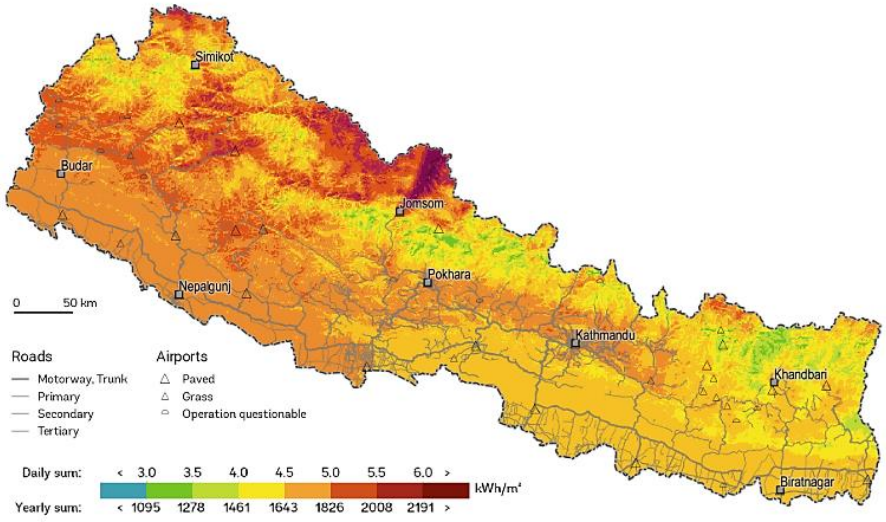


Figure 3-13 Sugarcane and bagasse production

3.3 Modern Renewable Energy Resources and Technologies

3.3.1 Solar

Nepal has a huge potential for solar energy. On average, there are 300 sunny days per year and 6.8 sunshine hours per day (Poudyal, et al., 2019). As shown in Figure 3-14, the northwest part of the country receives global horizontal irradiation reaching up to 5.5 kWh/m^2/day while the southern regions receive average GHI in the range between 4.4 kWh/m^2/day and 4.9 kWh/m^2/day. The specific solar PV electricity output capacity of the country lies between 1400 kWh/kWp and 1600 kWh/kWp (equals to average daily totals between 3.8 and 4.4 kWh/kWp). The mountain region has higher PV energy yield potential because of high elevation and low air temperature. Therefore, the hills and lower-elevation mountains with good GHI and lower temperatures are the best regions to develop solar PV systems in Nepal (World Bank, 2017). According to the Solar and Wind Energy Resource Assessment(SWERA) by the Alternative Energy Promotion Centre (AEPC), the commercial potential on-grid solar PV system in Nepal is estimated to be 2,100MW (UNEP/GEF, 2008). Similarly, almost 25% of the area of Nepal is suitable for CSP systems. Even if only 2% of the best solar irradiance is used for the power generation of 1829 MW of electricity can be generated.

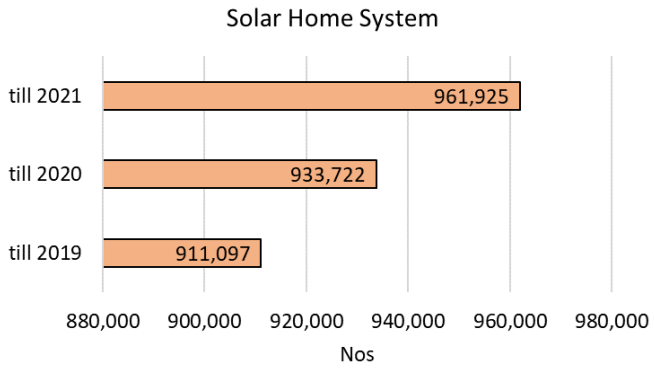


Source: SolarGIS

Figure 3-14 Global Horizontal Irradiation - a long-term average of daily and yearly totals.

AEPC has been the central government body for dissemination of the solar technologies all over Nepal. To date, there have been about 961 thousand residential Solar PV systems installed. The largest number of SHS have been installed in remote districts of western Nepal, and the access to grid electricity is poor. The number of SHS installations is on an increasing trend however the pace of installment has been affected by the earthquake and trade debacle after 2015. In addition to that, the end of load shedding also slowed down the demand in 2017. However, it has taken pace in 2017 and 2018. It again took a little impact due to COVID pandemic restrictions all over the nation in 2020.

Observing the installation of SHS by the administrative division, it can be seen that the largest number of SHS are installed in hilly regions, while Terai and mountain regions have the lowest. Almost all parts of Terai have the access to the national grid, and also have easy access to cheap alternatives to lighting. On other hand, the mountain region is very remote for the technology to reach. In that contrast, the accessible parts of hilly regions, but without access to the grid have the highest number of installations, which can be seen in Figure 3-15. The hilly regions of Lumbini and Karnali have the highest number of SHS. This pattern holds for all other provinces with districts in the hilly region.



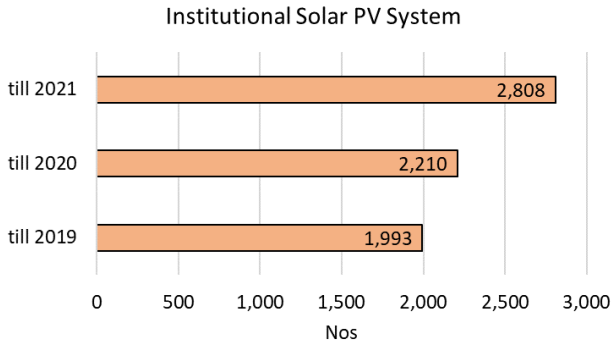
Province	Installed Share
Province 1	14.6%
Madhesh	3.7%
Bagmati	12.4%
Gandaki	5.4%
Lumbini	22.3%
Karnali	24.0%
Sudurpashchim	17.5%

Region	Installed Share
Terai	15.1%
Hill	68.5%
Mountain	16.4%

Figure 3-15 Installation of solar home systems until 2021

Figure 3-16 shows the distribution of ISPS installed in each province. It can be seen that the largest number are in Karnali, Sudurpaschim, and Province 1, which have lower access to grid electricity but also have hilly districts. However, capacity-wise, the total system capacity in Bagmati provinces

surpasses all followed by Karnali and Sudurpaschim. It can be understood that, in Bagmati province, most of the systems have a larger capacity per system than in other provinces. The average capacity of total installations comes around 1.76 kWp per system, whereas for Bagmati it is 2.83 kWp per system, while the lowest is in Sudurpaschim with 1.47 kWp per system.



Province	Installed Share
Province 1	18.1%
Madhesh	4.0%
Bagmati	15.6%
Gandaki	7.0%
Lumbini	12.1%
Karnali	22.9%
Sudurpashchim	20.3%

Region	Installed Share
Terai	11.2%
Hill	55.6%
Mountain	33.3%

Figure 3-16 Installation of Institutional Solar PV Systems until 2021

Meanwhile, the geography-wise distribution indicates that the hilly region has the largest number and capacity of ISPS installed, in addition to SHS. However, the ISPS installed in the Terai region is seen to have a larger capacity per system with an average of 2.14 kWp per system, while they are 1.90 kWp per system and 1.41 kWp per system for Hills and Mountains respectively. It can be understood that, with good access to roads and services, the system capacity can be larger, thus indicating the hurdle in the installation of larger systems in remote areas of Nepal.

Photovoltaic Pumping Systems (PVPS) for drinking water are installed mostly in hilly belts as seen where people need to travel over a long distance for drinking water supply. Figure 3-17 shows the installation status of the Photovoltaic Pumping System (PVPS) for the drinking water and irrigation system.

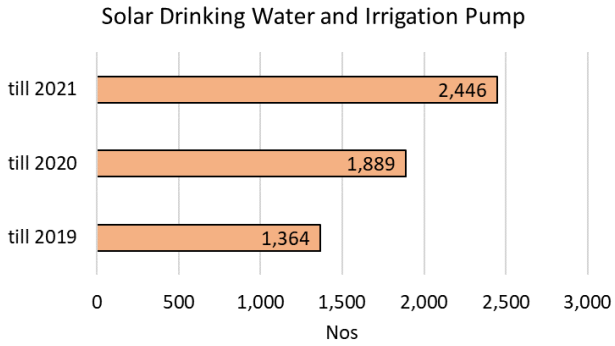


Figure 3-17 Installation of solar drinking water and irrigation systems until 2021

The largest number of PVPS for drinking water has been installed in hilly areas of Province 1 followed by Lumbini and Karnali provinces (Table 3-11). In the lowlands of Terai, where shallow boring is enough, it is least installed. Geography-wise also we can see the hilly region has the largest number of PVPS for drinking water installed, while there are some installed in very few districts of the mountain region.

The majority of PVPS for irrigation has been installed in districts in the Terai belt, along with very few in hilly, and the least number in the mountain region. It can be observed that, as opposed to previous solar PV systems, the number of PVPS installed is highest in the Terai plains – which are

the major agricultural area of Nepal. It can be seen from Table 3-11 that nearly 90% of the PVPS for irrigation has been installed in the Terai area. Although this system is gaining popularity in hilly areas as well, only 9% of the total systems are installed in hilly districts where the source of water is not far or the water table is not too deep. Province-wise data also indicates the same pattern – the Madhes Province with Terai plains has the highest number of PVPS for irrigation, followed by Lumbini and then Province 1.

Table 3-11 Installation of solar drinking water and irrigation systems until 2021

Solar Drinking water system

Province	Installed Share
Province 1	20.9%
Madhesh	1.6%
Bagmati	14.4%
Gandaki	14.4%
Lumbini	19.8%
Karnali	17.6%
Sudurpashchim	11.2%

Region	Installed Share
Terai	3.2%
Hill	92.5%
Mountain	4.3%

Solar Irrigation System

Province	Installed Share
Province 1	16.7%
Madhesh	45.4%
Bagmati	11.6%
Gandaki	0.4%
Lumbini	21.0%
Karnali	0.6%
Sudurpashchim	4.1%

Region	Installed Share
Terai	89.4%
Hill	8.7%
Mountain	1.8%

In addition to small isolated systems, in recent years. Large utility-scale plants are also being constructed and some are in operation. NEA operates about 1.35 MW plants while IPPs operate about 21 MW of solar plants. More projects are in pipeline with construction licenses and survey licensees. The list of the projects is given in Annex V.

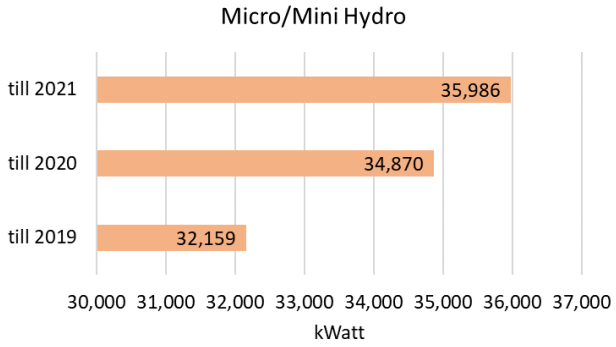
3.3.2 Micro and Pico hydro

Micro-hydro and pico hydro are small scare the hydro-power system that generates electric power below 100 kW and 1 kW capacity respectively. Pico hydro includes Peltric Sets and also technologies that use Pelton Turbine (low discharge and high head), Cross flow Turbine, and other technologies (high discharge and low head) depending on available discharge and head. These majorly serve nearby households through a local, decentralized, isolated mini-grid. These small hydro plants have been the more practical and cost-effective solutions for providing electricity in the rural and remote areas where extension of the national grid has been a challenge.

Nepal has immense hydropower potential. After the government started subsidizing the micro-hydro power plants in 1981, the development of micro hydropower gained a pace as a mechanism for rural electrification. As of 2018, the installed micro-hydropower plants have contributed up to 38 MW including pico-hydropower plants. Nepal has the potential to develop more than 50 MW of hydroelectricity from micro-hydropower plants. Recently in 2014, NEA approved a technical standard draft prepared by NEA and AEPC for the effective integration of Micro hydropower plants into the grid. Although the grid integration of MHPs into the national grid was mandated by the Electricity Act 1992, the first successful grid integration of 23kW MHP came into action only in 2018. As of 2020, four MHPs of a total 253kW have been integrated into the national grid while several are under study. AEPC has been coordinating with different stakeholders along with local communities to allow, facilitate, and create a conducive environment for the development of Micro and Pico hydro.

The majority of the MHPs are concentrated in mountain and hilly regions due to the availability of water sources in these areas. The districts in Terai, do not have the required parameters of MHP. i.e. enough water flow and elevation/head, they are least installed. The provincial statistics show provinces 1, Bagmati, and Gandaki have the largest numbers of MHP installed, while the Madhesh

province has none due to low lands and comparatively easier access to electricity. More than 1,800 MHPs provide electricity to 344 thousand households in the remote areas of Nepal. The capacity of MHP comes around 19 kW per project, and it is highest in Karnali and Sudurpaschim due to favorable environments such as water flow and high head.



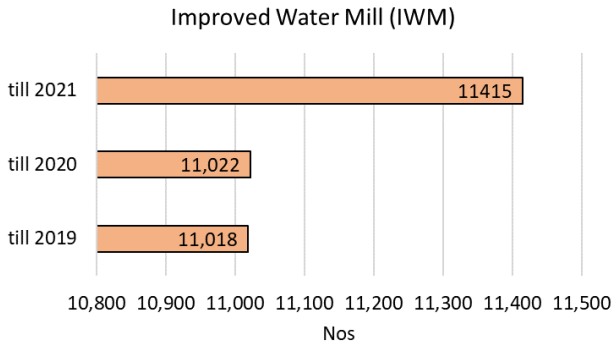
Province	Installed Share
Province 1	24.3%
Madhesh	0.0%
Bagmati	14.0%
Gandaki	20.7%
Lumbini	8.4%
Karnali	14.4%
Sudurpashchim	18.2%

Region	Installed Share
Terai	1.0%
Hill	64.4%
Mountain	34.6%

Figure 3-18 Installation of micro-hydro systems until 2021

Improved Water Mill (IWM) is a transitional technology that was put upon as an alternative to increase the efficiency of Traditional Water Mills (TWMs). Replacement of wooden parts (rotor and shaft) with metallic parts resulted in increased energy outputs well as efficient mechanization, helping both the millers and their users. Two types of IWMs are in practice: short shaft solely for grinding, and long shaft for grinding and other end uses such as paddy hulling and husking, rice polishing, saw-milling, oil expelling, lokta beating, chiura (flattened rice) making, and a number of others as per the need. IWM has been providing services to households at a cheap investment and maintenance cost within a short period required for the construction work. IWMs have also been used to generate electricity up to 3-5 kW, sufficient for lighting and operating small electric and electronic devices - suitable for remote small clustered hamlets. Improved water mills, like MHP, are distributed along the mountain and hilly regions while there are nominal to none in Terai plains and the regions of developed districts

Province-wise, the IWM is concentrated around Bagmati followed by Karnali and Sudurpaschim, while there are low numbers in other provinces. It is also well evident that the system is more often installed in hilly regions and mountain regions than in Terai, due to geographic and hydrological conditions in the higher terrains.



Province	Installed Share
Province 1	3.2%
Madhesh	0.0%
Bagmati	56.5%
Gandaki	1.8%
Lumbini	3.3%
Karnali	18.9%
Sudurpashchim	16.3%

Region	Installed Share
Terai	1.3%
Hill	72.5%
Mountain	26.3%

Figure 3-19 Installation of IWM until 2021

3.3.3 Biogas

Biogas is produced from organic matter as methane gas generated during the anaerobic digestion of organic matter. The manure of domestic animals (oxen and cows, buffaloes, etc), and human waste/excreta are the primary feeding material/source for this biogas system. The slurry comes as a by-product of this system and is looked upon as an effective organic and sustainable alternative to the use of chemical fertilizer which ultimately has saved money and maintained the clean and green surroundings/environment.

Nepal is an agricultural country with 60.4% of the total population engaged in this sector (MoF, 2021). The massive amount of biomass produced by livestock and farming activities makes biogas a suitable technology for cooking for a large population. The number of households with the potential for installation of a household biogas system is about 1.9 million, which represents about 42% of the total households in Nepal. A recent study by Adhikari and Adhikari (2021) has concluded the biogas potential and fuelwood saving per household is presented in Table 3.7.

Table 3.7: Annual biogas production and fuelwood saving potential of Nepal

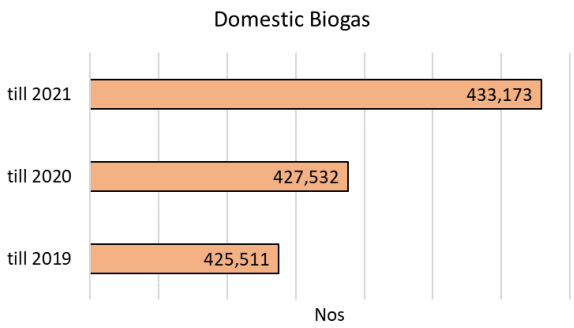
	Mountain	**Hill**	**Lowland**
Annual per capita fuelwood consumption (kg/year)	712	598	482
Annual per capita biogas[a] requirement (m3/year)	155	130	106
Annual net weight of fresh dung (kg/household/year)	3501	5386	7669
Average household size (number of people)	5.8	4	4.3
Annual potential biogas production (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

$1m^3$ biogas = 4.57 kg fuelwood ;
1 kg fresh dung = $0.036m^3$ biogas

GoN has been promoting biogas plants of different capacities under this system, such as 2cu.m, 4cu. m, 6cu. m, and 8cu. m plants under domestic biogas plants. For those plants, GGC 2047 and the modified design of GGC 2047 are being implied. The domestic biogas plant is popular and applicable in almost every district. Manang, on contrary, is much more remote and has less favorable conditions for the biogas plants. However, the majority of the plants are distributed along Terai and hilly belts.

At the provincial level, Bagmati has the largest number of residential biogas plants installed, followed by Gandaki, Lumbini, and Province 1 (Figure 3-20). Furthermore, by geographic region, it can be seen that almost all biogas plants are installed in Terai followed by the hilly region. This is because, Terai and hilly regions have an ample amount of feedstock being produced on one hand, while on the other, biogas requires a warm temperature to operate while also requires skilled manpower and building materials, which are comparatively easily available in Terai and hilly regions.

The biogas plants more than 12 cu. m. capacity falls under the Large Biogas Plant category. It is the advancement in Nepal's biogas technology achieved via the long-term practices on the modified GGC 2047 model and the learning from the international technological practices. The large biogas system includes the varieties of plants under its specific categorization including institutional, community-level biogas systems to commercial ones

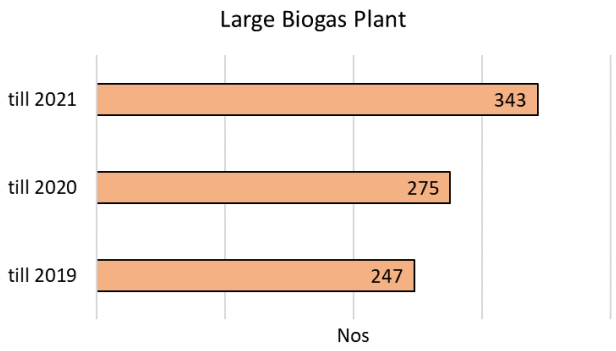


Province	Installed Share
Province 1	15.50%
Madhesh	6.30%
Bagmati	25.88%
Gandaki	18.88%
Lumbini	18.85%
Karnali	1.48%
Sudurpashchim	13.11%

Region	Installed Share
Terai	51.99%
Hill	46.05%
Mountain	1.96%

Figure 3-20 Installation of domestic biogas plants until 2021

Although the potential for large-scale biogas plants is ample, from various organic matters including municipal wastes, these plants have not been installed in large numbers. Like residential biogas plants, these large biogas plants are also concentrated in Terai and hilly districts. Province wise largest number of large biogas plants are built in province 1, followed by Bagmati and Gandaki provinces. The commercial sector is quite active in these provinces, in addition to proper solid waste management is in place.



Province	Installed Share
Province 1	39%
Madhesh	6%
Bagmati	24%
Gandaki	24%
Lumbini	7%
Karnali	0%
Sudurpashchim	1%

Region	Installed Share
Terai	52%
Hill	47%
Mountain	1%

Figure 3-21 Installation of large biogas plants until 2021

Most of these large biogas plants are institutional. However, a few biogas plants have been built at a commercial scale like 4,200 m^3 plants in Pokhara, 3,750 m3 plants in Nawalparasi, and 3,500 m3 plants in Syangja.

3.3.4 Wind

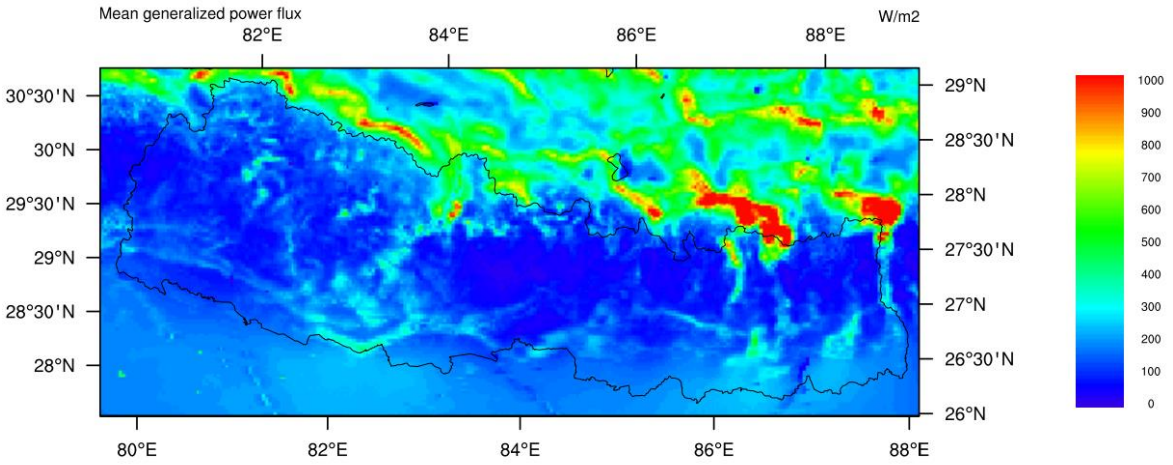
Wind power is the conversion of wind energy into electricity using wind turbines. The development of wind energy systems is accelerating at an unprecedented pace around the world, with the amount of electricity generated by wind increasing by almost 170 TWh (+11%) in 2020. Currently, 1592 TWh of electrical energy is generated from wind globally, which is almost as much as all the other renewable energy technologies combined (IEA, 2022).

3.3.2.1 Potential

AEPC has conducted a wind resource assessment of Nepal at 50m agl with a resolution of 5km. The report has shown more than 300 Watt/m^2 wind power density in Mustang and Solukhumbu, between 200-250 Watt/m^2 in Humla and Sankhuwasawa, between 150-200 Watt/m^2 in Myagdi and Manang, and between 100-150 Watt/m^2 in Bajhang, Darchula, Dolakha, Dolpa, Mugu, and Taplejung districts. The remaining districts have a wind power density of less than 100 Watt/m^2. Generally, wind power

densities less than or equal to 100 Watt/m^2 are not useful for wind energy harnessing. WPD greater than 200 Watt/ m^2 is normally taken into consideration for non-grid connected power generation while greater than 300 Watt/ m^2 is considered for grid connectivity of wind energy systems in developing countries. Considering only 10% of the area of Nepal having WPD of 300 Watt/m^2 for wind energy generation, Nepal has the potential of producing 3000MW of electricity from wind (UNEP/GEF, 2008).

Recently, the World Bank has also conducted a wind resource mapping of Nepal using a new and more sophisticated model known as Weather Research and Forecasting (WRF) model. The distribution of the mean annual generalized wind power density of Nepal at 100 m a.g.l. from WRF simulation at 3 km × 3 km grid spacing for the period 2004/08/4 to 2013/08/14 is shown in the figure below (World Bank, 2016).



at 100 m a.g.l. from WRF simulation at 3 km × 3 km grid spacing for the period 2004/08/4 to 2013/08/14 inclusive

Figure 3-22 Mean annual generalized wind power density for Nepal.

Despite the huge potential, there has been no significant development of wind energy in Nepal. The Nepal Electricity Authority (NEA) installed two wind turbines of 10 KW in Kagbeni, Mustang in 1989, which got destroyed within three months of project commencement (Ghimire & Poudel, 2010). As of 2018, the wind turbines installed in Nepal had a total generation capacity of 113.6 kW comprising the 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 has installed two wind turbines each of 5 kW capacities with 2 kW of solar hybrid system with the support of the Asian Development Bank in Nawalparasi, Dhaubadi VDC. It has also established a wind-solar hybrid system of 400 watts with 150 watts solar power projects in six different sites. More than 19 households of Dalit in Pyuthan including one Mosque and two secondary schools; one in Pyuthan and one in Palpa was directly benefitted from these microsystem projects. In the fiscal year 065/66 two more wind turbines had been added to Haibung VDC of Sindupalchock. More than 29 households benefited from this project (AEPC, 2022). In 2017, AEPC in collaboration with ADB installed a wind-solar hybrid system comprising 20 kW wind turbines and 15 kW peak solar panels at Hariharpurgadi village of Sindhuli district. The project served 83 rural households by producing 110 kWh energy per day to meet the demand of 87 kWh per day (ADB, 2017). The total solar-wind hybrid mini-grid system reached 1500 kW (SEMAN, 2022). Furthermore, there are various wind energy projects at various stages of construction as listed below.

Table 3.6: Wind energy projects at various stages of construction

S N	Project	Capacity	Promoter	VDC/District
1	Kagbeni Wind Energy Project	1 MW	Everest Wind Energy Pvt. Ltd.	Kagbeni (Mustang)
2	Wind Electric Power Tangbe	1 MW	Everest Wind Energy Pvt. Ltd.	
3	Mustang Wind Project	3MW	Future Wind Power Pvt. Ltd	Jomsom (Mustang)

(AEPC, 2022)

3.3.5 Organic Municipal Waste

Organic municipal waste can be used for energy generation via waste-to-energy technologies. Waste-to-energy is the process of generating electricity and/or heat by processing waste. As the amount of waste generated and the energy requirement increases with the increasing population, waste-to-energy presents itself as a renewable source of energy to ensure energy security.

In FY 2075/76 a total of 15581.9 mt of organic waste was generated in the metropolitan cities, sub-metropolitan cities, and municipalities of Nepal (CBS, 2021a). According to research, Kathmandu has the potential of producing 1,745 MWh of electricity from waste, Lalitpur Sub Metropolitan City has the potential of 278 MWh, and Pokhara has the potential of producing 244 MWh of electricity from waste (Sodari & Nakarmi, 2018). According to a recent study, 130294 m^3 of biogas can be generated by utilizing 100% of the organic fraction of municipal solid waste(OFMSW) in Kathmandu. The biogas produced can be used to fill up 21,045 LPG cylinders per day which can save NRs 515 million (Lohani, et al., 2021).

In 2017, a bio-methanization plant was set up in Teku, with the support of the European Commission and the government of Nepal, and has a daily capacity to convert 3 tons of OFMSW into biogas. However, after the initial months of operation, the plant has stopped functioning due to managerial and technical reasons (Lohani, et al., 2021). A waste-to-energy plant has also been established in Pamara, Dharan Sub-metropolitan with the capacity to process 30 tons of municipal waste per day. Apart from producing bio-CNG, the plant also produces 6.5 tons of organic fertilizers daily (AEPC, 2021).

As per the 2020 report on Waste Management baseline study by CBS, it has been estimated that annually around 2,200 tons of waste are collected per municipality totaling 6 million tons of waste. Composition-wise, organic content was found to be around 54% while the source of the waste was found to be the household sector. The average organic waste per municipality thus amounted to about 1,200 tons. On average 9.9% of the waste collected is used for manure making while 14% is recycled. The rest of the waste is dumped at the landfill, riverside, or openly and nearly 32% of the waste is burnt. These can be a very resourceful energy generation feedstock. The average quantity of waste collected from different sources and municipal categories is given in Annex VI.

3.4 Commercial Energy Resources

3.4.1 Electricity

3.4.1.1 Hydropower Potentials in Nepal

Nepal's theoretical hydropower potential has been estimated at 83,000 MW and its technically and economically feasible potential of about 45,000 MW and 42,000 MW respectively (Shrestha, 1966).

A study by Bajracharya (2015) shows the total theoretical estimation of annual mean flow to be 103,341 MW (Table 3-12).

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 recent study carried out by WECS (2019) for the estimation of hydropower potential shows the gross hydropower potential of 72,544 MW from three river basins: Koshi, Gandaki, and Karnali basin which covers 94% of the total gross potential of the country. Gross hydropower potential distributions in provinces based on the major three river basins are shown in Table 3-13. Province-1, which includes most of the Koshi basin incorporates the highest hydropower potential (22,619 MW)- which is 31.2% of total hydropower potential. Province-2 incorporates the lowest hydropower potential (275 MW)- which is 0.4% of the total potential. Similarly, Bagmati, Gandaki, Lumbini, Karnali, and Sudurpaschim provinces incorporate 14.6%, 20.7%, 3.7%, 18.9%, and 10.6% of the total potential respectively.

Table 3-13 Distribution of gross hydropower potential among different provinces based on 3 major river basin

SN	Province	Power Potential (MW)	% of Basin Potential (MW)
1	Province 1	22,619	31.2
2	Madhesh	275	0.4
3	Bagmati	10,568	14.6
4	Gandaki	14,981	20.7
5	Lumbini	2,677	3.7
6	Karnali	13,702	18.9
7	Sudurpaschim	7,722	10.6
Total		72,544	100

3.4.1.2 Development Hydropower Projects by NEA

Nepal Electricity Authority is the sole organization responsible for the operation and distribution of electricity supply in the country. As per NEA 2021, the total installed capacity developed by NEA stands at 582 MW. NEA's hydropower plants including small power stations generated a total of 2,810.74 GWh of electricity in FY 2020/21, a slight decrease of 6.96 % over the generation of 3021.04 GWh in FY 2019/20. As of June 2022, the peak demand is 1864 MW whereas the national demand is 1664 MW, and the remaining is exported to the neighboring country.

In addition to NEA's generation, the Independent Power Purchasers (IPPs) significantly contribute to the national hydropower plants' development. As of February 2022, The total installed capacity from IPPs stands at 1,440 MW. In addition, there is 53.4 MW addition from thermal power plants and 49.76 MW from grid-connected solar power plants. The total installed capacity thus reached 2,205 MW by February 2022.

Table 3-14 Total hydropower plant installations

	2019	2020	2021	2022*
Province 1	136.2	237.6	280.0	327.0
Madhesh	-	-	13.0	21.0
Bagmati	400.9	456.0	472.0	1,016.0
Gandaki	519.8	511.0	529.0	565.0
Lumbini	22.1	22.0	31.0	31.0
Karnali	6.3	11.0	11.0	11.0
Sudurpaschim	43.4	52.0	52.0	52.0
National	**1,128.7**	**1,289.6**	**1,388.0**	**2,023.0**
				*Till February 2022

The province-wise NEA-developed, hydropower plants projects are given in Annex VII

3.4.1.3 Under Construction, Planned, and proposed Hydropower Projects by NEA

The total under-construction hydropower projects under NEA stand at 487.1 MW. Similarly, the planned and proposed hydropower projects under NEA stand at 3,219.2 MW. Province 1 has the highest capacity with 1696 MW followed by Gandaki (1212.2 MW), Susurpashchim (210 MW), and Bagmati (95 MW).

3.4.1.4 IPP Constructed Hydropower Projects

Independent Power Producers (IPPs) have been playing a vital role in the development and operation of small and medium-scale hydropower projects since the hydropower development policy (MoWR, 2001). The total power purchased from Independent Power Producers (IPPs) within Nepal was 3,241 GWh, an increase of 8.36 % from the figure of 2,991 GWh in FY 2019/20. A total of 11 new projects developed by the Independent Power Producers (IPPs) with a combined installed capacity of 119 MW were commissioned in the FY 2020/21. This has increased the total number of IPPs-owned projects in operation to 108 with a combined installed capacity of 1016.36 MW.

A total of 138 projects to be developed by IPPs, with a combined installed capacity of 3506.8 MW are under construction after financial closure. Similarly, 99 IPPs-owned projects with a combined installed capacity of 1851.3 MW are at various stages of development. This has increased the total number of PPAs signed with the various IPPs to 345 with a combined installed capacity of 6172.75 MW as of FY 2020/21.

3.4.1.5 Electrification Status

The national electricity access is increasing in past few years with 93% access in 2020/21 and a target to achieve 100% access by 2023. The provincial electrification status along with national electricity access is shown in Figure 3-23. It shows that electricity access in Madhesh, Bagmati, Gandaki, and Lumbini provinces is comparable to the national average with more than 90% access in 2020/21 whereas Karnali province has the least access with only 35% access in 2020/21.

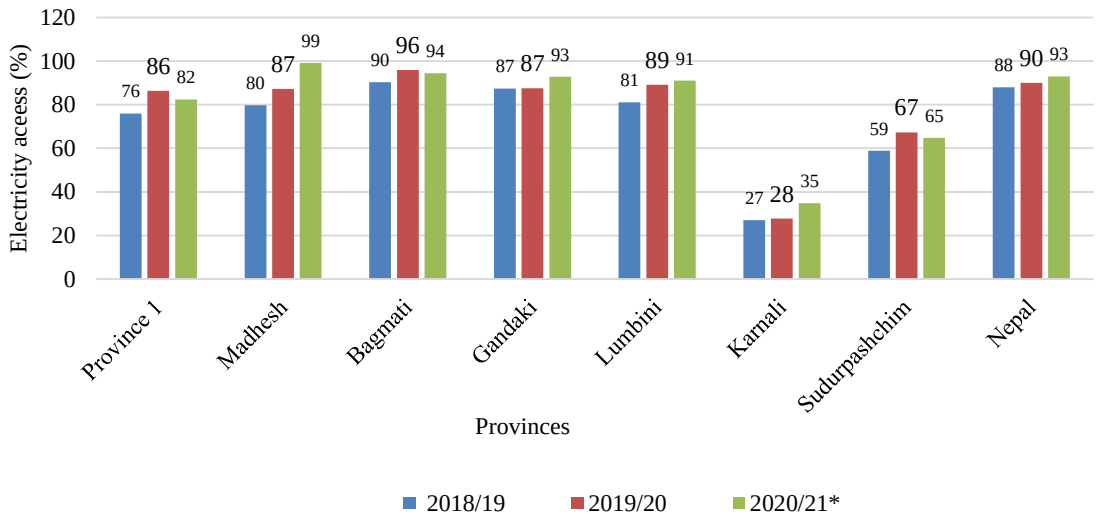


Figure 3-23 Provincial electrification status (MoF, 2021)

3.4.2 Coal

In Nepal low to medium-grade coal occurrences/ deposits are known in four stratigraphic positions (a) Quaternary peat/ lignite (b) Siwalik coal (c) Eocene Coal and (d) Gondwana coal. Peat/ lignite in Kathmandu valley is mined and used mainly in brick burning along with wood. Siwalik coal is not economically attractive because of scattered small occurrences. Eocene Coal occurs as irregular seams confined to orthoquartzite in Tosh, Siuja, Azimara, and Abidhara in Dang, and a few places in Sallyan, Rolpa, Pyuthan, and Palpa districts. Table 3-15 provides a summary of potential coal reserves in different parts of the country (Baskota, 2018). The data show that the country has a potential reserve of about 5 million tons, particularly in Province 5. However, the coal is not properly mined due to various reasons. So far 11 entrepreneurs were issued a license to excavate coal totaling 292 thousand tons.

Table 3-15 Summary of Coal Reserve in different Parts of the Country

Type of Prospect and Location	Description of the Prospect	Thickness (m)	Strike Length (m)	Width (m)	Possible Reserve (Million tons)	Remarks
Tosh Area, Dang	Three Mineable Seams					
Ghorahi sub-metropolitan (the then Saigha VDC) about 16 km north from Ghorahi along Gohari Hollery Roa	Tosh 1	2	2000	200	1.9	1 million ton reserve tested by exploratory drilling.
	Tosh 2	1.5	500	200		
	Tosh 3	1.8	1500	200		
Nearby Tosh Area, Dang	At Simdhara & Balikot	1.5	500	200	0.2	
Nearby Tosh area, Rolpa	Continuation of Tosh 1 at Khara beside Tosh	2	5	200	0.2	
Syuja Area Dang East of Tosh, 26 km NE of Ghorahi and 13 km from Hermok along Gorahi-Liban Road	Several thin layers at Syuja and Chhap and Harbang with one to two measurable seams	1.1-1.8	3000	200	1	Structurally controlled on both sides of Hurbang

Type of Prospect and Location	Description of the Prospect	Thickness (m)	Strike Length (m)	Width (m)	Possible Reserve (Million tons)	Remarks
						Syuja Syncline
Nearby Syuja, Pyuthan	One mineable seam at Loharpani and Murkutti	1-1.8	500	200	0.2	Hurban-Syuja Syncline
Tulsipur - Kapurkot Area of Dang and Salyan: with a peripheral distance of 10 to 15 km from Tulsiput	Several layers at Abhidhara, Naulopani, Dhorbang, KholechaurMeltakura, Dograban with one to two mineable seams at Pakhapani, Sibang and Khul Takura	0.75 -2.5	2000	200	1	Structurally controlled by Kapurkot, Phalabung thrust
Eastern Palpa, Palpa	One mineable seam at Simaldi and Chirtundanda, thin layers at Anghakhola, Purba Khola, and around Tansen	0.7-1.9	1000	200	0.25	Tansen Synclinorium
Western Palpa, Palpa	One mineable seam at Ripdikot danda and Phek area	0.7-1.9	500	200	0.2	Tansen Synclinorium
Gondawana Coal	Ajimara area around Tulsipur Dang	80	50	100	0.05	Fault controlled
Total reserve					5	

The primary production of this coal is about 10.9 thousand tons, which are mainly used in brick manufacturing industries. Also Nepal imports from India through private organizations under an agreement with Coal India Limited. Table 3-16 shows the indigenous coal production as per the Department of Mines and Geology and various types of coal imported into the country in three fiscal years as per the Department of Customs.

Table 3-16 Coal Production and Import in Nepal in tons

	2019	2020	2021
Own Production	-	7,250	10,948
Imports total	1,881,635	1,479,183	2,001,611
Anthracite, not agglomoreted	3201287	2,982,833	110479
Bituminous coal, not agglomerated	1056		207422
Other coal, not agglomerated,	1664409818	1,337,212,825	1911595559
Briquettes, ovoids, and similar solid fuels manufactured from coal	28675	79906	176426
Agglomerated lignite		2	14000
Coke and semi-coke of coal, of lignite or f peat; retort carbon	213993422.2	138907825	89507340
Coal gas, water gas, producer gas, and simi ar gases, not petroleum gases	326		
Total	**1,881,635**	**1,486,433**	**2,012,559**

3.4.3 Petroleum

Nepal Oil Corporation is the sole organization responsible for the import and distribution of petroleum products in Nepal. So far no proven reserves of petroleum suitable for commercial exploitation have been found in Nepal. All the petroleum products consumed in Nepal are imported from India or overseas in refined form for direct consumption. The NOC has current storage facilities of 68 thousand KL for all essential petroleum fuels except for LPG, which is bottled and distributed by private companies (Table 3-17).

Table 3-17 NOC Storage Capacity in different Locations of the Country

Province	Location	Storage Capacity (KL)				Total
		MS	HSD	SKO	ATF	
Province 1	Biratnagar	560	7,110	710	302	8,682
	Bhadrapur				48	48
Madhesh	Janakpur	30	140	70	32	272
	Amlekhgunj	3,430	19,840	760		24,030
Bagmati	Kathmandu	6,070	8,400	760	7,015	22,245
	Manthali				43	43
Gandaki	Pokhara	350	2,280	760	88	3,478
Lumbini	Bhairahawa	140	3,040	394	151	3,725
	Bhairahawa Pump	32	48			80
	Nepalgunj	210	2,280	760	303	3,553
Karnali	Surkhet			44	82	126
	Dhangadi	70	1,590	70	63	1,793
Sudurpashchim	Dipayal		46			46

Figure 3-24 presents the different types of petroleum products imported by NOC in different fiscal years. The impact of COVID is visible in petroleum imports in 2020 which shows a more than 10% decrease in petrol, diesel, and kerosene and a significant reduction of 31% in ATF imports compared to 20219. On the contrary, there is an increase in LPG consumption of 5% as most of the activities are limited to the household in 2020 due to the nationwide lockdown. The restriction on flights continues even in 2021 which further reduces ATF imports in 2021 while other petroleum products increased as the COVID impact slowed down and economic activities took pace in 2021. The increasing trend of LPG is also attributed to the growing consumption in rural areas.

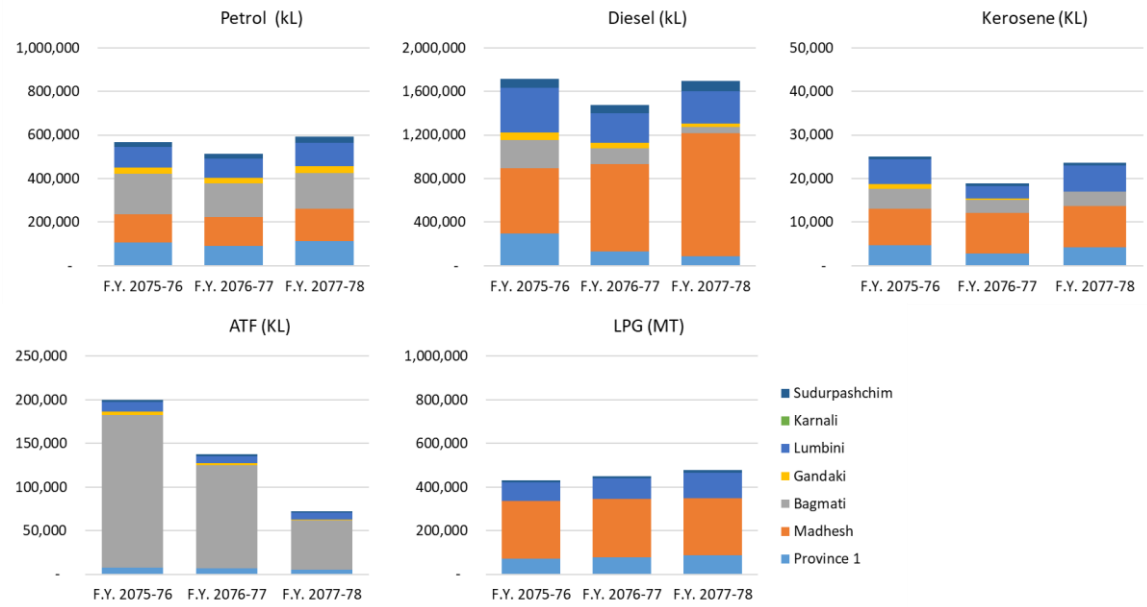


Figure 3-24 Petroleum products import in different FY in different provinces

The petroleum sales in different fiscal years in each province are shown in Figure 3-25. The sales show a bit different pattern than the import mainly due to two reasons. Firstly, the sales are lesser than the imports and the remaining quantity are in stock. Secondly, the depots that import, store and distribute petroleum are in different locations than where it is sold. Thus, the sales data seems much more distributed than the import data.

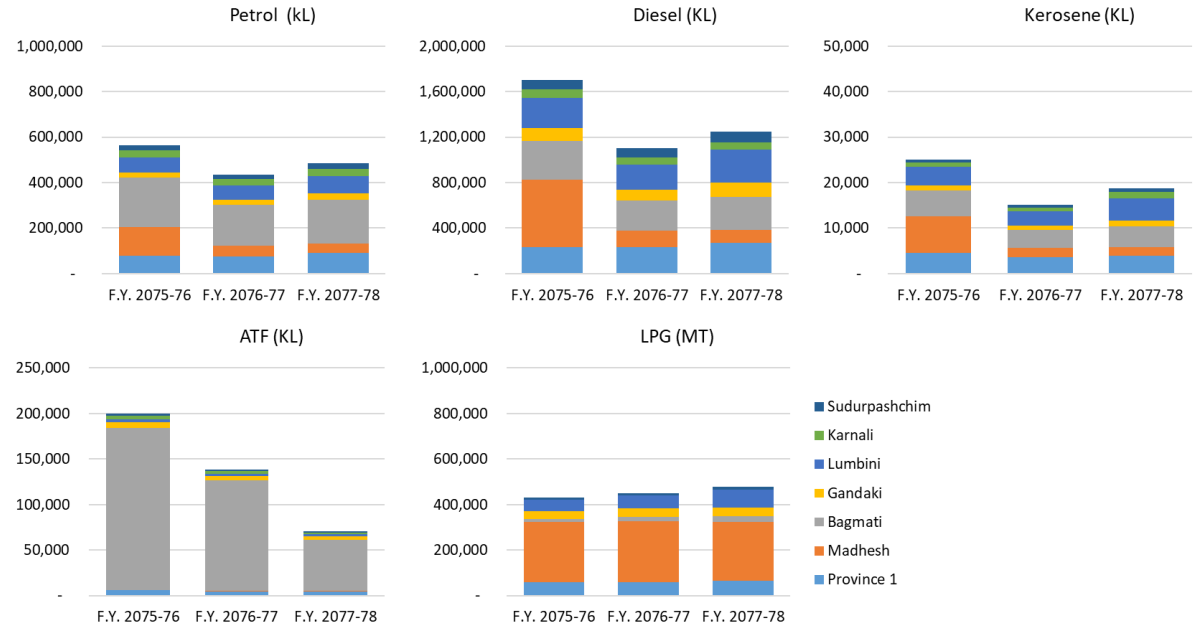


Figure 3-25 Petroleum products Sales in different FY in different provinces

Details of petroleum import and sales are given in Annex VIII.

4 Energy Consumption in Nepal

4.1 Energy Consumption by Fuel Types

The energy used in Nepal can be broadly divided into three categories: Traditional, Commercial, and Alternative. Traditional energy resources include all types of biomass resources used for energy production conventionally. All the energy resources with well-established market prices are grouped into the commercial energy category whereas, indigenous renewable energy resources that are used as an alternative and distributed energy source are grouped into the renewable category. The electricity generated by the hydropower plants, although being renewable by source, they have been listed under commercial energy as they are a commercial commodity with a specific cost per unit.

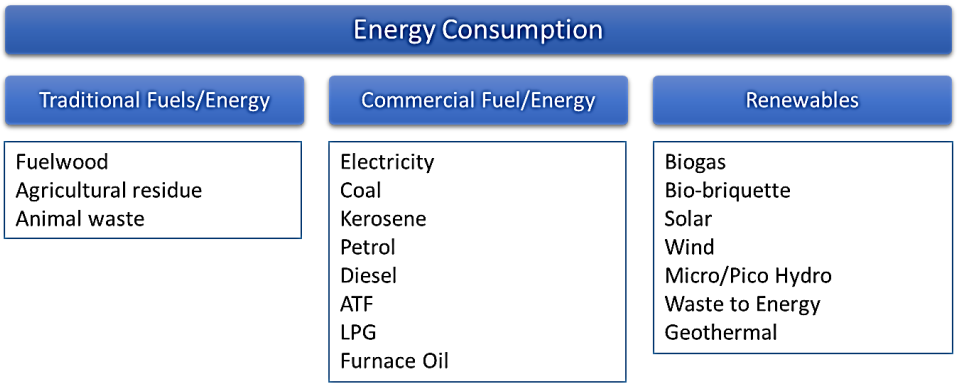


Figure 4-1 Energy Consumption Categorization

4.1.1 Energy Consumption in 2021

The energy consumption in the year 2021 has reached 626 PJ. To this year, the energy mix is still dominated by the traditional energy types. However, it is noteworthy to observe that the share of these fuel types has decreased over the past years. By 2021, the share of the highest used fuel, traditional biomass, has decreased to 66% from 87% in 2009. This is a clear indication of the energy transition to cleaner fuels. Among the traditional energy types, the fuelwood seems to be growing at the highest rate while the use of animal waste has decreased from 5.7% to 2.87%. In the meantime, the share of commercial energy use has increased. The consumption has increased taking the share of about 31% in 2021 which was 12% in 2009. Among the commercial fuels, coal and liquid petroleum are the highest-grown fuels for consumption. It is primarily due to an increase in economic sectoral activities, which is discussed in section 4.2 later. The use of renewable energy, excluding major hydropower, is also increasing. The rate of use of renewable energy is yet to compete with the growing demand for commercial energy types. The increased access to roads and electricity is the main factor for low preference for the use of alternative renewable energy sources. Nevertheless, the promotion of RETs is in a very optimistic stride and is driving the country towards cleaner energy.

Table 4-1 Energy Consumption in 2021

Category	Fuel Type	Energy (000 GJ)	000 TOE	GWh	% of National Total
Traditional	Fuelwood	377,790.36	9,023.37	104,941.77	60.38%
	Agricultural Residue	18,782.36	448.61	5,217.32	3.00%
	Animal Waste	17,967.02	429.14	4,990.84	2.87%
		414,539.75	**9,901.11**	**115,149.93**	**66.26%**
Commercial	Kerosene	831.03	19.85	230.84	0.13%
	Petrol	19,560.86	467.20	5,433.57	3.13%
	Diesel	63,465.44	1,515.85	17,629.29	10.14%
	ATF	2,218.29	52.98	616.19	0.35%
	LPG	21,802.75	520.75	6,056.32	3.48%
	Furnace Oil	3,399.09	81.19	944.19	0.54%
	Coal	58,445.58	1,395.95	16,234.88	9.34%
	Electricity	26,373.39	629.92	7,325.94	4.22%
		196,096.43	**4,683.68**	**54,471.23**	**31.34%**
Renewable	Biogas	9,756.95	233.04	2,710.26	1.56%
	Solar	4,759.67	113.68	1,322.13	0.76%
	Wind	1.87	0.04	0.52	0.00%
	Micro/Pico Hydro	514.96	12.30	143.05	0.08%
		15,033.46	**359.07**	**4,175.96**	**2.40%**
	Total	**625,669.64**	**14,943.86**	**173,797.12**	**100.00%**

4.1.2 Energy consumption in 2019 and 2020

The energy consumption trend during 2019, 2020, and 2021 has not been smooth, mainly due to the impact of COVID. It can be seen that the total energy consumption in 2020 decreased to 566 PJ from 589 PJ in 2019. The major consumption fall was found in commercial energy types since major economic activities were impacted. Meanwhile, the use of traditional energy, except animal waste, which have taken a decreasing trend with access to modern energy forms. With the reduction in Covid impact and boom in economic activities, the energy consumption jumped to 626 PJ in 2021. Along with it the use of commercial energy, primarily petroleum products decreased. As a result, the share of fuelwood increased. However, this increase in share is just a result of a decrease in other fuel types while the total energy did decrease overall. With the rise in economic sectors, the demand for commercial fuels again increased, which increased the share of these fuels in the overall scenario.

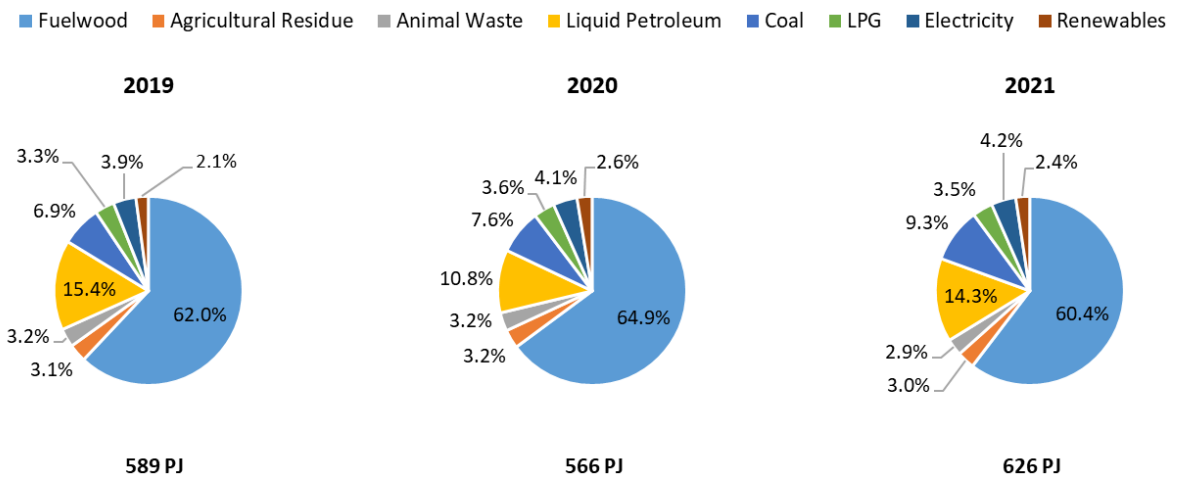


Figure 4-2 Energy consumption in 2019, 2020, and 2021

The detailed table of energy consumption in 2019, 2020, and 2021 is given in Annex IX.

4.2 Energy Consumption by Sectors

4.2.1 Sectoral energy consumption in 2021

The sectoral energy consumption also has changed over the last decade. Even though the residential sector is still the largest energy-consuming sector, its share in overall demand has come down to 63% in 2021, from 89% in 2009. This is due to multiple factors such as –

- growth in economic activities – resulting in more demand in economic sectors,
- use of modern technologies – that are dependent on commercial fuels
- energy transition – as a result of access to commercial fuels, and
- energy efficiency improvement with advancements in technologies – resulting in the requirement of less energy for the same amount of end-use activity.

The effect of growing economic activities is seen in other sectors – industrial, commercial as well as transport, and agriculture. Apart from these, the share of energy consumption is reaching 1% in the construction and mining sector – a significant sector in national development.

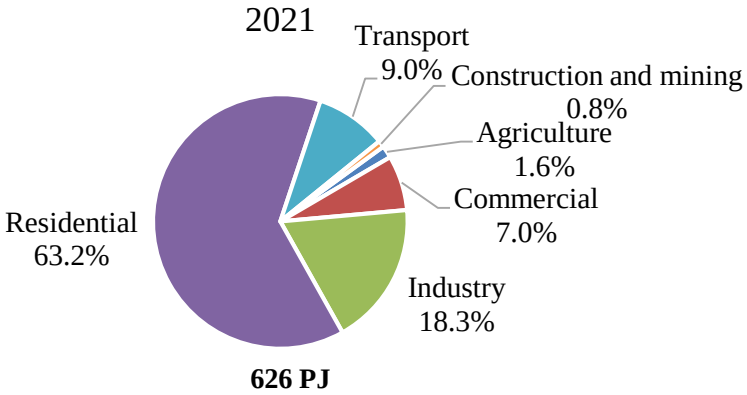


Figure 4-3 Energy consumption by sectors in 2021

4.2.2 Sectoral energy consumption in 2019 and 2020

The sectoral energy consumption in 2019 and 2021 has not changed a lot. However, due to the impact of the pandemic, the energy consumption in the economic sector was impacted during the fiscal year

2019/2020 (Figure 4-4). The impact in industrial and agriculture sectors was not as high as in the former as these activities continued to operate at lower volume during the period as well. Meanwhile, energy consumption in the residential sector increased during this interval with people staying at home. The change in the energy mix has been momentary during the lockdown period, and it went back to a similar pattern in 2021.

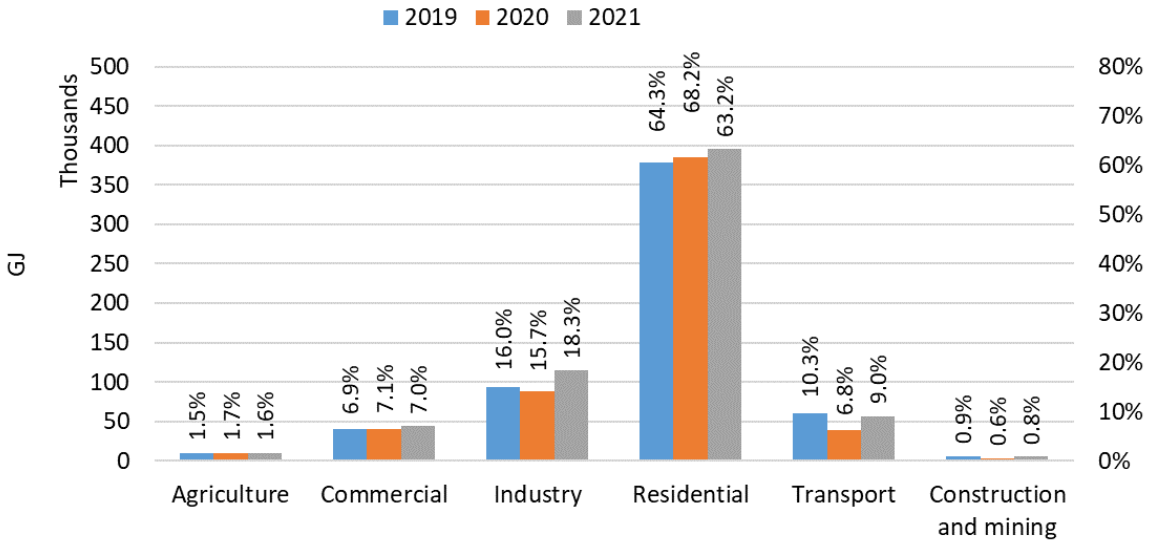


Figure 4-4 Sectoral energy in 2019, 2020 and 2021

4.2.3 Agriculture

The energy consumption in the agricultural sector is mainly in farming machinery such as water pumping, tilling, threshing and harvesting. Among these, water pumping is the most used activity and predominantly in the Terai region. In hilly regions, many irrigated land is gravity fed or depends on rainwater. In addition to that, except for a few large farming areas, the small holdings are still using draught animals for agricultural activities. In 2021, the agricultural sector consumed 9.8 PJ energy, among which 95.9% is diesel. Only 7.4% of farm machinery like water pumping and irrigation, are running on electricity because most of the farm machinery such as tillers and harvesters are mobile-type machinery. In addition to that most of the water, pumps are also diesel-powered. However, in recent years the popularity of the solar pumping system for irrigation has increased. Thus, in comparison to the 2009 status, 0.26% of agricultural sector energy consumption is now powered by solar and is expected to grow more in coming years.

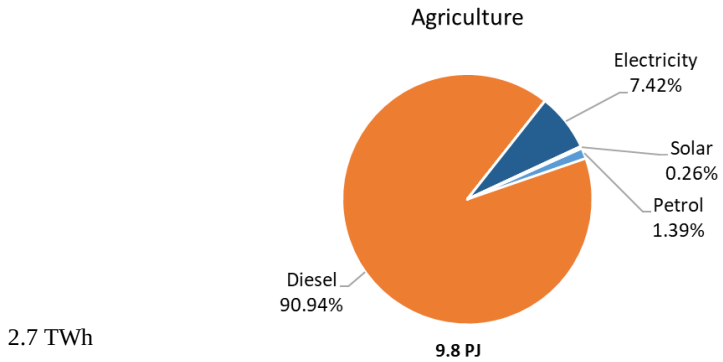


Figure 4-5 Energy consumption by fuel types agricultural sector in 2021

The average growth rate of energy consumption between 2019 and 2021 was 3.88%. It can be seen in the agriculture sector that it was one of the sectors that were least affected by COVID impact as it is a subsistence activity in Nepalese livelihood. The agricultural sector energy consumption in 2019 (9.1 PJ) went up by 3.83% to 9.4 PJ and 3.94% per annum to 9.8 PJ in 2020 and 2021 respectively.

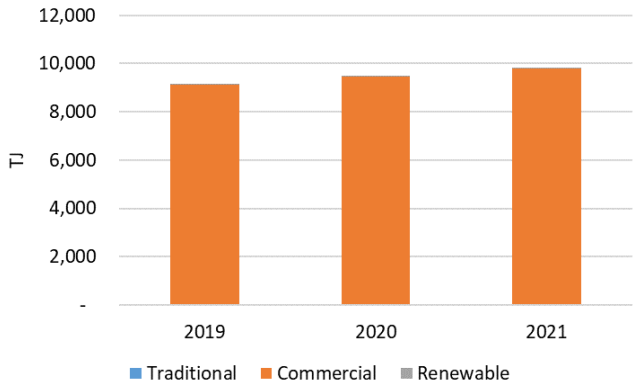


Figure 4-6 Energy consumption by fuel group in Agricultural sector in 2019, 2020 and 2021

The detailed data sets are given in Annex X.

4.2.4 Commercial

The commercial sector although being the growing economic sector, energy consumption in this sector only comes at a third in total, taking about 7% of national consumption. Although the commercial sector is expanding at a tremendous rate, the energy consumption rate is not as growing. This is mainly because this sector is not as energy-intensive as other sectors – the commercial entities mostly use electricity, which is highly efficient. In addition to that, the decrease in load shedding has cut the use of petroleum generator sets as well. The largest amount of energy used in the commercial sector is in form of thermal energy, used for cooking in the food and accommodation subsector. Thus, energy type-wise, the consumption of energy in the commercial sector is dominated by fuelwood followed by LPG. The least amount of energy is used from kerosene and diesel as with the availability of electricity, the use of generators has reduced. Meanwhile, the penetration of renewables, mainly solar (PV and thermal) has grown significantly.

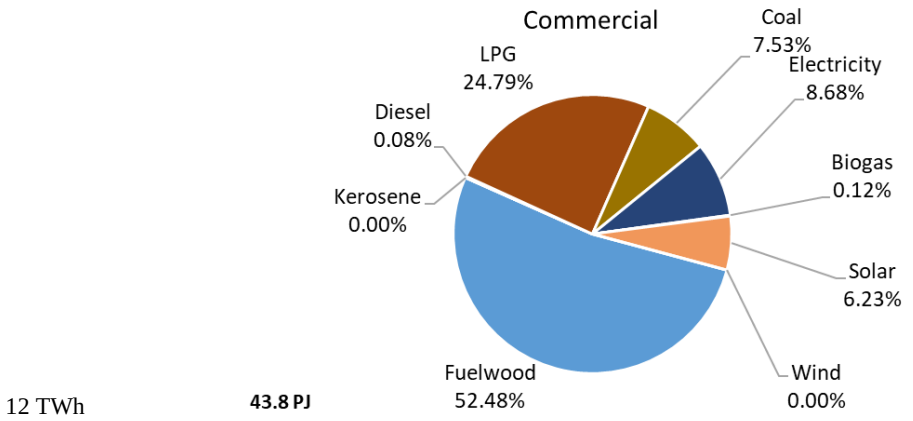


Figure 4-7 Energy consumption by fuel types Commercial sector in 2021

The Commercial sector was impacted by restrictions due to pandemic restrictions and thus the energy consumption dropped in 2020. However, the impact of the pandemic is not as prominent in the industrial, and transport sectors. The consumption reduced the rate by -1.39% in 2019 while it rebound

at the rate of 9.2% from 2020 to 2021. The overall growth from 2019 to 2020 was at the rate of 3.76%.

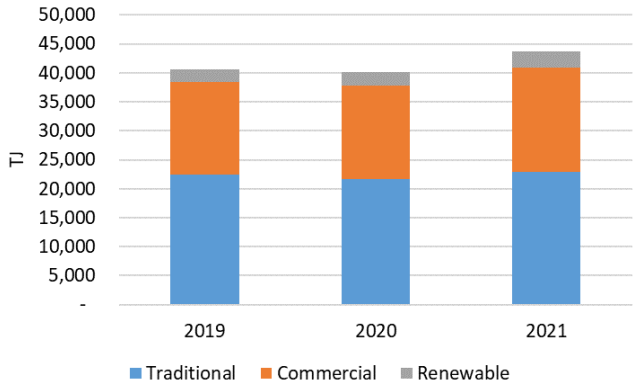


Figure 4-8 Energy consumption by fuel group in Commercial sector in 2019, 2020 and 2021

The detailed data sets are given in Annex X.

4.2.5 Industrial

The industrial sector is a highly energy-intensive economic sector. The total consumption in this sector totals 114.5 PJ, which comes as the second-highest energy-consuming sector in the national total taking a share of 16%. The major energy use in the industry sector is for thermal purposes. Thus, it is seen that coal is the highest used energy type in this sector, at 48%, along with fuelwood at 17% - which are used for furnaces. The agricultural residue is still used in a high quantity for boilers. With the increase in new technologies, the use of electricity for thermal purposes is also increasing but the pace of replacing the old technology is not sufficient yet. The consumption of diesel is also noticeable in industry, which is primarily used for motive power, including running generators. It is also used for thermal purposes in the boiler, along with furnace oil.

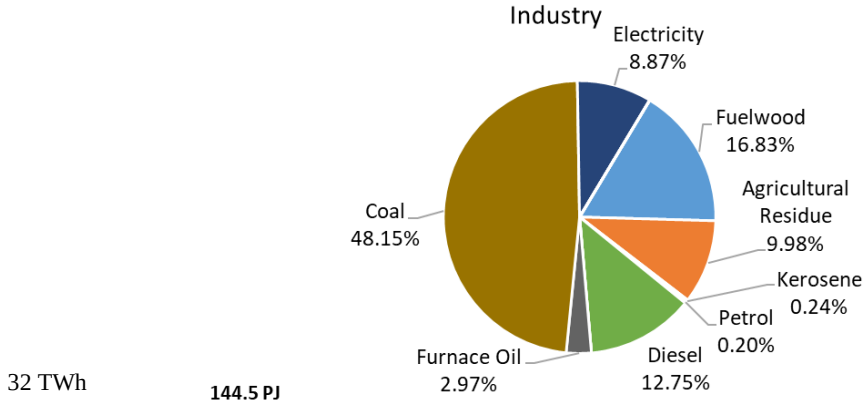


Figure 4-9 Energy consumption by fuel types Industrial sector in 2021

The Industrial sector also took a hit due to Covid restrictions. The energy consumption thus decreased at the rate of -5.8% in 2020. With loosened restrictions in industrial sector, consumption grew by 29% from 2020 to 2021.

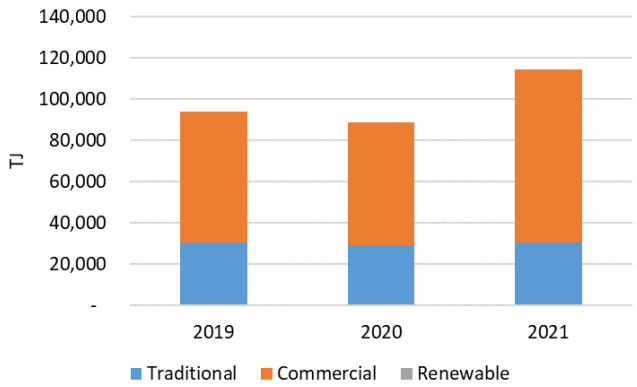


Figure 4-10 Energy consumption by fuel group in Industrial sector in 2019, 2020 and 2021

The detailed data sets are given in Annex X.

4.2.6 Residential

The residential sector is still the highest energy-consuming sector. In 2021, the residential sector consumed 396 PJ of energy, which is 64% of the national total. Although the total energy consumption in the residential sector has increased over the past decade, the energy intensity of the residential sector has decreased from about 14 GJ per capita to 13.2 GJ per capita in 2019. This outcome can be attributed to the energy transition through energy access to modern fuel and energy efficiency improvement. However, fuelwood still dominated the energy consumption in the residential sector at 84.9%. Even though the fuelwood is still the highest-energy type consumed, its share has decreased from 87% in 2009. Though this reduction in share does not seem significant, it has to be noted that, technologies using fuelwood are far less efficient than those which replaced those technologies. Thus, the only small increment can be seen in other fuels, not taking as much share. In addition to that, the use of clean energy cooking technologies and access to energy has been beneficial in reducing the dependency on traditional fuels, on other hand, modernization has increased dependence on LPG, which is imported fuel. The share of LPG consumption has increased to 2.76%, more than doubled in a decade. Thus, energy security-wise, the residential sector is still at risk. However, the promotion of alternative energy is also keeping up to provide clean energy. The share of biogas has increased to 2.5% and solar to 0.51%. Similarly, the use of electricity increased to nearly 3% from 1% in 2009.

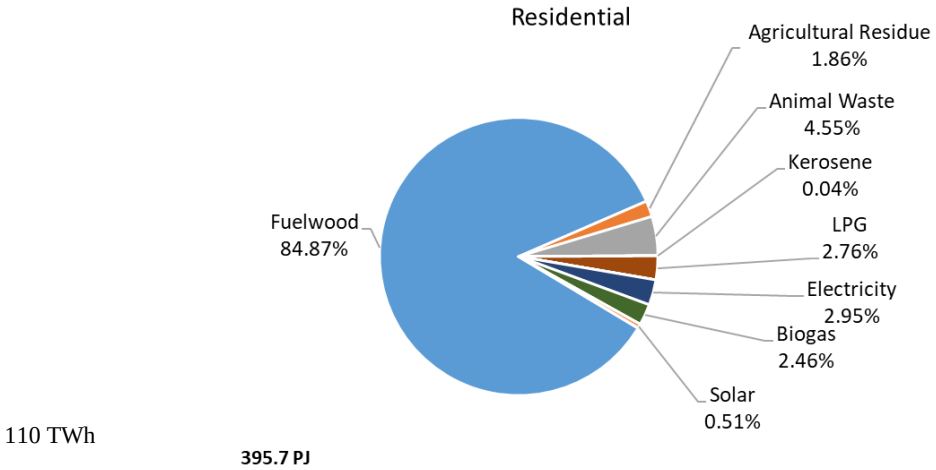


Figure 4-11 Energy consumption by fuel types Residential sector in 2021

The Residential sector, unlike other economic sectors, was less impacted by pandemic restrictions. The energy consumption in residential kept increasing from 2019 and 2020 at the rate of 1.8% and 2.66% respectively. In this course also, the use of traditional fuel was still predominant. Although the growth of renewable energy was impacted due to less access in 2020, it is growing again after loosened pandemic restrictions. Residential energy consumption increased at the rate of 2.23% per annum in the last two years, which is higher than the population growth rate. Thus, the energy intensity is seen to increase in the residential sector as well.

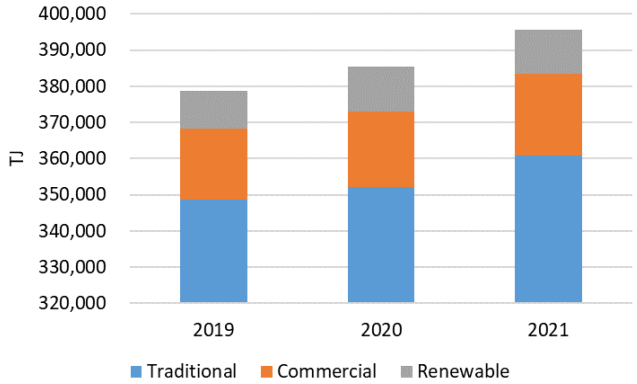


Figure 4-12 Energy consumption by fuel group in Residential sector in 2019, 2020 and 2021

The detailed data sets are given in Annex X.

4.2.7 Transport

Transportation is the third most energy-consuming sector in Nepal, which consumed 56.6 PJ of energy. It accounts for 10.3% of the national total. In terms of petroleum products energy, it is the highest energy-consuming sector among all the sectors. Less than 1% of electricity is used in this sector. Is it to be noted that the private EV transport system has yet to be accounted into transport sector energy as the electricity is summed up in the residential sector. However, with growing charging stations and dedicated lines for EV charging, its energy consumption can be expected to be visibly increased in the database as well. The energy consumption in the transport sector has been increasing as this sector is highly influenced by both economic as well as demographic status. By fuel type, diesel is the most consumed fuel. The largest share of diesel in the transport sector is used by freight vehicles as well as heavy passenger vehicles. On the other hand, a large portion of petrol is consumed by small private vehicles. The aviation fuel is shared by both national and international flights, however, the international flights consume more than 50% of the aviation fuel.

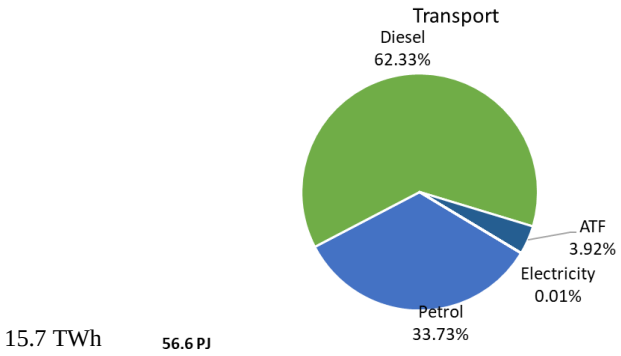


Figure 4-13 Energy consumption by fuel types Transport sector in 2021

The impact of the Covid pandemic is prominently visible in the transport sector as well when the transport system was also halted. Thus the consumption reduced by nearly 47% in 2020 in compare to 2020. With loosened restrictions, it increased by one and a half folds in comparison to 2020. However, due to ongoing restrictions in the aviation sector between 2020 and 2021, the total consumption did not grow as much.

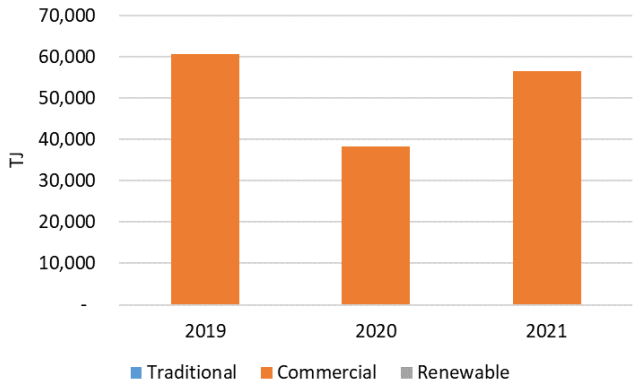


Figure 4-14 Energy consumption by fuel group in Transport sector in 2019, 2020 and 2021

The detailed data sets are given in Annex X.

4.2.8 Construction and Mining

The construction and mining sector is one of the sprouting as well as an important sector. It is seen that this sector consumed around 5.2 PJ of energy in 2021. Although it seems to consume only 0.89% of the total national energy, it has an essential impact on energy consumption as well as the economy. The energy consumed in this sector is primarily for the large on-site equipment including primarily diesel-operated generators. The use of fuelwood and kerosene are being replaced by using LPG and diesel for heating purposes. The energy consumed by the transportation of construction and mining vehicles comes from the transport sector.

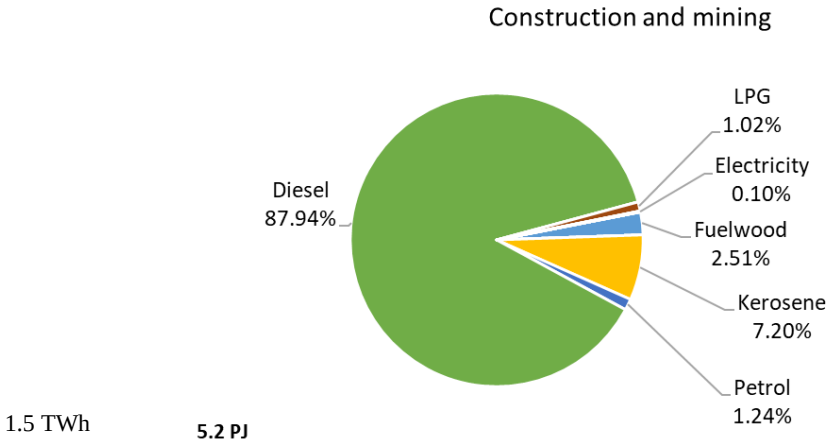


Figure 4-15 Energy consumption by fuel types Construction and Mining sector in 2021

The impact of Covid restrictions is visible in this sector as well. The Construction and Mining sector's energy consumption increased at the rate of 0.27% from 2019 to 2021 as it was also largely affected by pandemic restrictions during 2020.

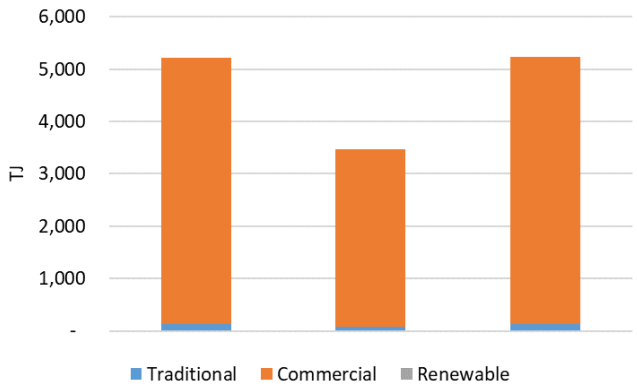


Figure 4-16 Energy consumption in Construction and Mining sector in 2019, 2020 and 2021

The detailed data sets are given in Annex X.

5 Energy Indicators

Final Energy Intensity

The energy intensities can indicate two things – the rate of energy consumption and energy efficiency. It can be seen from Table 5-1 that the energy intensity of Nepal is on the higher side. It is almost as much as double that of the global average and is still higher than the Indian average of 0.15 GJ per NRs 1000 (TERI, 2017). It is not only that Nepalese consume more energy, but it also indicated the status of energy efficiency is lower in Nepal than in India. The energy intensity in the residential sector has decreased in the past decade from about 14 GJ per capita to 13.3 GJ per capita in 2019. This shows the impact of modern energy access as well as clean energy technology penetrations. Meanwhile, the electricity intensity is a good sign of efficiency improvement as electric technologies are more efficient on one hand. In addition to that, since all electricity generated in Nepal is clean and indigenous, it also indicative of an environment-friendly pathway. The electricity per capita is also increasing which also indicates access to electricity as well as clean energy.

The energy intensity per value addition also is an indication of energy efficiency and technology used. The agricultural energy intensity is low since much of the agricultural activity is still done by human labor or draught animals. Meanwhile, the lower energy intensity in the commercial sector can be attributed to the use of efficient electric appliances uses. On the other hand, the industrial efficiency is very high, even than the national average. It is mainly due to the high dependence on petroleum products and coal. If they can be switched to electric and more efficient technologies, the energy intensity can be lowered. The example is right in our neighborhood, India, where electricity consumption is growing at the rate of 23% per annum. Thus, even though India is expanding the economy, the economic energy intensity is going down. The same can be done in Nepal by using indigenous electricity production.

Table 5-1 Final energy intensities

Parameter	Unit	2019	2020	2021
Final energy intensity	GJ per 1000 NRs Value Addition	0.28	0.27	0.29
	GJ per capita	20.62	19.82	21.92
Agriculture	GJ per 1000 NRs	0.01	0.02	0.02
Commercial	GJ per 1000 NRs	0.03	0.04	0.04
Industry	GJ per 1000 NRs	0.76	0.78	0.97
Residential	GJ per capita	13.27	13.51	13.86
Electricity	kWh per 1000 NRs	3.08	3.20	3.52
	kWh per capita	228	232	265
Residential Electricity	kWh per HH	218	251	296

Electricity Consumption

Table 5-2 gives consumer indices provided by NEA. It is seen that the average electricity price has been decreasing in past few years while the consumption is increasing. It is to be noted that the per capita consumption given by NEA differs from that in Table 5-1 as the NEA calculates the indices based on its sales, while there are other off-grid generations included in the above table.

Table 5-2 Consumer indices for electricity for NEA distributed electricity

	2019	2020	2021
Annual Unit sales per consumer	1420	1342	1425
Average price per kWh (Rs.)	10.48	11.57	9.76
Per capita sales	220	218	246.56
Distribution Loss	11.28%	10.28%	11.64%

(NEA, 2020: NEA, 2021)

Energy Shares

Table 5-3 shows the types of energy in the national total. The share of biomass is very high. Although traditional biomass is considered clean fuel in a developed country, in the case of Nepal, where it is used in an unsustainable way, using inefficient technologies, it is a polluting form of energy. Thus, it needs to be reduced. On the other hand, the share of renewable energy, including electricity from hydro, is in increasing trend which is a good sign. Meanwhile, the energy imported is also very high to be energy secure. This imported energy includes petroleum, coal as well as electricity. Thus, Nepal should give priority to reducing petroleum imports on the one hand and on the other manage the electricity such that it is not spilled in the wet season and needs to be imported in dry seasons.

Table 5-3 Energy share with respect to national consumption

Parameter	Unit	2019	2020	2021
Traditional biomass energy	Share in total	68.30%	71.26%	66.26%
Total Renewable energy*	Share in total	5.04%	6.42%	5.89%
Imported Energy	Share in total	27.5%	26.02%	28.71%

*includes electricity generated from hydropower

6 Energy Balance

An energy balance is a table that depicts the point of source and point of consumption of energy. Energy balance has three main components

1. Supply-side
2. Transformation or conversion side
3. Consumption side

The supply-side lists out all the incoming sources and resources including production of primary energy as well as imports and exports. The transformation side includes any conversion of energy from one to another for final use, such as hydro to electricity. The losses that occurred during the transformation are also depicted here. Finally, the consumption side indicates where and how much energy is being consumed.

The energy balances of Nepal for the years 2019, 2020, and 2021 are given in the following tables.

Table 6-1 Energy Balance for year 2021

Energy Balance 2020/21																					
	Traditional				Commercial										Renewables					
					Petroleum Products															
in TJ	Fuelwood	Agricultural Residue	Animal Waste	Total Traditional	Kerosene	Petrol	Diesel	ATF	LPG	Furnace Oil	Total Petroleum	Coal	Electricity	Total Commercial	Biogas	Solar	Wind	Micro/Pico Hydro	Total Renewables	Grand Total
Primary Supply																				-
Production	377,790	18,782	17,967	**414,540**	-	-	-	-	-	-	-	353	21,787	**22,140**	9,757	4,760	1.9	515	15,033	**451,713**
Imports	-	-	-	-	837	19,695	63,382	2,277	21,803	3,399	**111,393**	58,093	10,174	**179,659**	-	-	-	-	-	**179,659**
Exports	-	-	-	-	-	-	-	-	-	-	-	-	(158)	**(158)**	-	-	-	-	-	**(158)**
Stock changes	-	-	-	-	(6)	(134)	83	(59)	(0)	-	**(115)**	-	-	**(115)**	-	-	-	-	-	**(115)**
Total Primary Supply	**377,790**	**18,782**	**17,967**	**414,540**	**831**	**19,561**	**63,465**	**2,218**	**21,803**	**3,399**	**111,277**	**58,446**	**31,802**	**201,525**	**9,757**	**4,760**	**1.9**	**515**	**15,033**	**631,099**
Transformation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inputs	-	-	-	-	-	-	-	-	-	-	-	-	(31,802)	**(31,802)**	-	-	-	-	-	**(31,802)**
Electricity generation	-	-	-	-	-	-	-	-	-	-	-	-	31,802	**31,802**	-	-	-	-	-	**31,802**
T & D losses	-	-	-	-	-	-	-	-	-	-	-	-	(5,395)	**(5,395)**	-	-	-	-	-	**(5,395)**
Other losses, own-use etc.	-	-	-	-	-	-	-	-	-	-	-	-	(34)	**(34)**	-	-	-	-	-	**(34)**
Net supply to consumers	**377,790**	**18,782**	**17,967**	**414,540**	**831**	**19,561**	**63,465**	**2,218**	**21,803**	**3,399**	**111,277**	**58,446**	**26,373**	**196,096**	**9,757**	**4,760**	**1.9**	**515**	**15,033**	**625,670**
Final Consumption	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture	-	-	-	-	-	136	8,943	-	-	-	**9,079**	-	730	**9,809**	-	25	-	-	25	**9,834**
Commercial	22,964	-	-	**22,964**	-	36	37	-	10,848	-	**10,920**	3,295	3,800	**18,015**	52	2,724	-	-	2,775	**43,755**
Industry	19,274	11,432	-	**30,706**	278	231	14,597	-	2	3,399	**18,508**	55,150	10,164	**83,821**	-	-	-	-	-	**114,527**
Residential	335,421	7,350	17,967	**360,738**	176	-	-	-	10,900	-	**11,076**	-	11,668	**22,744**	9,705	2,011	1.9	515	12,233	**395,715**
Transport	-	-	-	-	-	19,093	35,280	2,218	0	-	**56,592**	-	7	**56,599**	-	-	-	-	-	**56,599**
Construction and mining	132	-	-	**132**	377	65	4,608	-	53	-	**5,103**	-	5	**5,109**	-	-	-	-	-	**5,240**
Total	**377,790**	**18,782**	**17,967**	**414,540**	**831**	**19,561**	**63,465**	**2,218**	**21,803**	**3,399**	**111,277**	**58,446**	**26,373**	**196,096**	**9,757**	**4,760**	**1.9**	**515**	**15,033**	**625,670**
Statistical Errors																				

Table 6-2 Energy Balance for year 2020

Energy Balance 2019/20																				
	Traditional				Commercial										Renewables					
					Petroleum Products															
in TJ	Fuelwood	Agricultural Residue	Animal Waste	Total Traditional	Kerosene	Petrol	Diesel	ATF	LPG	Furnace Oil	Total Petroleum	Coal	Electricity	Total Commercial	Biogas	Solar	Wind	Micro/Pico Hydro	Total Renewables	Grand Total
Primary Supply																				-
Production	366,847	18,254	17,878	**402,980**	-	-	-	-	-	-	-	234	21,643	**21,877**	10,141	4,080	1.4	436	14,658	**439,515**
Imports	-	-	-	-	671	17,046	55,062	4,330	20,494	374	**97,977**	42,969	6,224	**147,171**	-	-	-	-	-	**147,171**
Exports	-	-	-	-	-	-	-	-	-	-	-	-	(385)	**(385)**	-	-	-	-	-	**(385)**
Stock changes	-	-	-	-	10	(2,573)	(13,958)	40	(0)	-	**(16,481)**	-	-	**(16,481)**	-	-	-	-	-	**(16,481)**
Total Primary Supply	**366,847**	**18,254**	**17,878**	**402,980**	**682**	**14,473**	**41,104**	**4,370**	**20,493**	**374**	**81,496**	**43,203**	**27,482**	**152,182**	**10,141**	**4,080**	**1.4**	**436**	**14,658**	**569,819**
Transformation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inputs	-	-	-	-	-	-	-	-	-	-	-	-	(27,482)	**(27,482)**	-	-	-	-	-	**(27,482)**
Electricity generation	-	-	-	-	-	-	-	-	-	-	-	-	27,482	**27,482**	-	-	-	-	-	**27,482**
T & D losses	-	-	-	-	-	-	-	-	-	-	-	-	(4,252)	**(4,252)**	-	-	-	-	-	**(4,252)**
Other losses, own-use etc.	-	-	-	-	-	-	-	-	-	-	-	-	(30)	**(30)**	-	-	-	-	-	**(30)**
Net supply to consumers	**366,847**	**18,254**	**17,878**	**402,980**	**682**	**14,473**	**41,104**	**4,370**	**20,493**	**374**	**81,496**	**43,203**	**23,200**	**147,899**	**10,141**	**4,080**	**1.4**	**436**	**14,658**	**565,537**
Final Consumption	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture	-	-	-	-	-	133	8,713	-	-	-	**8,846**	-	597	**9,443**	-	19	-	-	19	**9,462**
Commercial	21,638	-	-	**21,638**	-	34	36	-	9,584	-	**9,654**	3,153	3,418	**16,225**	45	2,166	-	-	2,210	**40,073**
Industry	18,263	10,975	-	**29,238**	218	223	9,454	-	2	374	**10,271**	40,050	9,194	**59,515**	-	-	-	-	-	**88,753**
Residential	326,863	7,279	17,878	**352,019**	167	-	-	-	10,861	-	**11,027**	-	9,977	**21,005**	10,096	1,896	1.4	436	12,429	**385,453**
Transport	-	-	-	-	-	14,035	19,917	4,370	0	-	**38,322**	-	10	**38,332**	-	-	-	-	-	**38,332**
Construction and mining	84	-	-	**84**	296	48	2,985	-	47	-	**3,376**	-	4	**3,380**	-	-	-	-	-	**3,464**
Total	**366,847**	**18,254**	**17,878**	**402,980**	**682**	**14,473**	**41,104**	**4,370**	**20,493**	**374**	**81,496**	**43,203**	**23,200**	**147,899**	**10,141**	**4,080**	**1.4**	**436**	**14,658**	**565,537**
Statistical Errors																				

Table 6-3 Energy Balance for year 2019

Energy Balance 2018/19																					
	Traditional				Commercial										Renewables					
					Petroleum Products															
in TJ	Fuelwood	Agricultural Residue	Animal Waste	Total Traditional	Kerosene	Petrol	Diesel	ATF	LPG	Furnace Oil	Total Petroleum	Coal	Electricity	Total Commercial	Biogas	Solar	Wind	Micro/Pico Hydro	Total Renewables	Grand Total
Primary Supply																				-
Production	365,089	18,045	18,841	**401,975**	-	-	-	-	-	-	-	-	17,057	**17,057**	8,175	4,080	1.0	326	12,582	**431,614**
Imports	-	-	-	-	887	18,867	64,081	6,305	19,606	1,222	**110,968**	-	10,127	**121,095**	-	-	-	-	-	**121,095**
Exports	-	-	-	-	-	-	-	-	-	-	-	-	(126)	**(126)**	-	-	-	-	-	**(126)**
Stock changes	-	-	-	-	3	(132)	(476)	1	(0)	-	**(604)**	40,780	-	**40,176**	-	-	-	-	-	**40,176**
Total Primary Supply	**365,089**	**18,045**	**18,841**	**401,975**	**890**	**18,735**	**63,605**	**6,306**	**19,606**	**1,222**	**110,364**	**40,780**	**27,058**	**178,201**	**8,175**	**4,080**	**1.0**	**326**	**12,582**	**592,758**
Transformation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inputs	-	-	-	-	-	-	-	-	-	-	-	-	(27,058)	**(27,058)**	-	-	-	-	-	**(27,058)**
Electricity generation	-	-	-	-	-	-	-	-	-	-	-	-	27,058	**27,058**	-	-	-	-	-	**27,058**
T & D losses	-	-	-	-	-	-	-	-	-	-	-	-	(4,137)	**(4,137)**	-	-	-	-	-	**(4,137)**
Other losses, own-use etc.	-	-	-	-	-	-	-	-	-	-	-	-	(56)	**(56)**	-	-	-	-	-	**(56)**
Net supply to consumers	**365,089**	**18,045**	**18,841**	**401,975**	**890**	**18,735**	**63,605**	**6,306**	**19,606**	**1,222**	**110,364**	**40,780**	**22,864**	**174,008**	**8,175**	**4,080**	**1.0**	**326**	**12,582**	**588,565**
Final Consumption	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture	-	-	-	-	-	128	8,417	-	-	-	**8,546**	-	560	**9,106**	-	7	-	-	7	**9,113**
Commercial	22,456	-	-	**22,456**	-	35	37	-	9,169	-	**9,240**	3,266	3,453	**15,959**	40	2,183	-	-	2,223	**40,638**
Industry	19,907	10,837	-	**30,744**	303	241	14,449	-	2	1,222	**16,216**	37,514	9,756	**63,486**	-	-	-	-	-	**94,230**
Residential	322,597	7,208	18,841	**348,646**	176	-	-	-	10,390	-	**10,566**	-	9,075	**19,641**	8,135	1,890	1.0	326	10,352	**378,639**
Transport	-	-	-	-	-	18,270	36,141	6,306	0	-	**60,717**	-	16	**60,733**	-	-	-	-	-	**60,733**
Construction and mining	129	-	-	**129**	411	61	4,561	-	45	-	**5,079**	-	4	**5,083**	-	-	-	-	-	**5,212**
Total	**365,089**	**18,045**	**18,841**	**401,975**	**890**	**18,735**	**63,605**	**6,306**	**19,606**	**1,222**	**110,364**	**40,780**	**22,864**	**174,008**	**8,175**	**4,080**	**1.0**	**326**	**12,582**	**588,565**
Statistical Errors																				

7 Energy Pricing

Most of the energy resources in Nepal are not traded. However, fossil fuels are imported from outside the country. Prices of electricity and petroleum are controlled by the Government whereas free-market energy products namely coal, charcoal, and other petroleum products such as candles, raw petroleum, etc. are set in the market. The pricing strategy of the government is somewhat related to providing energy at low costs. Commercial energy resources particularly electricity, petroleum, and traded fuelwood are subsidized and distributed through different dealers or points. The market price of fuelwood was obtained from a provincial report, Petroleum product rates were obtained from Nepal Oil Corporation, and electricity energy price was obtained from the NEA.

Table 7-1 compares the market price, efficiency, and effective price of the major fuel types used for cooking purposes in Nepal. It can be seen that, in terms of cooking, electricity has become the cheapest option. It is also evident that they are energy efficient as well as clean energy as electricity is produced from hydropower. However, if the electricity is to be produced from thermal generators, and used in rice cookers, they are the most expensive option. The below data can indicate that policy should be faced towards electrification – promoting low wattage rice cookers for low connection capacity and high wattage induction cooktops where ever possible.

Table 7-1 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	10	3.60	15%	24.00
LPG	cylinder	1800	10.00	54%	18.66
Electricity - Rice cooker	Unit (kWh)	9.5	9.50	70%	13.57
Electricity - Induction cooktop	Unit (kWh)	9.5	9.50	85%	11.18
Kerosene	Liter	153	13.77	50%	27.54
Diesel (generator + ricecooker)	Liter	165	13.50	28%	48.21
Petrol (generator + ricecooker)	Liter	178	14.43	28%	51.54
Note:	Price of fuelwood is on basis of provincial reports of province 1 and Madhesh province, WECS, 2020 Price of LPG, Kerosene, Diesel, and petrol are from NOC as of May 15, 2022 Efficiencies of diesel and petrol generator sets are assumed to be 50% at full load condition Price of Electricity is as per Annual Report 2020, NEA 2021				

The pricing policy for the major petroleum products such as kerosene, HSD, petrol, ATF, and LPG is approved by the Government of Nepal. The NOC board can fix the price of other unregulated products. NOC has been currently applying Auto Petroleum Pricing Mechanism. After applying the mechanism, the selling price of the petroleum is adjusted instantly.

Table 7-2 Recent Trend of Petroleum Fuel Price

Effective Date	Petrol	Diesel	Kerosene	LPG	ATF (DP)	ATF (DF)
2022.05.14(2079.01.31)	170.00	153.00	153.00	1600.00	156.00	1545.00
2022.04.05(2078.12.22)	160.00	143.00	143.00	1600.00	156.00	1545.00
2022.03.16(2078.12.02)	155	138	138	1575	151	1495
2022.03.03(2078.11.19)	150	133	133	1575	136	1295
2022.02.20(2078.11.08)	145	128	128	1575	126	1195
2022.02.19(2078.11.07)	145	128	128	1575	116	1095
2022.02.01(2078.10.18)	142	125	125	1575	116	1095
2022.01.19(2078.10.05)	139	122	122	1575	106	995
2021.11.10(2078.07.24)	136	119	119	1575	101	895
2021.10.29(2078.07.12)	133	116	116	1500	96	853
2021.08.23(2078.05.07)	130	113	113	1450	86	770
2021.07.14(2078.03.30)	128	111	111	1425	84	754
021.07.06(2078.03.22)	129	112	112	1425	84	754
2021.06.23(2078.3.9)	127	110	110	1400	82	735
2021.06.06(2078.02.23)	125	108	108	1400	80	715
2021.06.05(2078.02.22)	125	108	108	1400	80	893
2021.05.16(2078.02.02)	123	106	106	1400	78	893
2021.04.17(2078.01.04)	121	104	104	1400	76	893
2021.04.04(2077.12.22)	120	103	103	1400	74	893
2021.03.16(2077.12.03)	118	101	101	1400	72	893
2021.03.01(2077.11.17)	116	99	99	1400	65	868
2021.02.16(2077.11.04)	114	97	97	1400	65	868
2021.02.10(2077.10.28)	112	95	95	1400	65	868
2021.01.18(2077.10.05)	110	93	93	1375	65	868
2020.12.12(2077.08.27)	108	91	91	1375	65	868
2020.10.01(2077.06.15)	107	89	89	1375	65	868
2020.09.16(2077.05.31)	107	90	90	1375	65	868
2020.09.1(2077.05.16)	107	91	91	1375	65	868
2020.08.16(2077.04.32)	105	91	91	1375	65	868
2020.08.02(2077.04.17)	104	90	90	1375	65	868
2020.07.10(2077.03.26)	102	88	88	1375	65	868
2020.06.30(2077.03.16)	101	87	87	1375	65	868

7.1 Electricity Pricing

The price structure for the electricity transmitted by the national grid and distributed is regulated by the Electricity Tariff Fixation Commission, while the isolated system along with the micro-hydro-generated electricity fixes the prices according to the generator. The tariff for different sectors of the economy is also different. Also for the residential sector, the tariff depends upon the amount of the unit consumed. In the industrial sector, the price of electricity is less compared to other sectors of the economy. Also, NEA has introduced Time of the Day meters for effective utilization of the energy generated. The domestic consumers' tariff structures are as shown as per NEA.

Domestic Consumers								
1.1 Single Phase Low Voltage (230 Volt)								
kWh (Monthly	5 Ampere		15 Ampere		30 Ampere		60 Ampere	
	Minimum Charge (Nrs.)	Energy Charge (Nrs/kWh)	Minimum Charge (Nrs.)	Energy Charge (Nrs/kWh)	Minimum Charge (Nrs.)	Energy Charge (Nrs/kWh)	Minimum Charge (Nrs.)	Energy Charge (Nrs/kWh)
0-10	30.00	0.00	50.00	4.00	75.00	5.00	125.00	6.00
11-20	30.00	3.00	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
101-150	100.00	9.50	125.00	9.50	150.00	9.50	200.00	9.50
151-250	125.00	10.00	150.00	10.00	175.00	10.00	200.00	10.00
251-400	150.00	11.00	175.00	11.00	200.00	11.00	250.00	11.00
Above 400	175.00	12.00	200.00	12.00	225.00	12.00	275.00	12.00

Three phase L ow Voltage (400 Volt)					
kWh (Monthly)	Up to 10 KVA		Above 10 KVA		
	Minimum Charge (Nrs.)	Energy Charge (Nrs/kWh)	Minimum Charge (Nrs.)	EnergyCharge (Nrs/kWh)	
00	0.00	11.50	1800.00	11.50	
Above 400		12.00			12.00

Three phase Medium Voltage (33/11 kV)		
	Minimum Charge (Nrs.)	Energy Charge (Nrs/kWh)
Up to 1000	10,000	11.00
Above 1001		12.00

8 Provincial Energy Synopsis

Nepal entered the federal system, the country is regrouped into 7 provinces with 77 districts and 753 local bodies. With this administrative division, WECS also initiated developing an energy database for the provincial level. WECS conducted the primary survey for Province 1 and Mahesh Province in 2019 to determine the situation of energy consumption and supply in both provinces. The study also included projecting the future energy demand under different economic scenarios and interventions.

8.1 Province 1

8.1.1 Energy Supply in Province 1

Fuelwood Supply

With the increasing population, the area under agriculture expanded and forests shrunk. The forest area in the Terai declined by 16,500 ha in the years from 2001 to 2010 and by 32,000 ha in the 19 years from 1991 to 2010. The annual rate of decrease in forest cover was 0.44% during the last nine years from 2001 to 2010 and was 0.40% during the last 19 years from 1991 to 2010/11. The annual rate of deforestation in all 20 Terai districts was 0.06%, excluding protected areas (FRA/DFRS, 2014). In Province 1 also the land under cultivation increased at cost of forest land. On the other hand, due to poverty, the demand for fuelwood increased despite the rapid growth in the commercial energy sector in the terai region, because the fuelwood is practically free if people afford time for collection. A large quantity of fuelwood is being collected from the community-managed and government-managed forests by the local people.

Table 8-1Forest Area and Actual Fuelwood Produced

District	Forest area (ha)	stem volume m^3	Annual firewood production (m^3)	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**

Petroleum Products

All the petroleum consumed in the country is imported from India. The only company that deals with the import and sales of petroleum products – that includes diesel, petrol, kerosene, and LPG is Nepal Oil Corporation Ltd. (NOC). The furnace oils and other oil residues are imported by the industries themselves. Thus, the supply of petroleum products is obtained from the regional offices of NOC. All the units for petrol or Motor Spirit (MS), Diesel, and Super Kerosene Oil (SKO) are in liters except for LPG in a metric ton (MT). These sales data represent the sales to depots in each district. However, it is to be noted that neither the sales from these depots are bound within the district only nor the supply in each district is bound by the capacity of depots only – there are inter boundary trade and transportation of petroleum fuels. Hence, the supply of petroleum products and their consumption may not tally properly.

Table 8-2Petroleum sales in 2075-76 in Province 1

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**

Electricity

Province 1, which has mountains and hills, has an abundance of water resources and there are several potential sites for hydropower development. The average potential for hydropower plants is around 20,500 MW in province 1 (Kandel, 2018). In addition to that, 66 MW of small hydropower potential from 84 and nearly 70 sites for 1 MWp of solar PV sites have been identified for decentralized generation of electricity (NPC, 2018). There are 29 IPPs hydropower projects, 4 major hydropower plants, and 5 small hydropower plants in province 1 (NEA 2019). There is 237.59 MW (226.796 MW from IPPs and 10.794 MW from NEA generation) installed capacity in the province. The district-wise electricity supply status as obtained from Nepal Electricity Authority for Province1 is shown below.

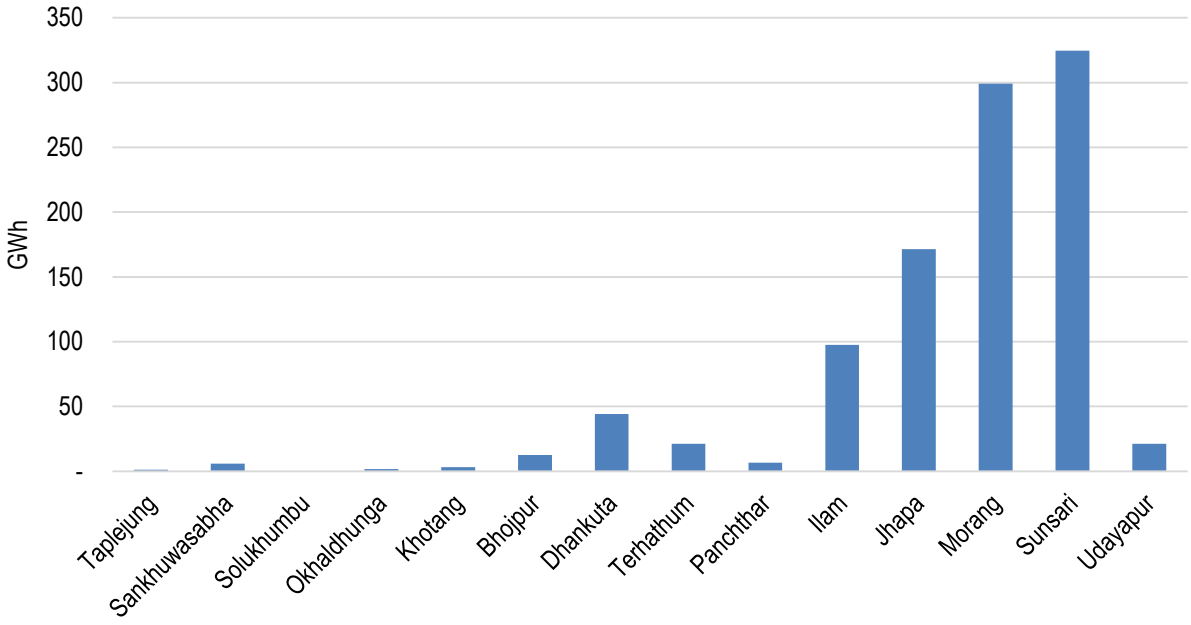


Figure 8-1Electricity sales in Province 1 in 2075 (NEA, 2019)

Province 1 consumed 1,011 GWh of electricity including consumption in all economic sectors (NEA database 2020). The three districts of Terai - Jhapa, Morang and Sunsari located in the industrial zone consumed 79% of total electricity consumption. However, electricity consumption in the mountainous region is extremely low. It could be due to poor access to electricity in remote areas. Comparatively, electricity consumption is lower in the Hilly region than in the Terai region.

As per NEA domestic consumption data, the electricity connection as per ampere capacity of households indicates that over 90% of the households lie within minimal amperage capacity of 5A, and 7% are connected with 6-15 A connection. Less than 1% have an electricity connection above 16A. In province 1, 76% of households have access to electricity (NEA, 2019).

Modern Renewable Energy Sources

Modern Renewable energy sources include wind, biogas, solar, micro-hydro, and other renewables. Alternative Energy and Promotion Centre (AEPC) is the leading organization working on the promotion of renewable energy in Nepal. Modern energy access is gradually increasing in Nepal with the current status of electricity access from renewables reaching 25% population. There has been a contribution of 32 MW of electricity from mini and micro-hydro schemes, 15 MWp from solar PV systems, and around 20 kW from wind energy. More than 1.5 million households have benefited from different renewable energy sources for cooking, lighting and productive end uses (MoPE, 2016).

According to AEPC, the number of installed plants for solar home systems (SHS), small solar home systems (SSHS), Mud Improved Cookstoves (MUDICS), domestic biogas, and Institutional solar PV system (ISPS) in province 1 is as shown in the table below. Approximately1,440 kWp from SHS, 243 kWp from SSHS, and 311kWp from ISPS have been installed in Province 1. In addition to these, solar photovoltaic pumping system (SPVPS) has gained much popularity among farmers. The average size of ISPS is 2kWp.

Most of the biogas plants are sized 4 cubic meters in the province. Due to the lowland of the region, there are no micro-hydro plants installed in Province 1. Recently 138 kW of the solar mini-grid power plant has been installed in the province of which 43 kW is installed in Morang and 95kW in Panchthar.

Table 8-3Number of Modern Renewable Technologies Installed in Province 1 (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**

8.1.2 Energy Consumption in Province 1

The total energy consumption in Province 1 in 2019 was 74PJ**.** Sector-wise, energy consumption in the industrial sector has the highest share in this province followed by the residential sector. Meanwhile, the solid fuels – firewood, biomass as well as coal dominated the energy source type. It is evident that there is a change in the energy mix as compared to previous studies at national and regional levels**.** Nearly 45% of the total energy demand is in the industrial sector. Source wise 55% of energy comes from renewables and that of non-renewables at around 45% respectively. This contrast in high usage of non-renewable energy is due to the big industries and high economic activities - demanding more commercial forms of energy.

Sector-wise, the industrial sector is predominant in terms of energy demand with nearly 45% of consumption out of the total final (Figure 8-2). Due to the highly industrial and commercial activities in this province, the energy share in the residential sector comes to be much lower than the share at the national average. Additionally, the reduction in energy consumption in the residential sector also can be attributed to energy transition and energy efficiency, discussed in a later section. Comparing this result to the national level sectoral share of the year 2011/12, we see that the share of residential energy consumption is almost half in Province 1, while that for the industry is more than 5 times. The main reason behind this is the presence of a large number of industries in this province. The impact of economic activity is also seen in the transport sector with the share taking 10% at the provincial level as compared to 7% at the national level.

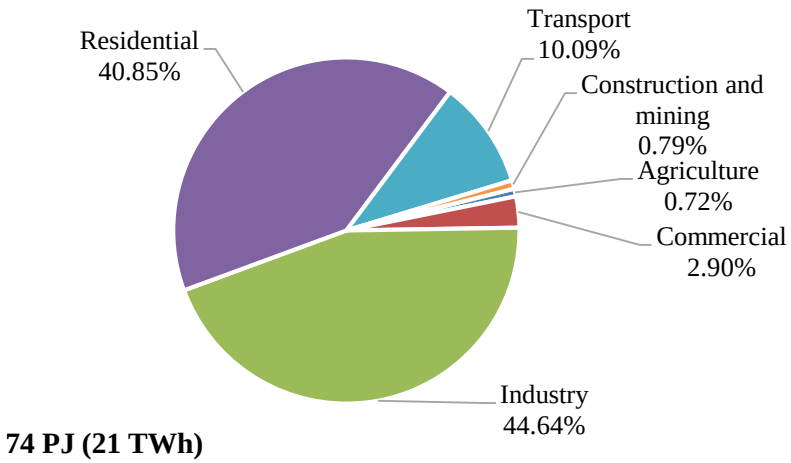


Figure 8-2: Energy Consumption Share in Province 1 by Sectors

The energy mix in Province 1 shows dominance of traditional renewables (biomass) (Figure 8-3). However, the share of firewood in total biomass seems lower than previous reference results. This could have happened because of stringent regulations regarding deforestation and access to agricultural residues as well as the transition to modern commercial energy sources. The share of coal is high due to its demand in industries. The share of liquid petroleum products surpasses the share of electricity consumption. It can be seen that all sectors are still highly dependent on imported fossil fuels as shown in Table 8-4.

Comparing this result to the national level fuel-wise share of the year 2011/12, we see that the share of fuelwood consumption is almost half in Province 1, while that of petroleum is as twice as in 2011/12. In addition to that, the share of coal is also very high at 21% - nearly five times that of the national share, and that of electricity is nearly twice as much at 7%. The main reason behind this is the huge economic activities in industries and the commercial sector in this province.

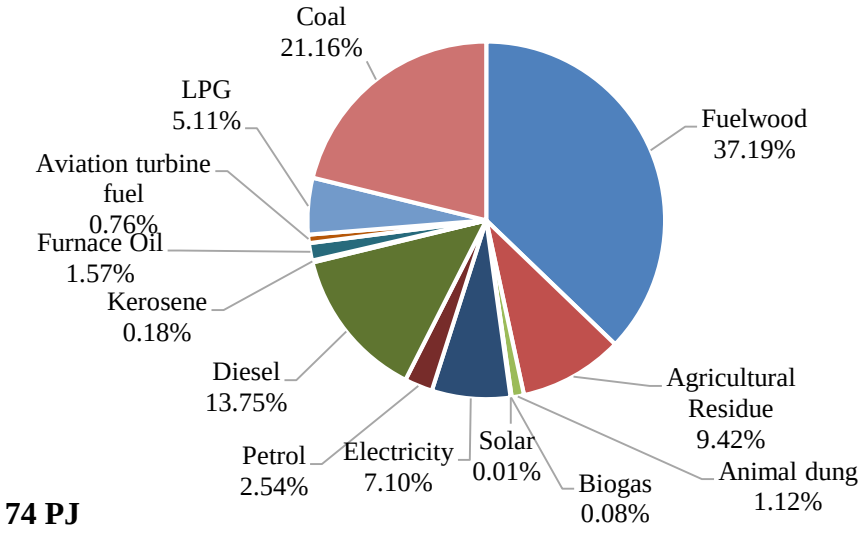


Figure 8-3: Energy Consumption Share in Province 1 by Energy Types

The energy consumption by physiological region is shown in Figure 8-4. It includes energy consumption in the agriculture, residential, commercial, and industry sectors in the province. Transport and construction and mining sectors are excluded since the survey for these two sectors was carried out at the provincial level.

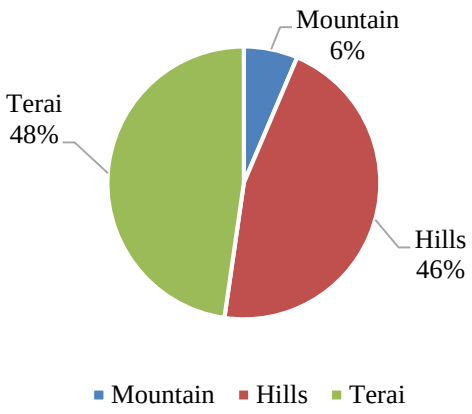


Figure 8-4: Energy Consumption Share in Province 1 by physiological region

Firewood is still the main source of energy in the residential sector, while the industrial sector thrives on the use of coal and diesel, primarily for thermal energy and motive power. The commercial sector is highly dependent on electricity and LPG as sources of energy while the transport and agricultural sectors still show huge dependency on fossil fuels. The shift from petroleum-based water pumping systems to solar PV powered can be seen in the agricultural sector in this province as well, however, due to geographic conditions, the penetration is lower.

Table 8-4: Energy Consumption in Province 1 by Sector and Fuel Type (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	Aviation turbine fuel	LPG	Coal	
Agriculture	-	-	-	-	-	0.09	0.08		534	-	-	-	-	-	534
Commercial	885	-	-	0.07	0.03	0.00	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	60.20	0.43	9.88	1,792	-	-	40	-	-	3,127	3.80	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

The scenario analysis has been carried out in three different economic growth scenarios. Among them, the main are Reference Economic Growth (REF) Scenario with assumptions,

- The average GDP growth rate of 6.3%
- The shares of each demand technology in the energy supply in future years will be the same as in the base year

And Sustainable Energy Development Scenario (SEDS) which has combined policy measures is considered an average annual GDP growth of 6.3% for various technology Interventions. The major focus is on electrification by renewable energy and energy efficiency in various demand technologies. The assumptions are in line with the various published reports and documents of Nepal Governmental agencies, IEA, IRENA, Paris Agreement, UN's SDGs programs, and other international energy and emissions-related programs.

The following are the major assumptions of this scenario.

- GDP growth rate according to reference case i.e. 6.3%.
- The shares of energy technologies vary in line with intervening strategies

The total energy demand in province 1 is expected to grow from the current level of 74 PJ in 2019 to 105 PJ in 2030 and 298 PJ in the year 2050 which accounts for an almost four folds increase. The average annual growth rate of energy demand is 4.6% for the reference case. Per capita, energy demand is expected to grow from 15 GJ in 2019 to 39 GJ in 2050 in this scenario. Meanwhile, in the SED scenario, the final energy demand would grow at the rate of 4% per annum whereas electricity demand grows at an average rate of 12% per annum from 2019-to 2050. Thus, the total energy demand in 2030 and 2050 is expected to be 95 PJ and 256 PJ respectively. Per capita, energy demand is expected to be 33 GJ in 2050.

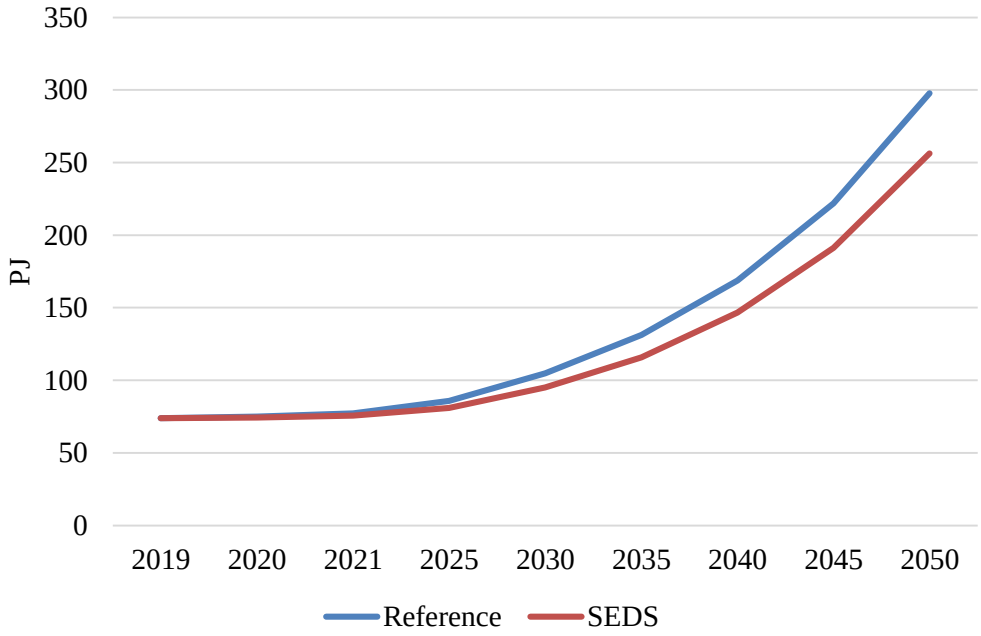


Figure 8-5: Total final energy demand in Province 1

8.2 Madhesh Province

8.2.1 Energy supply in Madhesh Province

Fuelwood Supply

The forest area in the Terai declined by 16,500 ha in the years from 2001 to 2010 and by 32,000 ha in the 19 years from 1991 to 2010. The annual rate of decrease in forest cover was 0.44% during the last nine years from 2001 to 2010 and was 0.40% during the last 19 years from 1991 to 2010/11. The annual rate of deforestation in all 20 Terai districts was 0.06%, excluding protected areas (FRA/DFRS, 2014). In Madhesh Province also the land under cultivation increased at cost of forest land. On the other hand, due to poverty, the demand for fuelwood increased despite the rapid growth in the commercial energy sector in the Terai region, because the fuelwood is practically free if people afford time for collection. A large quantity of fuelwood is being collected from the community-managed and government-managed forests by the local people.

Table 8-5Forest Area and Actual Fuelwood Produced

	Terai area in ha	Churia area in ha	Total area in 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	2,4400	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

Petroleum Products

All the petroleum consumed in the country is imported from India. The only company that deals with import and sales of petroleum products – that include diesel, petrol, kerosene, and LPG is Nepal Oil Corporation Ltd. (NOC). The furnace oils and other oil residues are imported by the industries themselves. Thus, the supply of petroleum products is obtained from regional offices of NOC. District wise sales data for 2075-76 is as shown in Table below. All the units for petrol or Motor Spirit (MS), Diesel and Super Kerosene Oil (SKO) are in kiloliters except for LPG in metric ton (MT). These sales data represent the sales to depots at each district. However, it is to be noted that neither the sales from these depots are bound within the district only nor the supply in each district is bound by the capacity of depots only – there are inter-boundary trade and transportation of petroleum fuels. Hence, the supply of petroleum products and their consumptions may not tally properly.

Table 8-6Petroleum 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**

(Source: NOC 2020)

Electricity

There is no sizeable hydropower potential in Madhesh Province. All the electricity through the national grid must be brought from other provinces. The only indigenous source of electricity could be the decentralized gensets that are used by industries – of which reliable data are not available and all the electricity produced is used within the industry. Thus, the main source of electricity is via the national grid distributed by Nepal Electricity Authority (NEA). The district-wise electricity supply status as obtained from NEA for Madhesh Province is shown in the Figure below. It shows Bara and Para have a comparatively high consumption of electricity due to mainly the number of industries located in the districts.

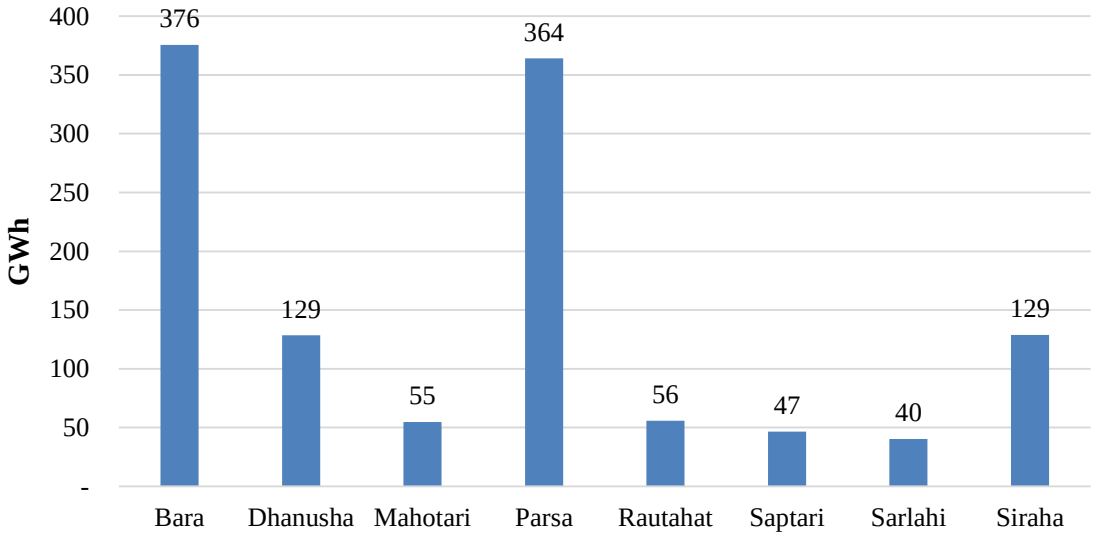


Figure 8-6: Electricity Consumption in Madhesh Province in 2075 (NEA, 2019)

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 electricity connection above 16 A. In Madhesh Province, 80% of households have access to electricity (NEA, 2019).

Modern Renewable Energy Sources

Modern Renewable energy sources include wind, biogas, solar, micro-hydro, and other renewables. Alternative Energy and Promotion Centre (AEPC) is the leading organization working on the promotion of renewable

energy in Nepal. Modern energy access is gradually increasing in Nepal with the current status of electricity access from renewables reaching 25% population. There has been a contribution of 32 MW of electricity from mini and micro-hydro schemes, 15 MWp from solar PV systems, and around 20 kW from wind energy. More than 1.5 million households have benefited from different renewable energy sources for cooking, lighting and productive end uses (MoPE, 2016).

According to AEPC, the number of installed plants for solar home systems (SHS), small solar home systems (SSHS), Mud Improved Cookstoves (MUDICS), domestic biogas and Institutional solar PV system (ISPS) in Madhesh Province is as shown in Table below. Approximately 190 kWp from SHS, 123 kWp from SSHS, and 184 kWp from ISPS have been installed in Madhesh Province. In addition to these, solar photovoltaic pumping system (SPVPS) has gained much popularity among farmers. There is a total of 498 SPVPS units, ranging from a capacity of 500 Wp to 3.5 kWp. Most of the biogas plants are sized 4 cubic meters in the province. Due to the low land of the region, there are no micro-hydro plants installed in Madhesh Province.

Table 8-7Petroleum 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**

8.2.2 Energy Consumption in Madhesh Province

The total energy consumption in Madhesh Province in 2019 was 63 PJ. The residential sector still dominated the sectoral energy consumption and wood and biomass were still the primary energy source type, change in energy mix can be observed as compared to previous studies at national and regional levels.

Sector-wise, the residential sector was still prevalent in terms of energy consumption with nearly 62% consumption out of total final energy. However, due to massive industrial and commercial activities in this province, the energy share in the residential sector comes to be lower than the share at the national average. Comparing this result to the national level sectoral share of the year 2011/12, we see that the share of residential energy consumption is lower by 20% in Madhesh Province, while that for the industry is nearly 3 times as much. The main reason behind this is the presence of a large number of industries in this province. The impact of economic activity is also seen in the transport sector with the share taking 9.2% at the provincial level as compared to 7% at the national level.

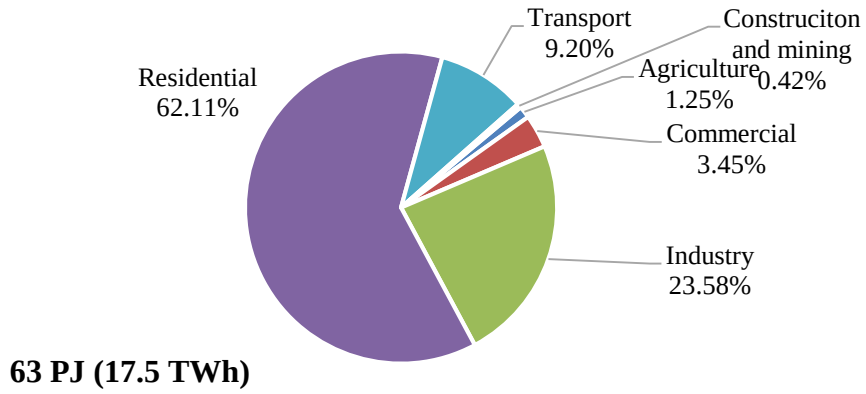


Figure 8-7: Energy Consumption Share in Madhesh Province by Sectors

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 huge dependency on fossil fuels. However, a shift from diesel power water pumping systems to solar-powered can be seen in the agricultural sector.

The energy mix in province two shows dominance of traditional renewable (biomass). However, the share of wood in total biomass seems lower than previous reference results, as the province is very much active in agricultural activities, thus having an abundance of agricultural residue and animal wastes. The share of LPG is nearly equal to the share of electricity, thus indicating the rise in dependence on imported fuel.

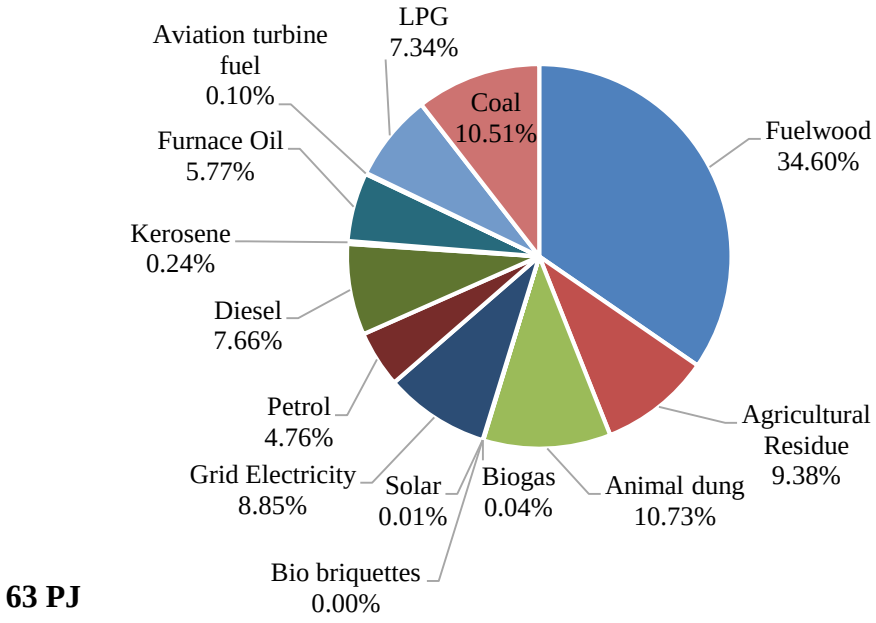


Figure 8-8: Energy Consumption Share in Madhesh Province by Energy Types

Comparing this result to the national level fuel-wise share of the year 2011/12, we see that the share of fuelwood consumption is almost half in Madhesh Province, while that of petroleum is as twice as in 2011/12 at the national level. In addition to that, the share of coal is also very high at 10.5% - more than 2 times that of the national share, and that of electricity is nearly thrice as much at 8.9%. The main reason behind this is the huge economic activities in industries and the commercial sector in this province.

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

	Renewables							Nonrenewable							Total
	Conventional renewable					New Renewables									
	Traditional biomass			Modern biomass											
	Fuelwood	Agricultural Residue	Animal dung	Biogas	Bio briquettes	Solar PV	Grid Electricity	Petrol	Diesel	Kerosene	Furnace Oil	Aviation turbine fuel	LPG	Coal	
Agriculture	-	-	-	-		0.30	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		8	5,588	3,009	4,842	155	3,645	62	4,638	6,638	63,174

The scenario analysis has been carried out in three different economic growth scenarios for Madhesh Province as well. Among them, the main are Reference Economic Growth (REF) Scenario with assumptions,

- The average GDP growth rate of 6.3%
- The shares of each demand technology in the energy supply in future years will be the same as in the base year

And Sustainable Energy Development Scenario (SEDS) which has combined policy measures is considered an average annual GDP growth of 6.3% for various technology Interventions. The major focus is on electrification by renewable energy and energy efficiency in various demand technologies. The assumptions are in line with the various published reports and documents of Nepal Governmental agencies, IEA, IRENA, Paris Agreement, UN's SDGs programs, and other international energy and emissions-related programs.

The following are the major assumptions of this scenario.

- GDP growth rate according to reference case i.e. 6.3%.
- The shares of energy technologies vary in line with intervening strategies

The total energy demand in Madhesh Province is expected to grow from the current level of 63.2PJ in 2019 to 83 PJ in 2030 and189 PJ in the year 2050 which accounts for threefolds of increase. The average annual growth rate of energy demand is 3.6% for the case. The per capita energy demand is expected to grow from 10 GJ in 2019 to 21 GJ in 2050 in this scenario. Meanwhile, in the SED scenario, the total energy consumption in 2030 and 2050 is expected to be 71 PJ and 144PJ respectively. Per capita, energy demand is expected to be 16 GJ in 2050. In this scenario, the final energy demand would grow at the rate of 3% per annum whereas electricity demand grows at an average rate of 10% per annum from 2019 to 2050.

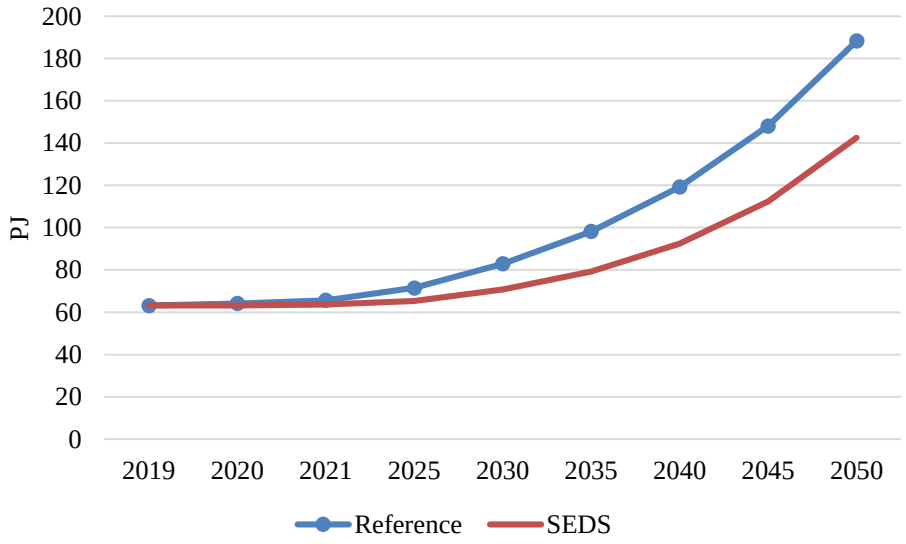


Figure 8-9 Total final energy demand in Madhesh Province

9 Conclusions

The overall energy consumption of Nepal is dominated by the use of non-commercial energy forms. However, there is a gradual shift to commercial energy sources and renewable energy sources. The supply and consumption situations of energy in FY 2075/76, 2076/77, and 2077/78 show a gradual change in energy consumption patterns as a result of modern energy access and energy efficiency improvement. However, 2020 was an exception as energy consumption decreased due to COVID where most of the economic activities halted.

The supply situation of the energy resources in the last three fiscal years was accessed through concerned energy institutions. The traditional energy sources include fuelwood, agri-residue, and animal waste supply. Forest covers 45% of the total area of Nepal. The Bagmati Province of the country has the highest total forest area (17.55%) while Madhesh Province has the lowest forest coverage area (4.37%). The annual energy potential of the sustainable fuelwood is estimated to be 203 PJ with Province 1 contributing the highest sustainable annual fuelwood yield (25.42%). The dry dung yield from the livestock was estimated to be 9.7 million tons in 2019. The energy potential from the dry dung was about 125 million GJ in the year 2019, which grew to 125 million GJ in 2020 and 127 million GJ in 2021. The total potential supply of residue in 2021 was estimated to be 26 million tons which were 24 million tons in 2020 and 23 million tons in 2019. The equivalent potential energy from the agri-residue was 442 million GJ in 2021 which was 406 million GJ and 416 million GJ in 2019 and 2020 respectively. The animal waste products from the livestock were estimated to be 6.8 million tons in 2019 which grew at the rate of 0.35% in 2020 and 1.1% in 2021. The energy potential from the dry dung was about 101.6 million GJ in the year 2019, which grew to 102 million GJ in 2020 and 103 million GJ in 2021

Modern energy resources include solar, wind, MHP, and waste-to-energy. The potential supply of solar is estimated to be 2100 MW in the country but the yield is limited to 22MW at a large utility scale. The installed capacity of micro-hydropower plants is 38 MW where the potential supply is more than 50MW. Wind on the other hand has the supply potential of 3000MW where the yield is limited. With the increasing municipal waste generation, the average organic waste per municipality amounted to about 1,200 tons. According to a recent study, 130294 m^3 of biogas can be generated by utilizing 100% of the organic fraction of municipal solid waste(OFMSW) in Kathmandu. The biogas produced can be used to fill up 21,045 LPG cylinders per day which can save NRs 515 million.

The commercial energy sources include electricity, coal, and petroleum products. The total installed capacity reached 2023 MW as of February 2022. The planned and proposed hydropower projects under NEA stand at 3,219.2 MW and that of IPPs is 6,172.75 MW as of FY 2020/21. To reach 100% electrification by 2023, the development of hydropower plants is gaining momentum in the country as the country even started to export some of the excess energy in the wet season. Coal and petroleum products that are mostly used in industries and transport are 100% imported with an insignificant amount of own coal production.

The energy consumption indicates an increasing trend with a slight dip in 2020 due to the global pandemic. The consumption in the year 2020/21 has reached 626 PJ which was 552 PJ in 2020 and 587 PJ in 2019. There was approximately a 4% reduction in energy consumption in 2020 due to the nationwide lockdown. However, in 2021 as the impact slowly decreased, the economic activities resumed and energy consumption grew at the rate of 11% from the previous year. The import of petroleum products (except LPG) decreased by more than 10% whereas LPG consumption increased at the rate of 5% in 2020 and 6% in 2021. The energy consumption by sources shows 68% of the

consumption of traditional energy followed by 30% commercial and remaining renewables. There is still a dominance of fuelwood in energy with a total share of 62%, followed by 15% liquid petroleum, 7% coal, 4.3% electricity, 3.6% LPG, 3% agri-residue, and 3% animal waste, and 2.45% renewables in 2021. The sectoral energy consumption has also changed over the last decade. In 2021, the residential sector consumed 62.8% followed by industry (15.7%), commercial sector (7.4%), transport (6.0%) agriculture (4.2%), and construction and mining (3.9%).

Final energy intensity indicates the rate of energy consumption and energy efficiencies. The final energy intensity in 2021 was calculated to be 21.35 GJ per capita which grew slightly from 2019. The energy intensity in the residential sector has decreased from about 14 GJ per capita in 2010 to 13.86 GJ per capita with the increasing access to modern energy, as well as clean energy technology penetrations. The electricity intensity is improving with the use of more efficient electric technologies. The electricity (including off-grid electricity) per capita increased from 228 in 2019 to 232 in 2020 and 265 in 2021. It shows the increasing use of clean energy in the country. Meanwhile, the residential electricity consumption has reached 480 kWh per household. The share of energy in national consumption shows a traditional energy share of 65%, imported energy share of 28.7%, and renewable energy (including electricity) share of 6% in 2021.

With the increasing energy consumption, the import of commercial energy resources is increasing. Also, the indigenous production of electricity and its consumption is growing lately with the nation aiming to generate 10,000 MW by 2028 and 100% electrification by 2023. There is a gradual shift in modern renewables as well with the increasing access to modern energy. Recently Nepal submitted the Second Nationally Determined Contributions (NDC) which also intends to reduce GHG emissions and emphasized the long-term strategy for Net-zero emissions by 2050, to achieve the target Nepal needs a paradigm shift from traditional energy sources to indigenous clean energy sources.

Recommendations

- The precise energy synopsis could be developed through the harmonized database and information system from the concerned institutions. The National Energy Information System (NEIS) is expected to bring it into action.
- The energy supply and consumption situation of a federal system of Nepal for province 1, Madhesh Province, and Bagmati province have already been completed and situation analysis of the remaining four provinces is undergoing. An integrated provincial energy analysis will give the updated nation energy scenario
- The more detailed information/data can increase the accuracy in estimation of renewable energy generation from isolated/distributed renewable energy systems
- The updated data on energy could be obtained with the inclusion of energy-specific questions in the annual household survey, National Living Standard survey, and sectoral surveys carried out by Central Bureau of Statistics
- The introduction of separate code for the energy related commodities by the Department of Custom could also provide the supply sources data for verification

References

ADB, 2017. *Nepal's Largest Wind-Solar Hybrid Power System Switched On to Connect a Small Village to the World,* s.l.: Asian Development Bank.

Adhikari, N. P. & Adhikari, R. C., 2021. Analysis of biogas production potential based on livestock dung availability: A case of household biogas plants in Nepal. *Biofuels*, p. 1–9.

Adhikari, N. P. & Denich, M., 2019. Potential of Crop Residues for Energy Production in Nepal. *Journal of the Institute of Engineering*, pp. 9-15.

AEPC, 2019. *Progress at Glance: A year in Review FY 2075/76 (2018/19),* s.l.: Alternative Energy Promotion Center.

AEPC, 2021. *Progress at Glance: Year in Review FY 2076/77(2019/20) and FY 2077/78(2020/21),* s.l.: Alternative Energy Promotion Centre.

AEPC, 2022. *Alternative Energy Promotion Centre - Achievements.* [Online] Available at: https://www.aepc.gov.np/achievement

Bajracharya, I., 2015. *Assessment of Run-Of-River Hydropower Potential and Power Supply Planning in Nepal using Hydro Resources,* s.l.: s.n.

Baskota, S. K., 2018. *Coal Resources and Their Status in Nepal,* s.l.: SAARC Energy Center.

Bhatt, B. P., Chhetri, S. G., Silwal, T. & Poudel, M., 2021. Economic Contribution of Forestry Sector to National Economy in Nepal. *J. of Resources and Ecology*, pp. 620-627.

CBS, 2018. *National Economic Census 2018,* Kathmandu, Nepal: Central Bureau of Statistics.

CBS, 2021a. *Waste Management Baseline Survey of Nepal 2020,* s.l.: Central Bureau of Statistics.

CBS, 2021. *Population Census 2021,* Kathmnadu Nepal: Central Bureau of Statistics.

CBS, 2022. *National Accounts Statistics of Nepal (2021/22 Annual Estimates).* [Online] Available at: https://cbs.gov.np/national-accounts-statistics-of-nepal-2021-22-annual-estimates/

DFRS/FRSIP, 1999. *Forest REsources of Nepal,* Kathmandu, Nepal: Department go Forest Research and Survey / Forest Resource Information System Project.

DFRS, 2015. *State of Nepal's Forests. Forest Resource Assessment (FRA) Nepal,* Kathmandu, Nepal: Department of Forest Research and Survey.

DFRS, 2020. *Land Cover in Nepal,* Kathmandu, Nepal: Department of Forest Research and Survey.

DoF, 2015. *Hamro Ban - 2073/74,* Kathmandu, Nepal: Department of Forest, MInistry of Forest and Environment, Government of Nepal.

FRA/DFRS, 2014. *Terai Forests of Nepal (2010e2012),* Babarmahal, Kathmandu: Forest Resource Assessment NepalProject/Department of Forest Research and Survey.

Ghimire, M. & Poudel, R. C., 2010. Wind Energy Resource Assessment and Feasibility Study of Wind Farm in Kaligandaki Riverbank of Mustang District. *Nepal J. Sci. Technol.*, p. 159–166.

GoN. (2020). Second Nationally Determined Contribution (NDC). Kathmandu: Government of Nepal.

IEA, 2018. *Global Energy and CO2 Status Report,* s.l.: International Energy Agency.

IEA, 2022. *Wind Power.* [Online] Available at: https://www.iea.org/reports/wind-power [Accessed 2022].

Kandel, K., 2018. *A Comprehensive Study of Hydropower Potential of Nepal.* Kathmandu: s.n.

Lohani, S. P., Keitsch, M., Shakya, S. & Fulford, D., 2021. Waste to energy in Kathmandu Nepal—A way toward achieving sustainable development goals. *Sustain. Dev.*, p. 906–914.

MoALD, 2021. *Statistical Information on Nepalese Agriculture* , Kathmandu, Nepal: MInistry of Agriculture and Livestick Development.

MoF, 2021. *Economic Survey*, Kathmandu, Nepal: Ministry of Finance.

MoF, 2022. *Economic Survey*, Kathmandu, Nepal: Ministry of Finance.

MOFE, 2020. *Current Status of Community Based Forest Management Models in Nepal,* Kathmandu, Nepal: Ministry of Forests and Environment, Singhadurbar.

MoFSC, 2016. *National Forest Reference Level of Nepal (2000 – 2010),* Singh Durbar, Kathmandu, Nepal: Ministry of Forests and Soil Conservation .

MoPE, 2016. *Renewable Energy Subsidy Policy*, s.l.: Ministry of Population and Environment.

MoWR, 2001. *The Hydropower Development Policy, 2001,* s.l.: Ministry of Water Resources (Then).

NEA, 2019. *Elelctricty sales.* s.l.:Nepal Electricity Authority.

NEA, 2021. *Annual Report 2020/2021,* Kathmnadu, Nepal: Nepal Electricity Authority.

NOC, 2021. *Petroelum Import and Sales Statictics,* s.l.: Nepal Oil Corporation.

NPC, 2018. *Universalizing Clean Energy in Nepal: Sustainable Distributed Generation and Grid Access to All (SUDIGGAA) by 2022,* Kathmandu, Nepal: National Planning Commission, Government of Nepal.

NPC. (2020). The Fifteenth Plan (FY 2019/20-2023/24). Kathmandu, Nepal: National Planning Commission, Government of Nepal.

Poudyal, R. et al., 2019. Mitigating the current energy crisis in Nepal with renewable energy sources.

Renew. Sustain. Energ.

SEC, 2018. *SAARC Energy Outlook 2030*, Mumbai, India: CRISIL Research.

Sodari, K. B. & Nakarmi, A. M., 2018. Electricity Generation Potential of Municipal Solid Waste of Nepal and GHG Mitigations. *J. Inst. Eng.*, p. 151–161.

Subedi, B. P. et al., 2014. *Private Sector Involvement and Investment in Nepal's Forestry: Status, Prospects and Ways Forward.*, Babarmahal, Kathmandu: Services Support Unit, 2014.: Study Report, Multi Stakeholder Forestry Programme..

SEMAN, 2022. SEMAN ar a Glance, Solar Electric Manufacturers' Association Nepal, Kathmandu, Nepal

TERI, 2017. *Energy intensity and India.* [Online] Available at: https://www.teriin.org/infographics/energy-intensity-and-india [Accessed 2022].

UNEP/GEF, 2008. *Solar and Wind Energy Resource Assessment in Nepal (SWERA)*, s.l.: United Nations Environment Programme.

WECS, 2010. *Energy Sector Synopsis Report Nepal*, Kathmandu: Secretariat, Water and Energy Commission, Ministry of Energy, Government of Nepal.

WECS, 2013. *National Survey of Energy Consumption and Supply Situation in Nepal*, Kathmandu, Nepal: Water and Energy Commission Secretariate.

WECS, 2019. *Assessment of Hydropower Potential of Nepal*, s.l.: Water and Energy Commission Secretariat.

WECS, 2021a. *Energy Consumption and Supply Situation in Federal System of Nepal - Province 1*, Kathmandu, Nepal: Water and Energy Commission Secretariat, GOvernment of Nepal.

WECS, 2021b. *Energy Consumption and Supply Situation in Federal System of Nepal - Province 2*, Kathmandu, Nepal: Water and Energy Commission Secretariat, Government of Nepal.

World Bank, 2016. *Wind resource mapping in Nepal: Interim Mesoscale Wind Modelling Report*, s.l.: The World Bank.

World Bank, 2017. *Solar Resource and Photovoltaic Potential of Nepal*, s.l.: The World Bank.

ANNEX

Annex I. GDP Structure

Gross Value Added by Industrial Division Rs. millions (at constant 2010/11 prices)												May12,2022 CBS, 2022	
NSIC	**Industrial Classification**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21 R**	**2021/22 P**
A	Agriculture, forestry and fishing	480	506	512	535	542	541	569	584	614	629	647	662
B	Mining and quarrying	9	9	9	10	11	10	12	13	15	15	16	17
C	Manufacturing	84	93	95	101	101	92	107	117	124	113	118	125
D	Electricity, gas, steam and air conditioning supply	14	17	17	17	17	16	20	22	24	28	29	40
E	Water supply; sewerage, waste management and remediation activities	9	10	11	12	13	14	15	15	16	16	16	16
F	Construction	93	93	95	104	107	107	127	142	153	146	154	168
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	221	227	233	247	258	251	278	326	352	312	330	360
H	Transportation and storage	77	83	89	95	101	101	105	118	128	113	118	123
I	Accommodation and food service activities	25	26	28	28	30	27	31	35	38	24	27	30
J	Information and communication	31	40	44	56	62	63	71	73	78	80	81	84
K	Financial and insurance activities	69	70	71	76	81	88	97	106	113	112	117	124
L	Real estate activities	143	145	148	151	153	153	160	162	168	172	176	182
M	Professional, scientific and technical activities	12	13	14	15	16	16	17	18	19	19	20	21
N	Administrative and support service activities	6	6	7	8	9	10	12	14	15	15	16	16
O	Public administration and defense; compulsory social security	64	66	70	73	79	81	87	91	96	102	105	109
P	Education	75	80	84	88	93	100	107	113	120	124	129	134
Q	Human health and social work activities	17	18	18	19	21	22	23	25	26	28	29	31
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
	Gross Domestic Product(GDP) at basic prices	1,436	1,507	1,554	1,643	1,700	1,700	1,847	1,983	2,109	2,058	2,137	2,254
	Taxes less subsidies on products	123	125	136	148	162	170	192	211	230	226	244	266
	Gross Domestic Product (GDP)	1,559	1,632	1,690	1,791	1,862	1,870	2,038	2,194	2,340	2,284	2,381	2,520
R = Revised/P = Preliminary													

Annex II. Forest Data

Forest Distribution by type

SN	Province	Area (000 ha)						Percent share
		Forest	Tree Cover 5-10%	Shrubs	OWL	Other land	Total	
1	Province 1	1,034.17	82.42	17.75	100.17	1,476.72	2,611.06	17.35
2	Madhesh	260.76	2.07	0.80	2.87	695.34	958.97	4.37
3	Bagmati	1,046.21	38.57	6.09	44.67	939.43	2,030.30	17.55
4	Gandaki	739.60	83.23	16.32	99.55	1,429.16	2,268.32	12.41
5	Lumbini	968.37	30.31	18.91	49.22	963.27	1,980.85	16.24
6	Karnali	902.82	168.02	47.50	215.52	1,828.31	2,946.65	15.14
7	Sudurpaschim	1,010.21	126.44	9.46	135.90	831.26	1,977.37	16.94
8	Entire Country	5,962.13	531.06	116.83	647.89	8,163.49	14,773.51	100

Land Cover Area by Physiographic Region (ha)

Physiographic Region	Forest	Other Wooded Land (OWL)			Other Land	Total
		Tree crown cover 5-10%	Shrub	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
National total	5,962,039	531,067	116,826	647,893	8,163,492	14,773,424

Community forest in Nepal

	Community groups	Forest area (ha)	Beneficiaries (Households)	Beneficiaries (Population)	Forest area covered w.r.t Province %	Forest Area Managed by Community %	Forest area covered w.r.t Nepal %
Province 1	4,832	551,791	701,771	3,621,360	48.65	17.35	8.35
Madhesh	619	125,947	617,228	3,611,242	47.77	3.96	1.90
Bagmati	8,213	593,495	695,165	3,483,552	54.41	18.66	8.98
Gandaki	5,168	449,665	523,592	2,919,897	55.02	14.14	6.80
Lumbini	4,657	576,570	865,040	4,753,860	59.17	18.12	8.72
Karnali	3,532	375,918	333,858	1,846,745	31.77	11.82	5.69
Sudurpaschim	4,447	507,580	587,733	3,370,144	44.29	15.96	7.68
	31,468	3,180,966	4,324,387	23,606,800		100.00	48.12

Annex III. Agriculture Data

Agri-residue supply potential in 2018/19 (MoALD 2020; MoALD 2021)

	Production in tons					
	paddy	**Maize**	**Wheat**	**Millet**	**total residue in tons**	**Total potential energy 000 GJ**
Mountain	150,376	221,484	80,556	58,825	1,195,115	19,306
Hills	1,206,132	1,780,487	544,642	241,024	8,896,653	145,092
Terai	4,253,507	711,663	1,380,470	14,374	13,470,433	242,078
	5,610,015	2,713,634	2,005,668	314,223	23,562,201	406,476
Province 1	1,237,954	831,379	192,249	97,180	5,310,782	89,914
Madhesh	1,495,045	161,764	582,565	1,663	4,712,008	85,276
Bagmati	521,446	598,000	159,444	69,465	3,140,415	51,819
Gandaki	427,689	423,308	93,433	99,740	2,396,745	39,369
Lumbini	1,188,675	369,898	496,117	10,869	4,489,926	79,184
Karnali	133,580	217,060	161,690	19,674	1,255,635	20,735
Sudurpashchim	605,626	112,225	320,170	15,632	2,256,689	40,179
	5,610,015	2,713,634	2,005,668	314,223	23,562,201	406,476

Agri-residue supply potential in 2019/20

	Production in tons					
	paddy	**Maize**	**Wheat**	**Millet**	**total residue in tons**	**Total potential energy 000 GJ**
Mountain	825,622	692,844	255,953	97,746	4,272,223	71,528
Hills	1,480,279	1,433,302	552,777	157,892	8,352,584	139,322
Terai	3,244,977	709,531	1,376,562	65,316	11,572,396	205,727
	5,550,878	2,835,677	2,185,292	320,954	24,197,203	416,577
Province 1	1,245,545	867,717	176,710	95,201	5,384,039	91,007
Madhesh	1,420,437	175,640	601,708	1,641	4,645,958	83,835
Bagmati	510,200	617,762	168,431	69,675	3,192,337	52,570
Gandaki	408,737	433,561	99,400	106,138	2,413,583	39,485
Lumbini	1,185,493	398,462	508,459	11,784	4,590,492	80,744
Karnali	134,407	225,238	196,296	20,404	1,359,647	22,495
Sudurpashchim	646,059	117,297	434,288	16,111	2,611,147	46,440
	5,550,878	2,835,677	2,185,292	320,954	24,197,203	416,577

Agri-residue supply potential in 2020/21

	Production in tons					
	paddy	**Maize**	**Wheat**	**Millet**	**total residue in tons**	**Total potential energy 000 GJ**
Mountain	880,092	735,613	271,080	99,212	4,532,042	75,930
Hills	1,577,939	1,521,780	585,446	160,260	8,862,271	147,909
Terai	3,459,061	753,330	1,457,916	66,296	12,299,437	218,716
	5,917,091	3,010,723	2,314,441	325,768	25,693,750	442,554
Province 1	1,327,718	921,281	187,153	96,629	5,716,718	96,689
Madhesh	1,514,149	186,482	637,269	1,666	4,940,864	89,169
Bagmati	543,860	655,896	178,385	70,720	3,386,045	55,795
Gandaki	435,703	460,325	105,274	107,730	2,555,326	41,850
Lumbini	1,263,705	423,059	538,509	11,961	4,879,607	85,848
Karnali	143,274	239,142	207,897	20,710	1,441,589	23,860
Sudurpashchim	688,682	124,538	459,954	16,353	2,773,601	49,344
	5,917,091	3,010,723	2,314,441	325,768	25,693,750	442,554

Annex IV. Animal waste Data

Animal waste production in 2018/19 (MoALD 2020; MoALD 2021)

	Livestock population				
	Cattle	**Buffalo**	**Total annual dry dung potential in tons**	**Actual dry dung production in tons**	**000 GJ**
Mountain	858,598	511,389	439,958	307,971	4,595
Hills	3,166,029	3,405,028	4,488,371	3,141,860	46,877
Terai	3,360,410	2,952,831	4,809,214	3,366,450	50,227
	7,385,037	6,869,248	9,737,542	6,816,280	101,699
Province 1	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	745,796	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
	7,385,037	6,869,248	9,737,542	6,816,280	101,699

Animal waste production in 2019/20

	Livestock population				
	Cattle	**Buffalo**	**Total annual dry dung potential in tons**	**Actual dry dung production in tons**	**000 GJ**
Mountain	864,797	472,833	418,743	293,120	4,373
Hills	3,130,491	3,331,954	4,405,409	3,083,786	46,010
Terai	3,463,597	3,032,797	4,947,350	3,463,145	51,670
	7,458,885	6,837,584	9,771,502	6,840,051	102,054
Province 1	1,981,755	1,108,914	1,962,605	1,373,823	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
	7,458,885	6,837,584	9,771,502	6,840,051	102,054

Animal waste production in 2020/21

	Livestock population				
	Cattle	**Buffalo**	**Total annual dry dung potential in tons**	**Actual dry dung production in tons**	**000 GJ**
Mountain	869,381	479,879	423,583	296,508	4,424
Hills	3,147,085	3,380,732	4,457,848	3,120,494	46,558
Terai	3,481,957	3,077,812	4,999,359	3,499,551	52,213
	7,498,423	6,938,423	9,880,790	6,916,553	103,195
Province 1	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
	7,498,423	6,938,423	9,880,790	6,916,553	103,195

Annex V. Solar PV systems and Projects

NEA Solar Projects Under Operation (DoED, 2021)

S.N.	Projects	Capacity(KW)
1	Simikot	50
2	Gamgadhi	50
3	Battar (Nuwakot)	1250
	Total	1350

IPP's Solar Projects Under Operation

S.N.	Developer	Project	Location	Capacity (kW)
1	Kathmandu Upatyaka Khanepani bewasthapan Board	Solar	Lalitpur	680.4
2	Surya Power Company Pvt. Ltd.	Bishnu Priya Solar Farm Project	Nawalparasi	960
3	Ridi Hydropower Development Co. Ltd.	Butwal Solar Project	Rupandehi	8500
4	Eco Power Development Company Pvt. Ltd	Mithila Solar PV Electric Project	Dhanusha	10000

Solar projects provided with construction license

S. N.	Project	Capacity (MW)	Promoter	VDC/District
1	Block No 1 Solar Farms Project	5.1	Nepal Electricity Authority	Charghare (Nuwakot)
2	Block No 2 Solar Farms Project	8.3	Nepal Electricity Authority	Charghare (Nuwakot)
3	Bel Chautara Solar Farm Project	5	Solar Farm Pvt. Ltd.	Khairenitar (Tanahu)
4	Som Radha Krishna Solar Farm Project	4.4	Nepal Solar Farm Pvt. Ltd	Rupakot (Kaski)
5	Solar PV Pratappur	5	National Solar Power Company	Pratappur (Nawalparasi)
6	Chandranigahpur Solar Project	4	Api Power Company Pvt. Ltd	Chandranigahapur (Rautahat)
7	Bhrikuti Solar Power Project	9	First Solar Developers Nepal Pvt. Ltd.	Barakulpur (Kapilbastu)
8	Grid Connected Solar Project Block 4, Nuwakot	1.37	Nepal Electricity Authority	Bidur N.P. (Nuwakot)
9	Grid-Connected Solar Power Project, Dhalkebar, 33 kV S/S	3	Sagarmatha Energy & Construction Pvt. Ltd.	Dhalkebar (Dhanusha)
10	Grid Connected Solar PV Project, Ramgram, Nawalparasi	2	Saurya Bidhyut Power Pvt. Ltd	
11	Grid-Connected Solar Power Project, Duhabi, 33 kV S/S	8	Global Energy & Construction Pvt. Ltd.	Duhabi (Sunsari)
12	Utility Scale Solar PV	6.8	G I Solar Pvt. Ltd,	Banigama (Morang)
13	Solar PV Project Banke, block-2	10	Pure Energy Pvt. Ltd	Raniyapur (Banke)
14	Solar PV Project, Raniyapur, Block 1	10	Pure Energy Pvt. Ltd	Raniyapur (Banke)
15	Grid Connected Solar PV Project, Ganeshpur, Kapilbastu	10	Positive Energy Pvt. Ltd	Ganeshpur (Kapilbastu)
16	Solar Power Project, Dhalkebar 11 kV S/S	1	Api Power Company Ltd.	Dhalkebar (Dhanusha)
17	Baigundhara Solar PV project	5	East Solar Pvt. Ltd	Gaurandaha (Jhapa)
18	Mithila 2 Solar PV Project, Dhanusa	10	Eco Power Development Pvt. Ltd.	Begadawar (Dhanusha)
19	Dharamnagar Solar Farm Project	10	Pashupati Renewables Pvt. Ltd.	Birpur (Kapilbastu)

Solar projects provided with survey license

S.N.	Project	Capacity (MW)	Promoter	VDC/District
1	Bhadrapur Solar PV Project	5	Rairang Hydropower Development Company Ltd	Bhadrapur NP (Jhapa)
2	Grid Connected Solar PV Project, Birendranagar Surkhet	1.2	G.C.Solar Energy Group	BirendraNagar N.P. (Surkhet)
3	Grid Connected Solar PV Project, Lamahi	10	Pioneer Energy Pvt. Ltd	Satbariya (Dang)
4	Grid Connected Solar PV Project, Lamahi 1	10	Progressive Energy Pvt. Ltd	Satbariya (Dang)
5	Grid Connected Harmony Solar Farm, Bardiya	5	Harmony Solar Pvt. Ltd	Neulapur (Bardiya)
6	Kalikhola Solar PV Project	3	Goodluck Glocal Power Energy Pvt. Ltd	Bidur N.P. (Nuwakot)
7	Birgunj Solar PV Project	7	Kantipur Energy Investment & Construction Pvt. Ltd.	Itiyahi (Bara)
8	Mithila Solar Project	5	Solar Star Pvt. Ltd.	Hariharpur (Dhanusha)
9	Jira Bhawani Sedawa PV Project	7.7	Tarai Solar Pvt. Ltd.	Sedhawa (Parsa)
10	Pratappur Solar PV Project	10	National Solar Power Company	Pratappur (Nawalparasi)
11	Belbari Solar PV Project	10	Shreeyanshi Urja Pvt. Ltd.	Belbari (Morang)
12	Bhangaha Solar PV Project, Mahottari	100	Mithila Energy Pvt. Ltd.	Loharpatti (Mahottari)
13	Tek Samundra Solar PV Projecty, Thakurbaba	5	Tek Samundra Khetibari Pvt. Ltd.	Neulapur (Bardiya)
14	Parwanipur Solar PV Project	8	Api Power Company Ltd.	Rampur Tokani (Bara)
15	Udyapur Solar PV Project	10	Sunlight Energy Pvt. Ltd	Jogidaha, Gaighat (Udayapur)
16	250MW Grid connected Solar Project in Kohalpur and Banganga	250	Risen Clean Energy Nepal Pvt. Ltd.	
17	Jhimruk On Grid Solar Project	7	Butwal Power Company Limited	Khaira (Pyuthan)
18	Sonaha Solar Farm Project	10	Bharati Laxmi Energy Pvt. Ltd	Suryapatawa (Bardiya)
19	Lahan Solat PV Project	10	Eco Sun Power Development Pvt. Ltd	Lahan N.P. (Siraha)
20	Lalbandhi Solar PV Project	10	Eco Gham Power Company Pvt. Ltd.	Lalbandi (Sarlahi)
21	Solududhakuna Solar PV Project	10	Gham Kheti Pvt. Ltd.	Tingla (Solukhumbu)
22	Kalikhola-A Solar Electricity Project	7	Goodluck Glocal Power Energy Pvt. Ltd	
23	Dharamnagar Solar Farm-II	15	Pashupati Renewables Pvt. Ltd.	
24	Nepalgunj SVP Power Plant	200	G.T. Energy Pvt.Ltd.	
25	Jhapa SPV Power Plant	300	G.T. Energy Pvt.Ltd.	Surunga (Jhapa)
26	Solar PV Plant Block 2, Kailali	10	Advik energy Limited	Godawari (Kailali)
27	Solar PV Plant, Block-1, Kailali	10	Advik energy Limited	Godawari (Kailali)
28	Amarawati Solar Project Part 1	10	Amarawati Solar Energy Pvt. Ltd	Godawari (Kailali)
29	Amarawati Solar Project Part 2	10	Amarawati Solar Energy Pvt. Ltd	Godawari (Kailali)
30	Gami Solar Energy Project	3	Gami Telecom Solutions and Infrastructure Pvt. Ltd.	Begadawar (Dhanusha)

Solar Projects which have applied for construction license

S No	Project	Capacity (MW)	Promoter	VDC/District
1	Grid-Connected Solar Power Project, Lahan , 33 kV S/S	4	Asian Tech Corporation Pvt. Ltd.	Lahan N.P. (Siraha)
2	Solar Power Project, Simara, 11 kV S/S	1	Api Power Company Ltd.	
3	Grid Connected Solar PV Project Part II, Kapilbastu	10	Positive Energy Pvt. Ltd	Ganeshpur (Kapilbastu)
4	Grid Connected Solar Project, Shivasatakshi Jhapa	10	Jhapa Energy Limited	Panchganchi (Jhapa)
5	Grid Tied Solar Farm Project	3.09	Nepal Electricity Authority	Charghare (Nuwakot)
6	Grid Tied Solar Farm Project Block n. 5	6.5	Nepal Electricity Authority	Bidur N.P. (Nuwakot)

Annex VI. Waste Data

Annual Average Waste Collection per Municipality by Waste Types and Categories

Waste Type	FY	Metropolitan City (mt/Year)	Sub Metropolitan City (mt/Year)	Municipality (mt/Year)	Annual Average of Municipalities (mt/ Year/Municipality)	Daily Average of Municipalities (mt/ Day/Municipality)
Organic	FY 2073/74	12,734.00	2,269.80	829.8	1,153.30	3.2
	FY 2074/75	13,478.00	3,044.20	950	1,214.60	3.3
	FY 2075/76	10,669.50	4,088.20	824.2	1,206.10	3.3
Inorganic	FY 2073/74	8,787.00	1,005.70	518.3	698	1.9
	FY 2074/75	9,725.00	1,338.70	504.6	666.8	1.8
	FY 2075/76	7,100.00	1,525.90	551.9	743.5	2
Other	FY 2073/74	5,145.00	228	194.8	379.6	1
	FY 2074/75	5,446.00	213.5	155.6	283	0.8
	FY 2075/76	6,200.00	229.7	177.5	283	0.8
Total	FY 2073/74	26,666.00	3,503.50	1,543.00	2,231.00	6.1
	FY 2074/75	28,649.00	4,596.30	1,610.20	2,164.40	5.9
	FY 2075/76	23,969.50	5,843.70	1,553.60	2,232.70	6.1

Annual Average Organic Waste Collection per Municipality by Years

Waste Type	FY	Metropolitan City	Sub-Metropolitan City	Municipality	Average
Textile (mt)	FY 2073/74	3,811.00	141.3	117	183.1
	FY 2074/75	4,034.00	162	106.3	159.5
	FY 2075/76	2,514.50	146.8	124.2	173.1
Leather (mt)	FY 2073/74	2,018.00	16.3	62.3	114.2
	FY 2074/75	2,136.00	20.3	55.3	96.5
	FY 2075/76	1,342.00	19.8	50	86.3
Paper (mt)	FY 2073/74	4,708.00	169	131.7	221.8
	FY 2074/75	4,983.00	202.3	137.9	207
	FY 2075/76	3,494.00	735.4	107.1	207.3
Agricultural/Garden management (mt)	FY 2073/74	1,076.00	699.7	444.2	472.8
	FY 2074/75	1,139.00	836	536.4	558.8
	FY 2075/76	2,343.00	1,808.00	393.9	506.3
Other Organic (mt)	FY 2073/74	1,121.00	1,243.50	74.7	161.5
	FY 2074/75	1,186.00	1,823.50	114	192.8
	FY 2075/76	976	1,378.30	148.9	233.2
Total of Organic Waste (mt)	FY 2073/74	12,734.00	2,269.80	829.8	1,153.30
	FY 2074/75	13,478.00	3,044.20	950	1,214.60
	FY 2075/76	10,669.50	4,088.20	824.2	1,206.10

Average Quantity of Waste Collected from Different Sources and Municipal Categories

Categories	Household waste (kg/day)	Business House/Commercial Complex waste (kg/day)	Industrial House/ District waste (kg/day)	Educational Institutes waste (kg/day)	Health Institutions/ Hospitals waste (kg/day)	Other(kg/day)	Total Quantity (kg/day)
Metropolitan City	15920 (42.6)	7720 (20.7)	4460 (11.9)	4680 (12.5)	4560 (12.2)	-	37340 (100.0)
Sub-Metropolitan City	3316 (30.2)	3025 (27.6)	1544 (14.1)	1322 (12.1)	594 (5.4)	1171 (10.7)	10973 (100.0)
Municipality	1441 (38.9)	932 (25.2)	310 (8.4)	358 (9.7)	381 (10.3)	282 (7.6)	3704 (100.0)
Overall	1784 (38.6)	1142 (24.7)	436 (9.5)	477 (10.3)	467 (10.1)	313 (6.8)	4619 (100.0)

Annex VII. Hydropower Plants

NEA developed hydropower plants in different provinces (NEA, 2021)

S. No.	Power Stations	District	Total Installed Capacity (MW)	Actual Generation (MWh)		
				2075/76	2076/77	2077/78
Province 1						
1	Puwa	Ilam	6.2	34,193	34,915	34,477
2	Chatara	Sunsari	3.2	2,698	1,822	3,352
3	Multifuel	Morang	39		3	0
		Total	48.4	36,891	36,739	37,829
Bagmati Province						
1	Upper Trishuli 3A	Rasuwa, Nuwakot	60	16,186	407,551	314,768
2	Kulekhani I	Makwanpur	60	91,184	162,972	195,157
3	Kulekhani II	Makwanpur	32	44,677	81,483	95,229
4	Trishuli	Nuwakot	24	123,741	128,973	121,211
5	Devighat	Nuwakot	15	86,851	92,053	85,429
6	Kulekhani III	Makwanpur	14	0	20,365	35,565
7	Sunkoshi	Sindupalchowk	10.05	62,157	62,246	55,917
8	Panauti	Kavrepalankchowk	2.4	3,006	2,887	2,948
9	Sundarijal	Kathmandu	0.64	3,587	2,815	3,922
10	Pharping	Kathmandu	0.5			
11	Hetauda Diesel	Makwanpur	14.41	116	57	54
		Total	233	431,504	961,403	910,201
Gandaki						
1	Kaligandaki 'A'	Syangja	144	871,914	871,466	817,713
2	Mid-Marsyangdi	Lamjung	70	471,323	446,625	398,846
3	Marsyandi	Tanahu	69	475,176	443,852	398,920
4	Modi	Parbat	14.8	69,401	66,913	60,471
5	Seti	Kaski	1.5	10,030	11,158	11,682
6	Fewa	Kaski	1	1,532	2,127	1,851
		Total	300.3	1,899,375	1,842,141	1,689,483
Lumbini Province						
1	Gandak	Parasi	15	11,951	10,338	12,123
		Total	15	11,951	10,338	12,123
Sudurpashchim						
1	Chameliya	Darchula	30	161,396	160,812	151,247
		Total	30	161,396	160,812	151,247
	GRAND TOTAL		**626.7**	**2,541,116**	**3,011,432**	**2,800,883**

NEA Under Construction, Planned and Proposed Hydropower Plants in different provinces (NEA, 2021)

NEA Hydropowers Under Construction			
	Project	**District**	**Capacity(KW)**
Bagmati Province			
1	Upper Tamakoshi Hydropower Project	Dolakha	456
4	Upper Sanjen	Rasuwa	14.6
5	Sanjen	Rasuwa	42.5
6	Rasuwagadi	Rasuwa	111
7	Madhya Bhotekoshi	Sindhupalchowk	102
8	Upper Trishuli 3B	Rasuwa/ Nuwakot	37
		Total	763.1
Gandaki Province			
2	Tanahu Hydropower Project	Tanahu	140
3	Rahuganga HEP	Myagdi	40
		Total	180
		GRAND TOTAL	943.1

NEA Hydropower Planned and Proposed			
SN	**Hydropowers**	**District**	**Capacity(KW)**
Province 1			
1	Upper Arun HEP	Sankhuwasabha	1061
4	Dudhkoshi Storage HEP	Khotang/ Okhaldhunga	635
		Total	1696
Bagmati Province			
6	Tamakoshi V HEP	Dolakha	95
		Total	95
Gandaki Province			
2	Upper Modi A HEP	Kaski	42
3	Upper Modi HEP	Kaski	18.2
5	Uttar Ganga Storage HEP	Baglung	828
7	Aadhikhola Storage HEP	Syangja	180
9	Begnas Rupa Pump Storage HEP	Kaski	150
		Total	1218.2
Sudurpashchim			
8	Chainpur Seti HEP	Bajhang	210
		Total	210
		Total	3219.2

IPPs Operation, Under Construction, Planned and Proposed Hydropower Plants in different provinces

	IPPs operation	**IPPs under construction**	**IPPS Planned Projects**
	Installed capacity MW	**MW**	**Installed capacity MW**
Province 1	236.8	700.596	378.842
Madhesh	13	14	14
Bagmati	255.7714	1875.933	618.278
Gandaki	255.088	748.901	814.105
Lumbini	24.61	11.415	11.885
Karnali	8.55	28.85	12
Sudurpashchim	20.826	127.09	2.233
	814.6454	3506.785	1851.343

Annex VIII. Petroleum Data

Petroleum products import in different FY in different provinces (NOC, 2021; DOC, 2021)

	Petrol(KL)	Diesel (KL)	Kerosene (KL)	ATF (KL)	LPG (MT)
F.Y. 2075-76					
Province 1	105,907	298,545	4,780	7,740	72,534
Madhesh	130,376	593,584	8,284	-	265,060
Bagmati	184,624	260,496	4,620	175,056	-
Gandaki	30,640	73,060	1,000	3,880	-
Lumbini	94,648	404,772	5,660	10,992	82,587
Karnali	-	-	-	-	-
Sudurpashchim	20,632	84,448	660	2,440	9,429
Total	566,827	1,714,905	25,004	200,108	429,609
F.Y. 2076-77					
Province 1	89,664	130,088	2,760	6,588	78,059
Madhesh	133,276	805,088	9,392	-	267,522
Bagmati	153,620	144,688	2,940	118,264	-
Gandaki	26,360	49,800	340	2,820	-
Lumbini	88,724	267,308	2,900	8,004	93,577
Karnali	-	-	-	-	-
Sudurpashchim	20,484	76,564	592	1,748	9,905
Total	512,128	1,473,536	18,924	137,424	449,063
F.Y. 2077-78					
Province 1	111,724	89,024	4,168	5,584	88,169
Madhesh	149,104	1,129,966	9,500	-	259,376
Bagmati	165,308	52,580	3,400	56,060	-
Gandaki	29,680	30,928	-	1,300	-
Lumbini	109,652	298,616	5,860	7,656	117,009
Karnali	-	-	-	-	-
Sudurpashchim	26,232	95,088	656	1,664	13,198
Total	591,700	1,696,202	23,584	72,264	477,752

Petroleum products Sales in different FY in different provinces

	Petrol(KL)	Diesel (KL)	Kerosene (KL)	ATF (KL)	LPG (MT)
F.Y. 2075-76					
Province 1	79,822	234,772	4,507	6,185	60,008
Madhesh	125,427	589,913	8,069	-	265,060
Bagmati	215,461	339,297	5,658	177,679	12,525
Gandaki	23,129	117,383	1,105	6,293	34,485
Lumbini	67,235	264,490	4,059	3,704	48,103
Karnali	31,192	71,923	986	3,854	-
Sudurpashchim	20,599	84,378	700	2,421	9,429
	562,866	1,702,157	25,086	200,137	429,609
F.Y. 2076-77					
Province 1	76,937	234,828	3,609	4,755	57,770
Madhesh	46,178	141,169	1,999	698	267,522
Bagmati	179,912	264,156	3,923	121,242	20,289
Gandaki	21,708	95,650	1,012	4,533	36,952
Lumbini	62,175	225,086	3,157	2,877	56,624
Karnali	27,439	61,671	745	2,822	-
Sudurpashchim	20,481	77,446	613	1,753	9,905
	434,831	1,100,006	15,058	138,680	449,063
F.Y. 2077-78					
Province 1	89,780	268,151	3,924	4,329	65,592
Madhesh	41,942	114,219	1,865	717	259,376
Bagmati	192,346	293,012	4,583	56,228	22,577
Gandaki	27,515	122,820	1,328	4,173	40,232
Lumbini	76,227	289,773	4,832	1,970	76,777
Karnali	30,892	64,739	1,472	1,326	-
Sudurpashchim	26,101	95,176	703	1,656	13,198
	484,803	1,247,890	18,707	70,400	477,752

Annex IX. Energy Consumption

2019

Category	Fuel Type	Energy (000 GJ)	000 TOE	GWh	% of National Total
Traditional	Fuelwood	365,088.96	8,720.00	101,413.60	62.03%
	Agricultural Residue	18,045.11	431.00	5,012.53	3.07%
	Animal Waste	18,840.60	450.00	5,233.50	3.20%
		401,974.67	**9,601.00**	**111,659.63**	**68.30%**
Commercial	Kerosene	889.87	21.25	247.19	0.15%
	Petrol	18,735.01	447.48	5,204.17	3.18%
	Diesel	63,604.81	1,519.17	17,668.00	10.81%
	ATF	6,306.28	150.62	1,751.75	1.07%
	LPG	19,605.69	468.27	5,446.02	3.33%
	Furnace Oil	1,221.93	29.19	339.43	0.21%
	Coal	40,780.08	974.02	11,327.80	6.93%
	Electricity	22,864.38	546.11	6,351.22	3.88%
		174,008.06	**4,156.11**	**48,335.57**	**29.56%**
Renewable	Biogas	8,174.99	195.26	2,270.83	1.39%
	Solar	4,080.09	97.45	1,133.36	0.69%
	Wind	1.04	0.02	0.29	0.00%
	Micro/Pico Hydro	325.94	7.79	90.54	0.06%
		12,582.07	**300.52**	**3,495.02**	**2.14%**
Total		**588,564.80**	**14,057.63**	**163,490.22**	**100.00%**

2020

Category	Fuel Type	Energy (000 GJ)	000 TOE	GWh	% of National Total
Traditional	Fuelwood	366,847.42	8,762.00	101,902.06	64.87%
	Agricultural Residue	18,254.45	436.00	5,070.68	3.23%
	Animal Waste	17,877.64	427.00	4,966.01	3.16%
		402,979.50	**9,625.00**	**111,938.75**	**71.26%**
Commercial	Kerosene	681.51	16.28	189.31	0.12%
	Petrol	14,473.37	345.69	4,020.38	2.56%
	Diesel	41,104.14	981.76	11,417.82	7.27%
	ATF	4,369.79	104.37	1,213.83	0.77%
	LPG	20,493.49	489.48	5,692.64	3.62%
	Furnace Oil	373.99	8.93	103.89	0.07%
	Coal	43,203.07	1,031.89	12,000.85	7.64%
	Electricity	23,200.05	554.12	6,444.46	4.10%
		147,899.40	**3,532.52**	**41,083.17**	**26.15%**
Renewable	Biogas	10,140.70	242.21	2,816.86	1.79%
	Solar	4,080.09	97.45	1,133.36	0.72%
	Wind	1.42	0.03	0.39	0.00%
	Micro/Pico Hydro	435.89	10.41	121.08	0.08%
		14,658.11	**350.10**	**4,071.70**	**2.59%**
Total		**565,537.01**	**13,507.62**	**157,093.61**	**100.00%**

(MoF, 2022; WECS, 2021; NOC 2021; AEPC, 2021; NEA, 2021; DoC, 2021; calculations)

Annex X. Sectoral Energy Consumption

Agricultural Sector

	2019	2020	2021
Fuelwood	-	-	-
Agricultural Residue	-	-	-
Animal Waste	-	-	-
Kerosene	-	-	-
Petrol	128.35	133.08	136.34
Diesel	8,417.34	8,712.73	8,942.76
ATF	-	-	-
LPG	-	-	-
Furnace Oil	-	-	-
Coal	-	-	-
Electricity	560.06	596.94	729.70
Biogas	-	-	-
Bio-briquette	-	-	-
Solar	7.10	18.89	25.29
Wind	-	-	-
Micro/Pico Hydro	-	-	-
	9,112.85	9,461.63	9,834.09

Commercial Sector

	2019	2020	2021
Fuelwood	22,455.56	21,638.15	22,964.13
Agricultural Residue	-	-	-
Animal Waste	-	-	-
Kerosene	-	-	-
Petrol	34.98	34.07	35.51
Diesel	36.54	35.53	37.10
ATF	-	-	-
LPG	9,168.73	9,583.92	10,847.60
Furnace Oil	-	-	-
Coal	3,265.90	3,153.46	3,295.35
Electricity	3,452.97	3,417.84	3,799.61
Biogas	40.39	44.97	51.67
Bio-briquette	-	-	-
Solar	2,183.04	2,165.53	2,723.80
Wind	-	-	-
Micro/Pico Hydro	-	-	-
	40,638.11	40,073.46	43,754.78

Industrial Sector

	2019	2020	2021
Fuelwood	19,906.96	18,262.79	19,273.78
Agricultural Residue	10,836.80	10,975.50	11,432.08
Animal Waste	-	-	-
Kerosene	303.16	218.45	278.07
Petrol	240.66	223.16	231.33
Diesel	14,448.78	9,453.95	14,597.05
ATF	-	-	-
LPG	1.71	1.79	2.03
Furnace Oil	1,221.93	373.99	3,399.09
Coal	37,514.18	40,049.61	55,150.22
Electricity	9,755.77	9,193.71	10,163.52
Biogas	-	-	-
Bio-briquette	-	-	-
Solar	-	-	-
Wind	-	-	-
Micro/Pico Hydro	-	-	-
	94,229.97	88,752.96	114,527.19

Residential Sector

	2019	2020	2021
Fuelwood	322,597.14	326,862.63	335,420.90
Agricultural Residue	7,208.31	7,278.95	7,350.28
Animal Waste	18,840.60	17,877.64	17,967.02
Kerosene	175.55	166.79	175.82
Petrol	-	-	-
Diesel	-	-	-
ATF	-	-	-
LPG	10,390.15	10,860.65	10,899.78
Furnace Oil	-	-	-
Coal	-	-	-
Electricity	9,075.49	9,977.37	11,668.28
Biogas	8,134.60	10,095.74	9,705.28
Bio-briquette	-	-	-
Solar	1,889.96	1,895.68	2,010.59
Wind	1.04	1.42	1.87
Micro/Pico Hydro	325.94	435.89	514.96
	378,638.78	385,452.76	395,714.78

Transportation Sector

	2019	2020	2021
Fuelwood	-	-	-
Agricultural Residue	-	-	-
Animal Waste	-	-	-
Kerosene	-	-	-
Petrol	18,269.69	14,035.01	19,092.85
Diesel	36,140.77	19,917.37	35,280.34
ATF	6,306.28	4,369.79	2,218.29
LPG	0.09	0.10	0.11
Furnace Oil	-	-	-
Coal	-	-	-
Electricity	15.91	9.84	6.98
Biogas	-	-	-
Bio-briquette	-	-	-
Solar	-	-	-
Wind	-	-	-
Micro/Pico Hydro	-	-	-
	60,732.75	38,332.11	56,598.58

Construction and Mining Sector

	2019	2020	2021
Fuelwood	129.30	83.84	131.55
Agricultural Residue	-	-	-
Animal Waste	-	-	-
Kerosene	411.16	296.27	377.14
Petrol	61.33	48.05	64.83
Diesel	4,561.38	2,984.55	4,608.19
ATF	-	-	-
LPG	44.99	47.03	53.23
Furnace Oil	-	-	-
Coal	-	-	-
Electricity	4.18	4.34	5.29
Biogas	-	-	-
Bio-briquette	-	-	-
Solar	-	-	-
Wind	-	-	-
Micro/Pico Hydro	-	-	-
	5,212.34	3,464.09	5,240.22

Annex XI. Energy conversion table

	to -->															
from	MJ	TCE	cub m	btu	toe	boe	kWh	kwyr	kcal	TJ	Gcal	Mtoe	Mbtu	GWh	GWyr	PJ
MJ	1	3.41208E-05	0.02684061	947.8672986	2.388E-05	0.0001751	0.277777778	3.171E-05	238.8459	0.000001	0.0002388	2.388E-11	0.0009479	2.778E-07	3.171E-11	1E-09
TCE	29307.6	1	786.633946	27779715.64	0.7	5.131	8141	0.9293379	7000000	0.0293076	7	0.0000007	27.779716	0.008141	9.293E-07	2.931E-05
cubm	37.256973	0.001271239	1	35314.66672	0.0008899	0.0065227	10.34915928	0.0011814	8898.6752	3.7257E-05	0.0088987	8.899E-10	0.0353147	1.035E-05	1.181E-09	3.726E-08
btu	0.001055	3.59975E-08	2.8317E-05	1	2.52E-08	1.847E-07	0.000293056	3.345E-08	0.2519824	1.055E-09	2.52E-07	2.52E-14	0.000001	2.931E-10	3.345E-14	1.055E-12
toe	41868	1.428571429	1123.76278	39685308.06	1	7.33	11630	1.3276256	10000000	0.041868	10	0.000001	39.685308	0.01163	1.328E-06	4.187E-05
boe	5711.869	0.194893783	153.310066	5414093.869	0.1364256	1	1586.630286	0.1811222	1364256.5	0.005711869	1.3642565	1.364E-07	5.4140939	0.0015866	1.811E-07	5.712E-06
kWh	3.6	0.000122835	0.09662621	3412.322275	8.598E-05	0.0006303	1	0.0001142	859.84523	0.0000036	0.0008598	8.598E-11	0.0034123	0.000001	1.142E-10	3.6E-09
kwyr	31536	1.076034885	846.445568	29891943.13	0.7532244	5.521135	8760	1	7532244.2	0.031536	7.5322442	7.532E-07	29.891943	0.00876	0.000001	3.154E-05
kcal	0.0041868	1.42857E-07	0.00011238	3.968530806	0.0000001	7.33E-07	0.001163	1.328E-07	1	4.1868E-09	0.000001	1E-13	3.969E-06	1.163E-09	1.328E-13	4.187E-12
TJ	1000000	34.12084238	26840.6129	947867298.6	23.88459	175.07404	277777.7778	31.709792	238845897	1	238.8459	2.388E-05	947.8673	0.2777778	3.171E-05	0.001
Gcal	4186.8	0.142857143	112.376278	3968530.806	0.1	0.733	1163	0.1327626	1000000	0.0041868	1	0.0000001	3.9685308	0.001163	1.328E-07	4.187E-06
Mtoe	4.187E+10	1428571.429	1123762780	3.96853E+13	1000000	7330000	11630000000	1327625.6	1E+13	41868	10000000	1	39685308	11630	1.3276256	41.868
Mbtu	1055	0.035997489	28.3168466	1000000	0.0251982	0.1847031	293.0555556	0.0334538	251982.42	0.001055	0.2519824	2.52E-08	1	0.0002931	3.345E-08	1.055E-06
GWh	3600000	122.8350326	96626.2064	3412322275	85.984523	630.26655	1000000	114.15525	859845228	3.6	859.84523	8.598E-05	3412.3223	1	0.0001142	0.0036
GWyr	3.154E+10	1076034.885	846445568	2.98919E+13	753224.42	5521135	8760000000	1000000	7.532E+12	31536	7532244.2	0.7532244	29891943	8760	1	31.536
PJ	1E+09	34120.84238	26840612.9	9.47867E+11	23884.59	175074.04	277777777.8	31709.792	2.388E+11	1000	238845.9	0.0238846	947867.3	277.77778	0.0317098	1

MJ	Megajoule
TCE	tons of coal equivalent
Cub m	cubic meter
Btu	British thermal unit
Toe	tones of oil equivalent
Boe	barrels of oil equivalent
kWh	kilowatt-hours
kWyr	kilowattyears
kcal	kilocalorie
TJ	terajoule
Gcal	gigacalorie
Mtoe	million toe
Mbtu	milliom bt
GWh	gigawatthours
GWyr	giiawattyear
PJ	petajoule