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Electricity Demand Creation in Residential Sectors of Nepal

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Abstract

This research examines electricity demand in Nepal's residential sector, analyzing consumption patterns, demand-stimulation techniques, infrastructure challenges, affordability, and the consequences of rising demand. It emphasizes the need for sustainable growth through ongoing regulations, community involvement, and technology improvements. Nepal is transitioning to renewable energy but currently accounts for only 8.87% of total power use. The study uses the LEAP energy model to project electricity demand from 2021 to 2045 under various scenarios.

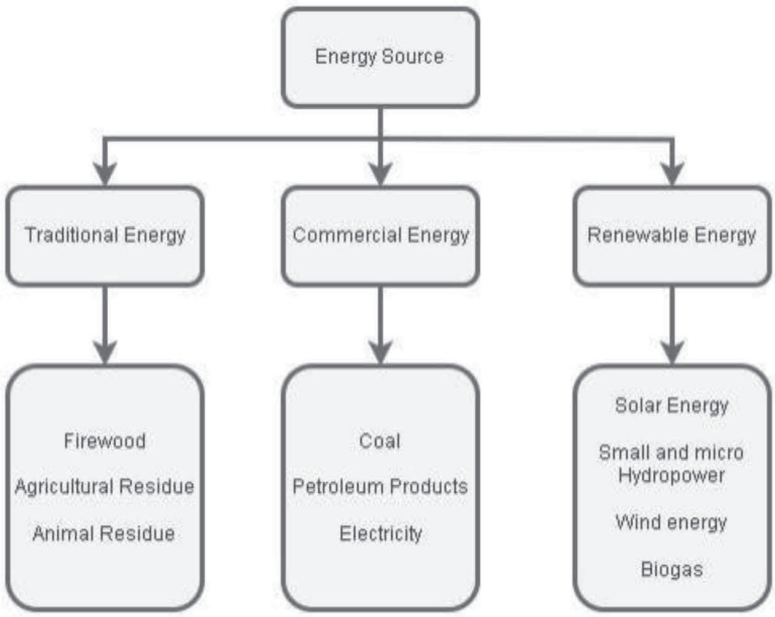
Introduction

Nepal, a landlocked nation in the Himalayas rich in natural resources like hydropower, faces significant energy challenges. Its residential sector, encompassing homes and small enterprises, plays a crucial role in energy consumption, accounting for 64% of the nation's total energy use. Energy consumption has increased at a 4% annual rate over the past decade, driven by factors like population growth, urbanization, and improved living standards. While traditional energy sources like fuelwood still dominate at 85%, there is a notable shift towards commercial sources (coal, petroleum products, and electricity) at 31% and renewable energy sources at 2%. Electricity use has risen from 1% in 2009 to 3%. Energy intensity in the residential sector decreased from 14 GJ per capita to 13.2 GJ per capita in 2019, reflecting cleaner energy technologies and improved energy access. Nepal has made remarkable progress in increasing its energy production capacity, with an annual growth rate of 16.29% over the past five years and a 10.63% rate over the past decade. However, electricity production has outpaced consumption, indicating potential oversupply in the future. To address this situation, Nepal is focusing on increasing electricity demand strategically through initiatives like the "Electricity Demand Creation in Different

Sectors" research. This effort aims to optimize energy resources, reduce reliance on imported fossil fuels, and create a more electrified and resilient future. It underscores the importance of informed policy choices and responsible strategies to achieve the country's energy goals effectively.

Literature review

Energy access is vital for a nation's progress, closely linked to economic growth and population expansion. C ountry’s development is measured by its energy consumption, influenced by factors like population density, economic activity, technology, climate, and energy prices. Energy management strategies aim to boost efficiency, cut costs, and minimize environmental impact through energy-efficient technologies, behavior changes, and renewable energy adoption.



The residential sector's growth is crucial for economic development, and electricity demand is integral to global energy networks. As global energy consumption rises, understanding and managing household power demand becomes critical. Domestic power use significantly impacts sustainability and overall energy efficiency. Embracing renewable energy in households gains importance in the transition to cleaner energy sources. Promoting domestic energy production is cost-effective, reducing the need for energy exports. Thus, increasing national energy demand is only 0.4% of cooking is done using electricity and Nepal has possibility to switch into electric medium in future years. Similarly, water boiling consumes 2.136% of energy also space heating

consumes 0.57% of energy, space cooling consumes 1.32768% of the energy, lighting consumes 1.2556% of energy, electrical appliances consume 3.453% energy and other end use uses 11.689% of energy.

Nepal's energy landscape includes 2130 MW from various sources like IPPs, NEA, and subsidiaries, with an additional 3260 MW from hydropower stations under development. In 2022, the country is expected to produce 11,064 GWh of electricity, with NEA contributing 3259 GWh, subsidiaries providing 1976 GWh, independent power producers delivering 4286 GWh, and 1543 GWh imported from India. Total electricity sales in Nepal for 2022 reached 9,316 GWh. The nation's installed capacity is anticipated to meet peak demand by 2022, with a growing consumer base. The Nepal Electrical Authority oversees the creation, distribution, and management of electrical supply, with a hydropower capacity potential of nearly 83,000 megawatts. The transmission directorate is responsible for planning, constructing, maintaining transmission lines, substations, and necessary upgrades. Progress is evident in completed transmission projects and line lengths, ensuring steady development in the transmission sector.

In 2021, total power usage in Nepal reached 7313 GWh, marking a significant increase over 25 years, growing nearly 10 times from 328.72 GWh in 1996 to 3241.189 GWh in 2021 in the residential sector. According to the 2022 energy synopsis report, the residential sector accounted for the highest electricity consumption at 44.24%, followed by the industrial sector at 38.54% and the commercial sector at 14.41%. The Compound Annual Growth Rate (CAGR) of 9.586% highlights the continuous growth in electricity consumption, with the residential sector leading the increase. This trend is indicative of rising electricity demand in the residential sector. The projection for electricity demand also shows an upward trend, from 1847.52 GWh in 2015 to 11632.15 GWh in 2030 during peak hours. This demand encompasses the residential sector, where there is a significant need for electricity to operate various components. To achieve sustainability and combat climate change, transitioning to electrical mediums is essential. Technologies in the residential sector, including cooking, water boiling, space heating, space cooling, lighting, electrical appliances, and others, play a pivotal role in this transition.

Policies

The Government of Nepal, in partnership with various development partners, has devised plans and policies to promote electricity and electricity-based technologies in the country. Key initiatives include aligning with Sustainable Development Goals (SDGs), aiming for widespread electricity access, increased per capita electricity consumption, and expanding hydropower capacity. Additionally, there is a strong focus on transitioning to electric vehicles in both public and private transportation. The Second Nationally Determined Contribution plan emphasizes a substantial increase in clean energy production, with specific targets for renewable energy sources and electric vehicle adoption. These initiatives reflect Nepal's commitment to sustainable energy development and transportation, contributing to its economic growth and environmental objectives.

Methodology

Data Collection and Energy Demand Modeling in Nepal's Residential Sector

The study on Nepal's residential sector relied on government reports and data from agencies like CBS, NEA, AEPC, and WECS. Data collection directly covered provinces One, Two, and Three, with projections for other provinces. Energy demand modeling, using the MAED, MARKAL, and LEAP models, played a crucial role in forecasting future energy needs and optimizing energy systems. These tools helped analyze the current energy situation, predict future demand, and assess different energy scenarios, benefiting stakeholders and decision-makers alike.

Scenarios for Future Energy Consumption and Policy Considerations in Nepal's Residential Sector

The study explores potential scenarios for future energy consumption in Nepal's residential sector, considering different GDP growth rates and national policies related to demand creation. Data from government reports, yearbooks, and official websites of agencies like CBS, NEA, AEPC, and WECS were used. Key factors influencing these scenarios include current energy consumption, end-user technology effectiveness, technological advancement, and economic expansion, which were input into the LEAP model.

Three growth scenarios (low, medium, and high) from 2021 to 2050 were considered, with average GDP growth rates of 2.5%, 4.27%, and 6.5%. GDP and population were identified as major drivers for household growth in the residential sector, with population elasticity at 1.04 and GDP elasticity at 0.02. These factors were used to project the number of households and, consequently, future energy demand.The scenarios examined include:

Business as Usual (BAU) Scenario:

Assumes no significant technological changes or shifts in social attitudes. Relies on the current average GDP growth rate of 4.27% to meet electricity demand.

Sustainable Development Goal (SDG) Scenario: Aligns with the United Nations' SDGs for sustainable development. Targets include achieving per capita GDP growth of at least 7%, reducing solid fuel usage for cooking, and increasing the use of LPG. Second

Nationally Determined Contribution (NDC) Scenario: Aims to increase clean energy production to 15,000 MW by 2030, with a focus on renewable sources. Targets include the adoption of electric stoves, improved cookstoves, and household biogas plants.

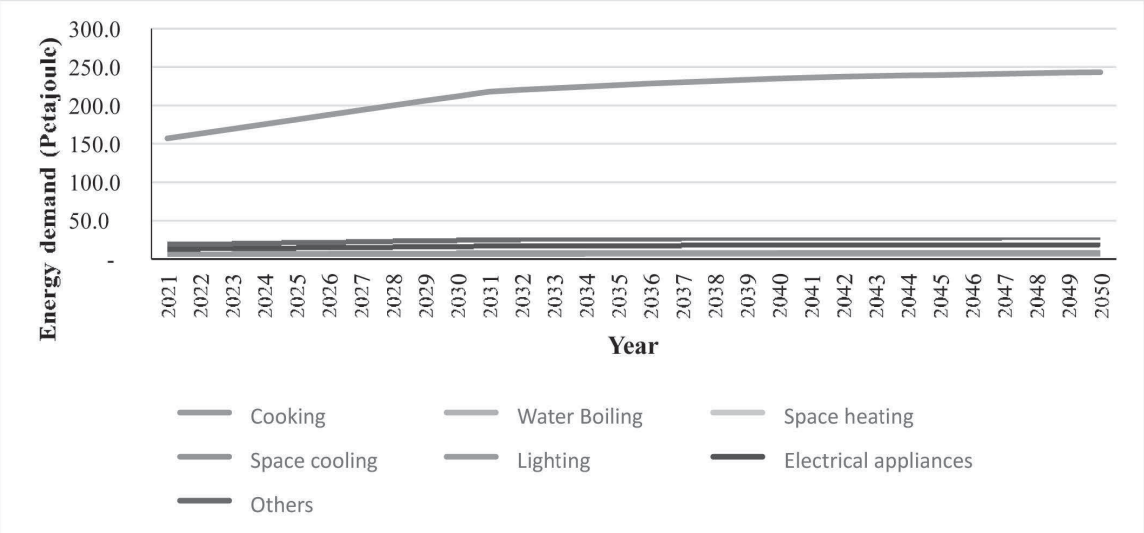
Nepal's Long-Term Strategy for Net Zero Emission (LTS) Scenario: Targets 100% electrification in various residential end-uses by 2030. Aims for per capita GDP growth of at least 7%. Overall, these policy scenarios encompass a range of potential outcomes, considering both technological advancements and shifts in societal attitudes toward energy consumption. The scenarios are guided by national and global goals for sustainable development and clean energy adoption.

Results and discussion

Energy Forecasting Business As Usual (BAU) Scenario

Urban BAU Scenario

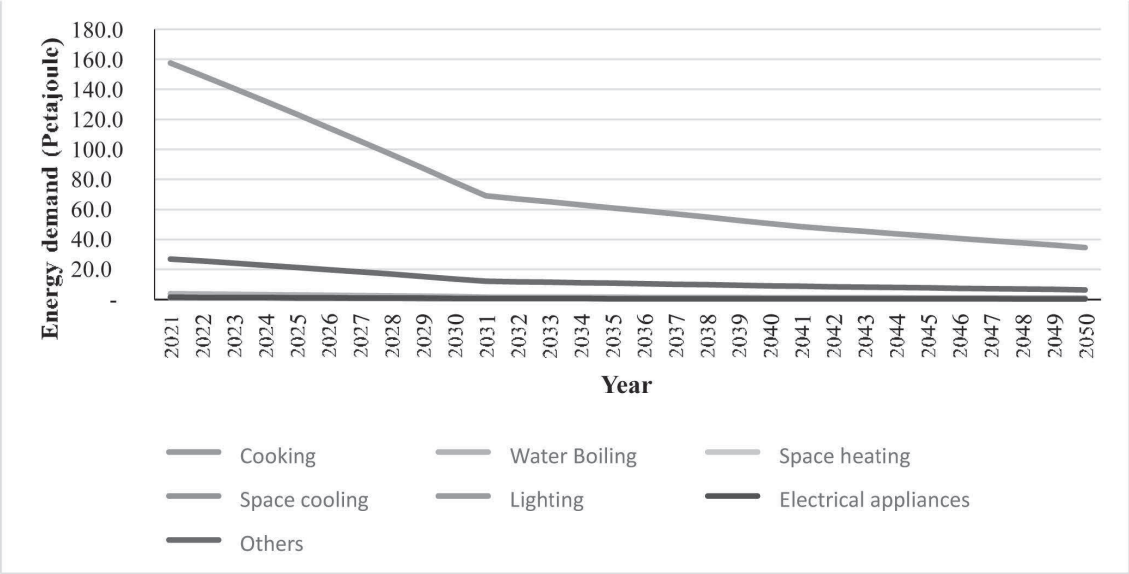
In the urban sector, energy demand was 202.1PJ in 2021 and is projected to increase to 312.8PJ with current GDP growth. Cooking activities account for a significant portion, consuming 157.1PJ in 2021, expected to rise to 243.3PJ by 2030. This increase is driven by the rapid adoption of electrification strategies for more energy-efficient and sustainable cooking practices, along with rural-to-urban migration intensifying cooking energy demand in urban areas.



Rural BAU Scenario

In rural areas, energy demand was 193.6PJ in 2021 and is expected to decrease to 43.3PJ in a medium growth scenario by 2030. Cooking activities have a significant impact on rural energy consumption, using 157.4PJ in 2021. This reduction is driven by two key factors: changing fuel

Usage patterns favoring more energy-efficient practices and ongoing rural-to-urban migration, which lowers energy demand in rural regions.

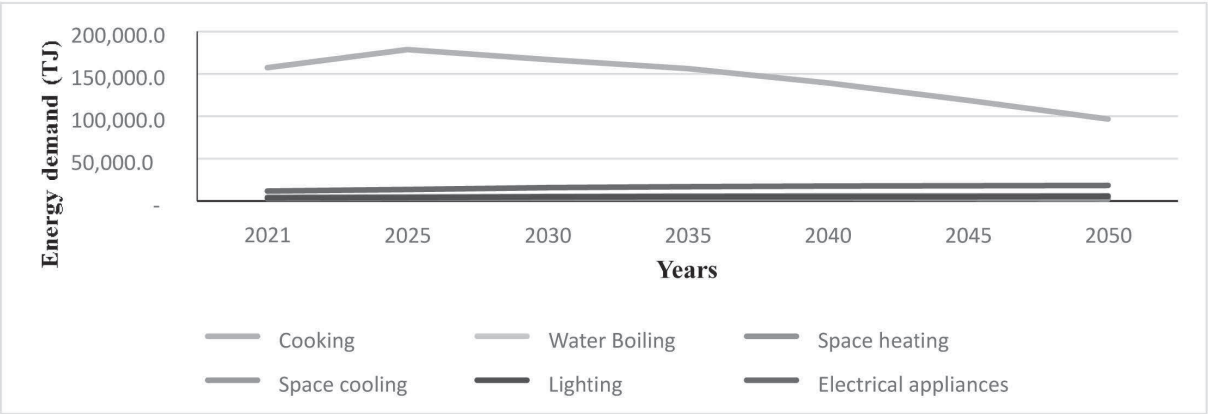


Sustainable Development Goal (SDG) scenario

End use wise demand

i. Urban sector

Due to electrification, energy demand for cooking decreases, while electricity demand increases significantly in urban areas from 2025 to 2050. In other end uses, there are slight changes in energy demand due to population growth. The use of firewood and solid fuels for various purposes decreases, while the demand for electricity rises substantially, driven by electrification initiatives.



For instance: Cooking energy demand decreases due to electrification, targeting a 30% reduction in primary cooking sources by 2050. Firewood consumption decreases significantly for water boiling, space heating, and lighting, with almost complete electrification. Solar energy use for lighting and increasing adoption of electrical appliances contribute to higher electricity demand. Overall, these changes align with Sustainable Development Goals (SDG) targets and a shift towards more sustainable and energy-efficient practices in urban areas.

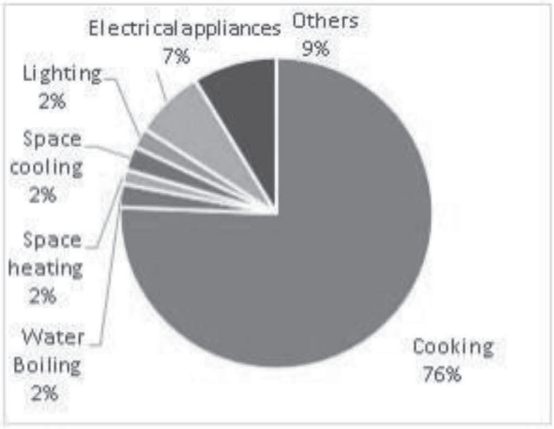


Figure 4-4 Urban sector energy demand 2030 end use wise

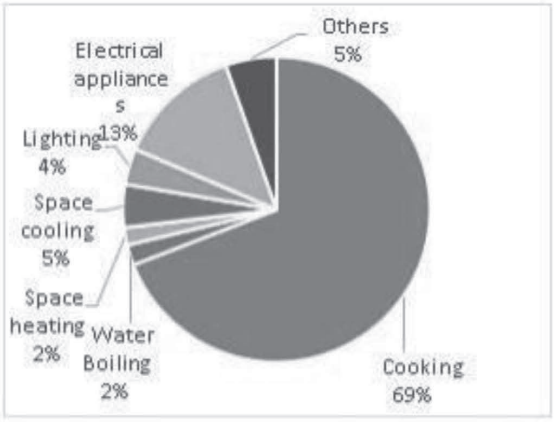
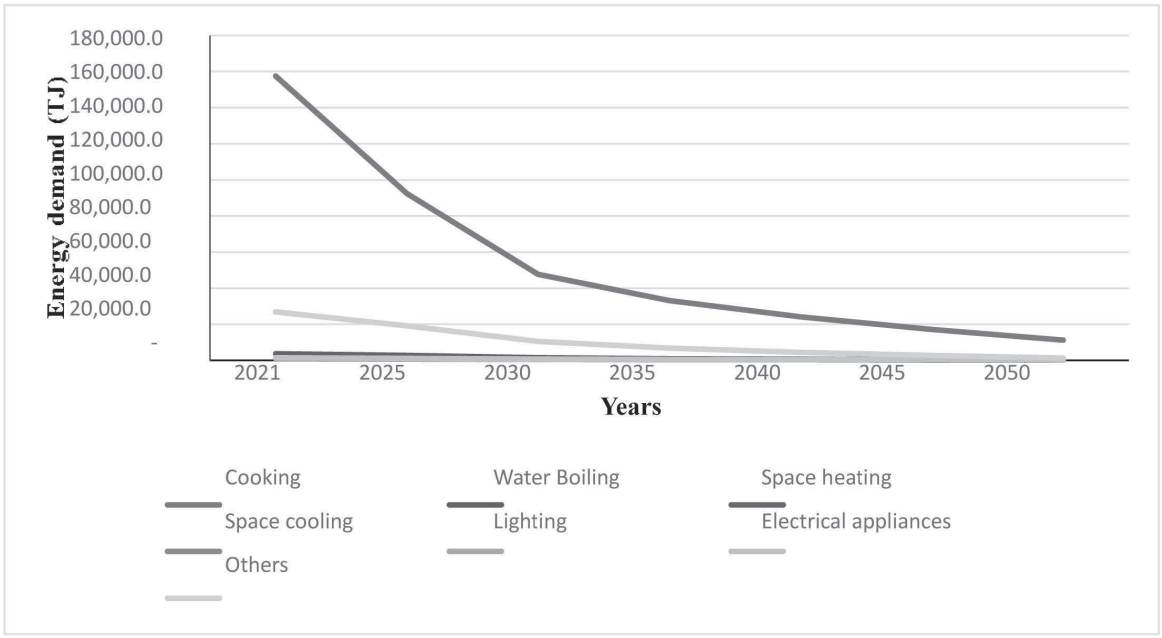


Figure 4-5 Urban sector energy demand 2050 end use wise

ii. Rural Sector

The energy demand for cooking in rural areas is expected to decrease rapidly due to urbanization and shifting populations to urban areas. This trend is driven by initiatives to reduce the use of solid fuels such as firewood and increase the use of LPG and electricity for cooking. By 2030, the use of firewood for cooking is projected to decrease significantly. For water boiling and space heating purposes, similar trends are observed with a reduction in the use of solid fuels and an increase in electricity demand due to electrification efforts. In the case of space cooling, electricity is the primary source, and its demand is expected to decrease due to a declining rural population as people move to urban areas. Kerosene usage for lighting is anticipated to decrease significantly, and the demand for electricity and solar lighting is also expected to decline as rural populations decrease. Overall, the shift away from solid fuels and the electrification of rural areas are driving changes in energy demand patterns, with electricity and LPG becoming more prominent sources of energy, particularly by 2050, to meet Sustainable Development Goals (SDGs).



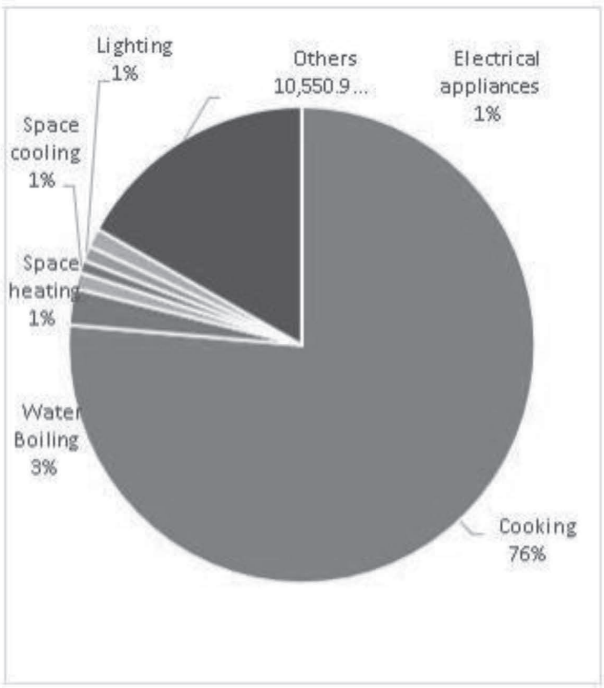


Figure 4-7 Rural electricity demand 2030 end use wise

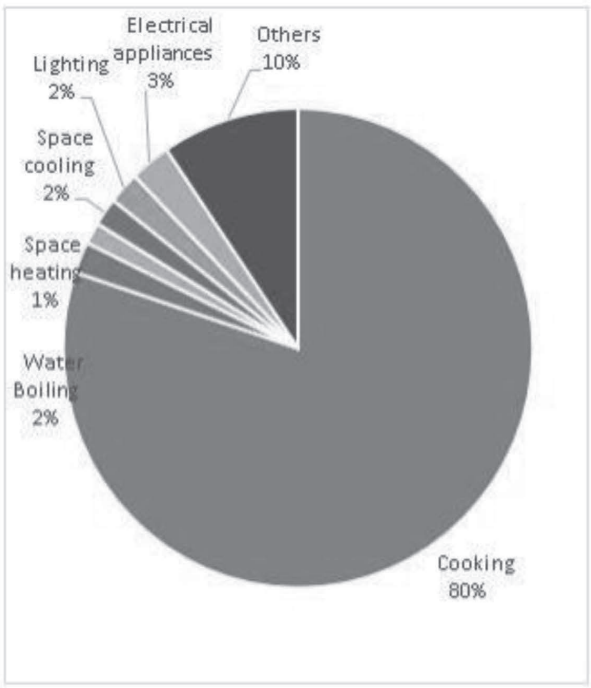


Figure 4-8 Rural electricity demand 2050 end use wise

Fuel wise SDG scenario

The reduction of solid fuel usage, particularly firewood, is a significant trend, reaching zero usage by 2050. This decline is a result of efforts to meet Sustainable Development Goals (SDGs) and reduce reliance on traditional solid fuels. In contrast, the demand for electricity and LPG (liquefied petroleum gas) is steadily increasing due to electrification initiatives and greater use of LPG for lighting and heating. By 2030, the use of wood is projected to account for 53% of total energy usage, eventually dropping to 0% by 2050 as per SDG targets. In contrast, electricity consumption is expected to rise to 17% of total energy usage by 2030, with electricity and LPG jointly contributing 44% and 56%, respectively, to total energy use by 2050, in line with SDG objectives.

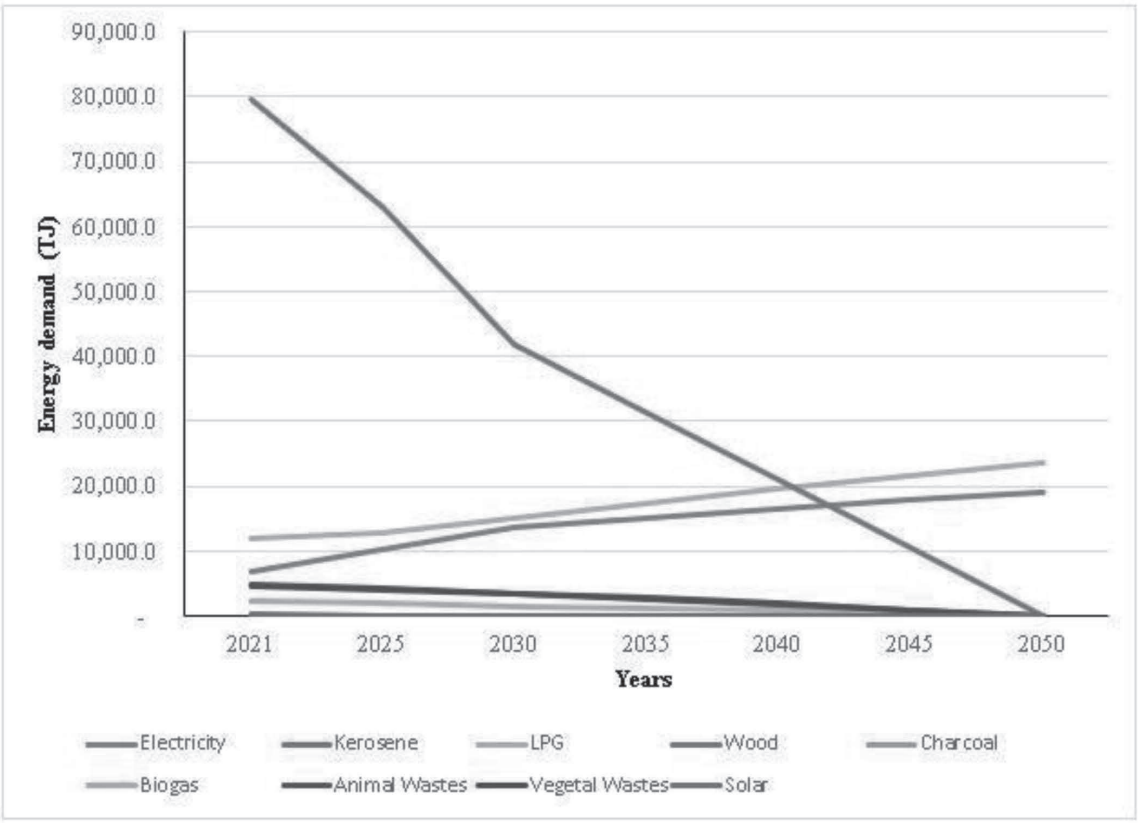


Figure 4-9 Fuel wise overall demand according to Sustainable Development Goals

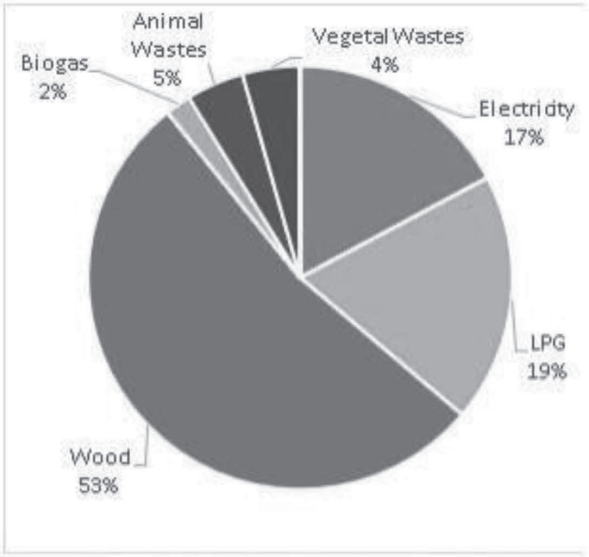


Figure 4-10 Fuel wise electricity demand 2030 SDG

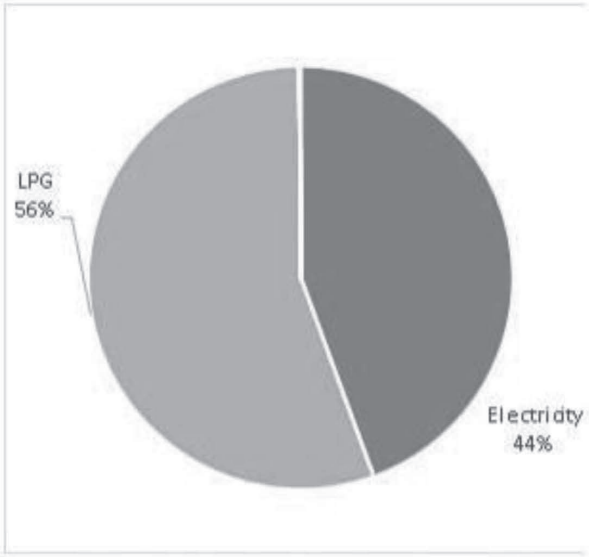


Figure 4-11 Fuel wise electricity demand 2050 SDG

Second Nationally Determined Contribution (NDC) scenario

End-use wise demand

i. Urban sector

The National Determined Contributions (NDC) for urban energy in this analysis outline significant shifts in energy demand and sources:

- Cooking: Energy demand for cooking is set to decrease substantially, reaching 76% of total energy usage by 2030 and 63% by 2050. The NDC emphasizes the adoption of electric stoves, improved cookstoves, and biogas plants. Consequently, electricity consumption is expected to increase, reaching 16% of total energy usage by 2050.
- Water Boiling: Electrification strategies will lead to a reduction in the use of solid fuels, LPG, and briquettes. This will result in a substantial increase in electricity demand, growing from 473.8 TJ to 2588.1 TJ by 2050.
- Space Heating: As electrification advances, there will be a decrease in the use of firewood, agricultural residue, and LPG for space heating. Electricity demand for space heating is projected to rise from 473.8 TJ to 2588.1 TJ by 2050.

- Space Cooling: The increasing prevalence of air conditioners will drive up electricity demand for space cooling, growing from 4063.4 TJ to 6371 TJ by 2050.
- Lighting: Electrification efforts in lighting will reduce the use of kerosene, leading to a surge in electricity demand for lighting, increasing from 3202.8 TJ to 5187.4 TJ by 2050. Solar lighting will also experience growth.
- Electrical Appliances: Urbanization will fuel demand for electrical appliances, resulting in a substantial increase in electricity consumption, growing from 11728.7 TJ to 18389.4 TJ by 2050.
- Other End Uses: Solid fuel, LPG, and biogas usage will decrease in other end uses. Simultaneously, electricity demand will experience significant growth, surging from 18 TJ to 7466 TJ by 2050.

Overall, the NDC initiatives aim to reduce reliance on solid fuels, promote electrification, and encourage the adoption of renewable energy sources to meet urban energy demands.

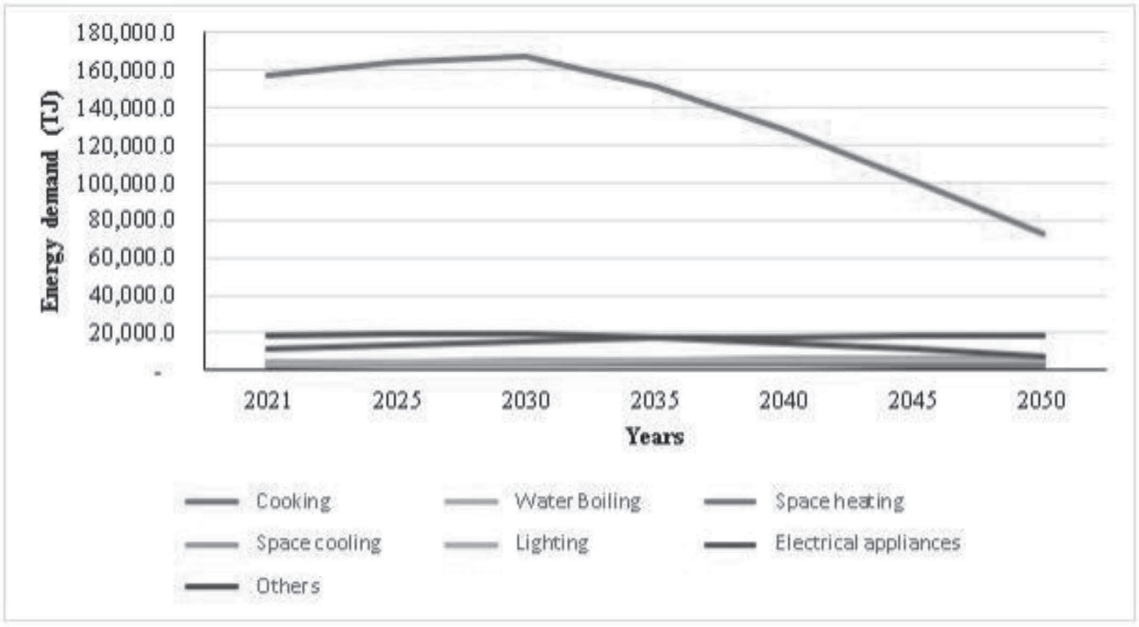


Figure 4-12 Second Nationally Determined Commissions (NDC) Urban Energy demand

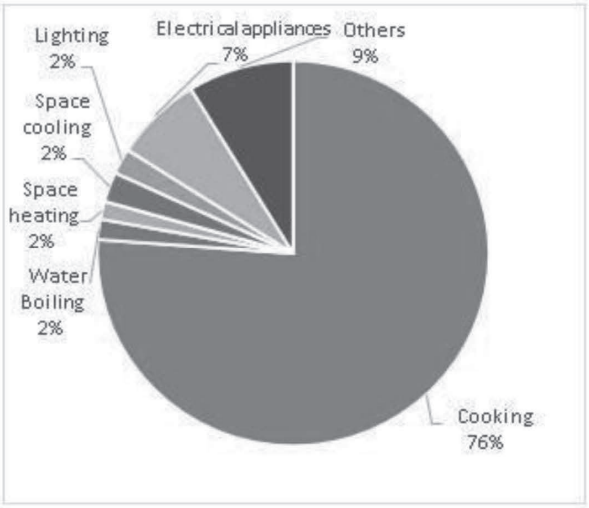


Figure 4-13 Urban energy demand 2030 end use wise NDC

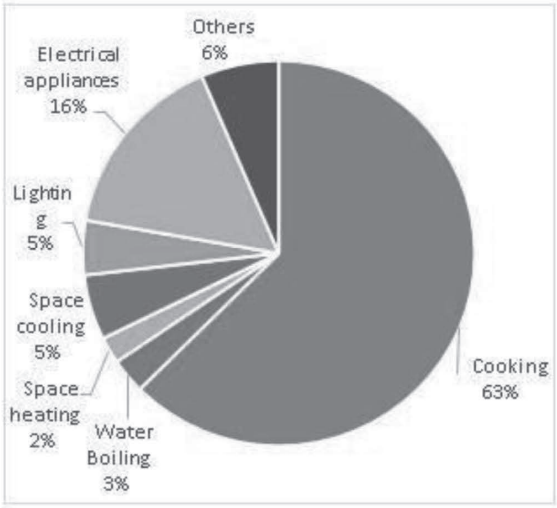


Figure 4-14 Urban energy demand 2050 end use wise NDC

ii. Rural sector

In the rural sector, several noteworthy trends related to energy usage emerge due to an increase in population and rapid electrification strategies:

- Cooking: The adoption of electric cookstoves and improved cookstoves results in a substantial reduction in energy usage for cooking. By 2030, energy usage for cooking is expected to decrease to 81% of total energy consumption, further dropping to 76% by 2050. This shift is primarily due to the decreased reliance on traditional solid fuel cooking methods like firewood.
- Electric Appliances: The use of electric appliances is on the rise in rural areas, with their share of total energy consumption increasing from 1% in 2030 to 3% by 2050. This reflects the trend of rural electrification and the growing demand for electrical devices.
- Water Boiling: The implementation of electrification strategies leads to a decrease in the use of solid fuels, LPG, and biogas for water boiling. This results in a significant increase in electricity demand for water boiling, projected to rise from 19 TJ to 150.17 TJ by 2030 and further to 238.37 TJ by 2050.
- Space Heating: Energy demand for space heating sees a notable shift away from firewood, with a decrease from 1535.8 TJ to 552.9 TJ by 2030. The increasing use of electric heaters and air conditioners contributes to a rise in electricity demand for heating, reaching 206 TJ by 2050.

- Space Cooling: The demand for electricity in space cooling, primarily driven by fans, coolers, and air conditioners, decreases from 1030.5 TJ to 206.25 TJ by 2050. This decrease is attributed to the continuous migration of the rural population to urban areas.
- Lighting: Electrification efforts lead to a reduction in the use of kerosene and biogas for lighting, resulting in a decrease in energy demand for rural lighting from 948 TJ to 290 TJ by 2050. This decline is due to the ongoing shift of the rural population to urban regions.
- Other End Uses: The demand for other fuels besides electricity, such as solid fuels, LPG, and biogas, decreases significantly as rural areas experience rapid electrification. This shift results in a substantial increase in electricity demand for other end uses, growing from 9.15 TJ to 1337.5 TJ by 2050.

In summary, the rural sector is witnessing a transformation in energy usage patterns, driven by increased electrification and a decreasing reliance on solid fuels and traditional energy sources. These changes are influenced by population growth and the migration of rural residents to urban areas.

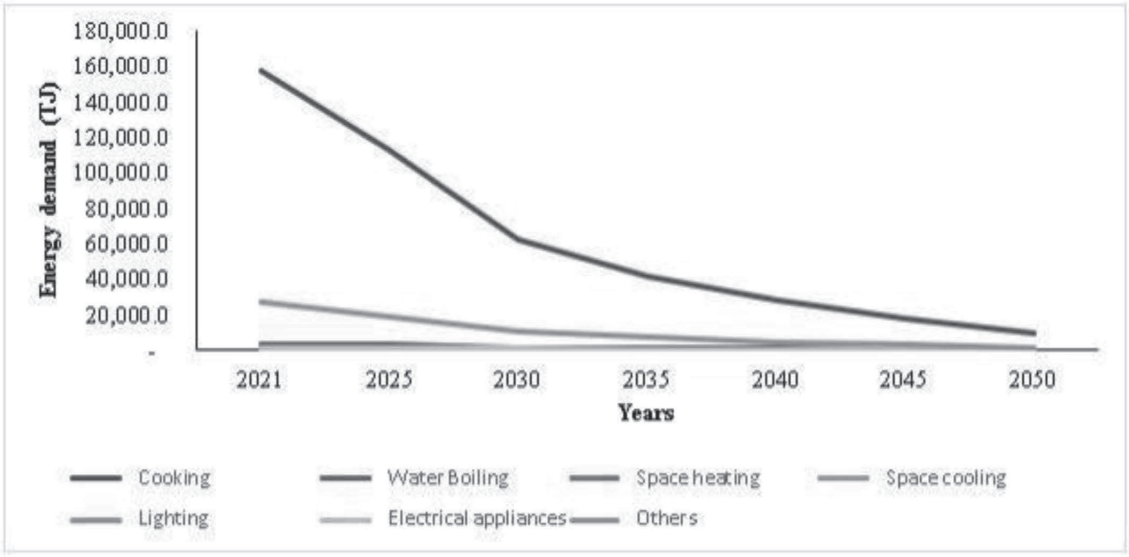


Figure 4-15 Second Nationally Determined Commissions Rural Energy demand

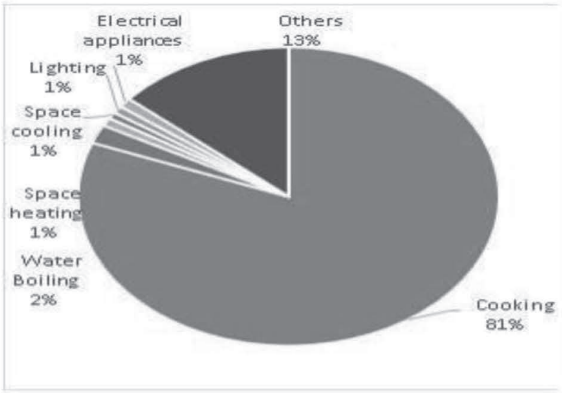


Figure 4-16 Rural energy demand 2030 end use wise NDC

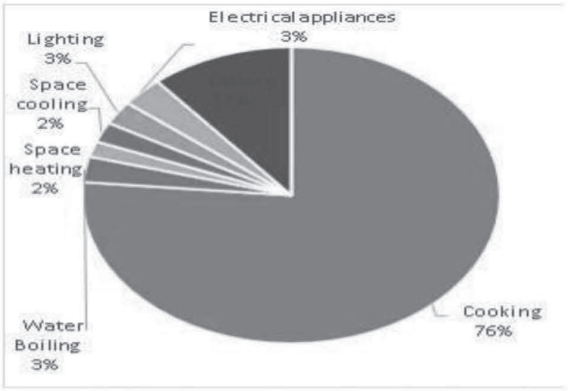


Figure 4-17 Rural energy demand 2050 end use wise NDC

Fuel-wise NDC scenario

The analysis shows a significant reduction in the use of firewood as a result of the NDC's efforts to promote electric and improved cookstoves, leading to a decrease in reliance on solid fuels. This shift toward electrification is accompanied by a notable increase in electricity demand, which is projected to rise from 17% of total energy usage in 2030 to 77% by 2050. Additionally, the NDC's initiatives also aim to increase the utilization of LPG and biogas, further contributing to the diversification of energy sources in the future

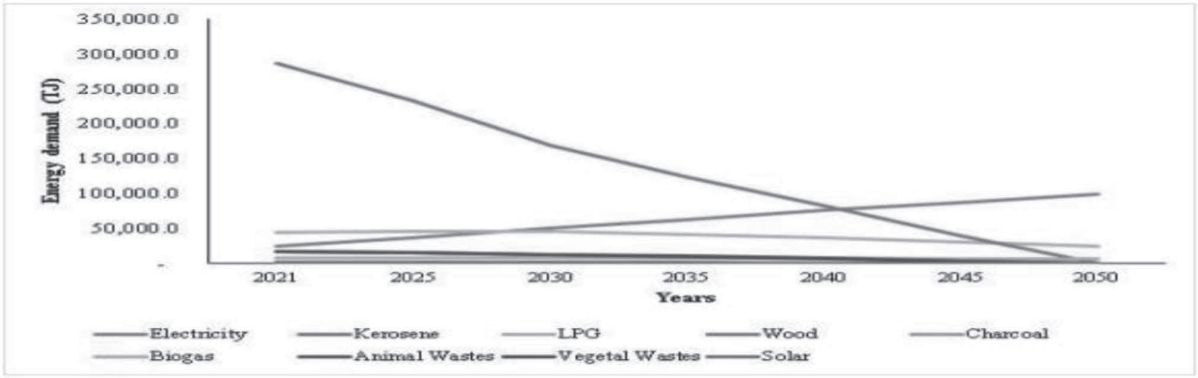


Figure 4-18 Fuel wise overall demand according to Second Nationally Determined Commission (NDC)

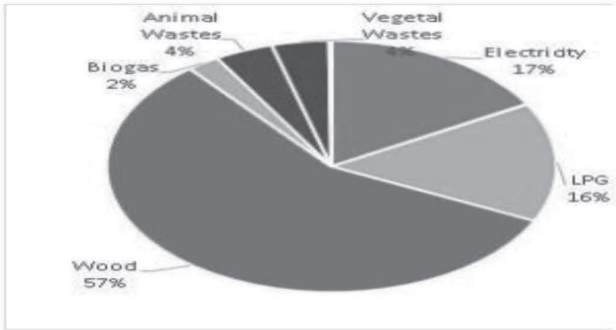


Figure 4-19 Fuel wise energy demand 2030 NDC

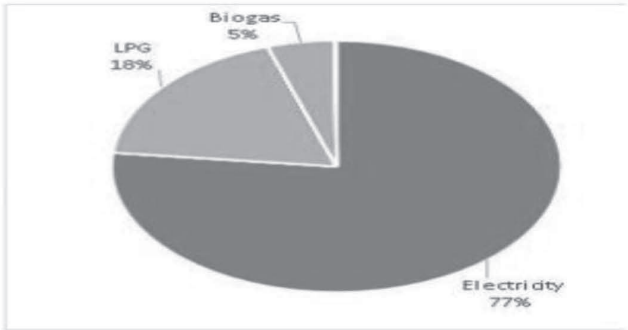


Figure 4-20 Fuel wise energy demand 2050 NDC

Nepal's long-term strategy for net zero emission (LTS) scenario

LTS targets to achieve per capita GDP growth of at least seven percent by 2030 and acquire 100% electrification in different end uses of residential sector.

End-use wise demand

i. Urban sector

In the urban sector, rapid electrification efforts have led to a substantial reduction in the use of solid fuels, particularly for cooking, thanks to the adoption of energy efficient technologies. This shift towards electrification has also resulted in s ignificant increase in electricity demand, driven by the use of electric appliances and water boilers for heating. Here are the key findings:

- Cooking Fuel Transition: The consumption of firewood for cooking is expected to decrease significantly, dropping from 102,683TJ to 95,986TJ by 2030, and eventually reaching zero by 2050, in line with a 100% electrification target.
- Increased Electricity Demand: Electricity demand is projected to experience substantial growth, surging from 1,071TJ to 59,805TJ by 2050. This growth is primarily due to increasing electrification efforts and the growth of urban populations.
- Heating Transformation: The use of solid fuels, LPG, and biogas for heating purposes is anticipated to decrease significantly, with electric water boilers becoming more prevalent. This shift will result in increased electricity demand for heating, rising from 146TJ to 3,009TJ by 2050.
- Space Heating: There will be a noticeable decline in the use of solid fuels, LPG, and briquettes for space heating. Electric heaters will become the preferred choice, leading to electricity demand increasing from 473.8TJ to 2,588TJ by 2050.
- Space Cooling: Electricity will be the primary energy source for fans, coolers, and air conditioners. Consequently, electricity demand for space cooling is expected to rise significantly, increasing from 4,063TJ to 6,371TJ by 2050.
- Lighting Transition: The use of kerosene for lighting will be completely phased out due to electrification and the adoption of electric bulbs. Electricity demand for lighting is projected to increase from 3,202TJ to 5,283TJ by 2050. Solar lighting will experience initial growth and then decline as electrification reaches 100%.
- Electrical Appliances: Demand for electricity in operating electrical appliances is set to increase substantially, rising from 11,728TJ to 18,389TJ by 2050.

This increase is driven by the exclusive use of electricity for these devices. Additionally, other end uses will reduce their reliance on solid fuels, biogas, and LPG, resulting in increased electricity demand from 18TJ to 7,466TJ by 2050. Overall, the urban sector is undergoing a significant transformation towards electrification, which is leading to changes in energy consumption patterns and a notable increase in electricity demand across various end use

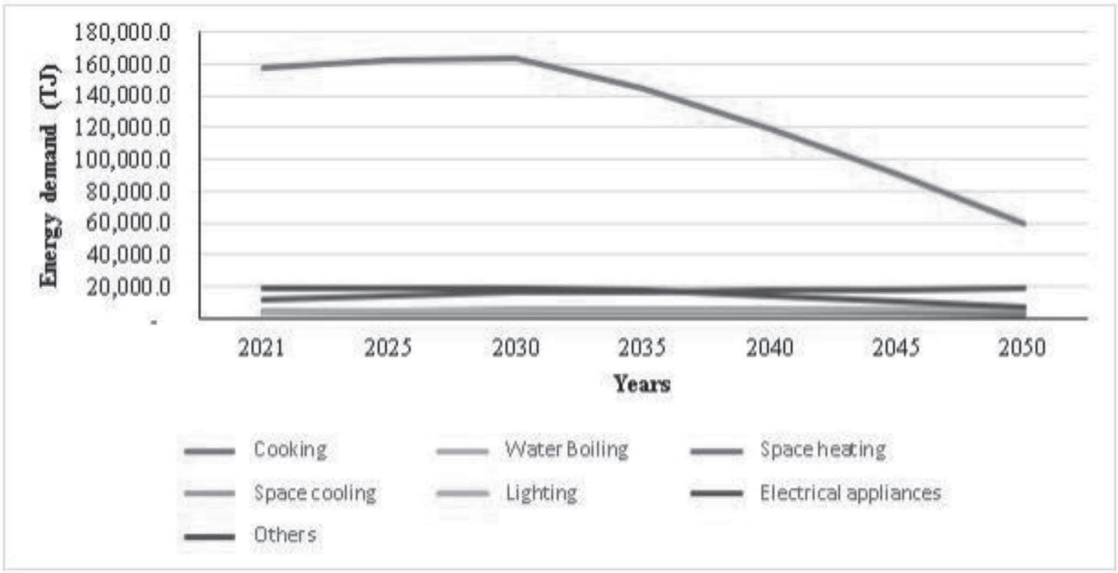


Figure 4-21 LTS Urban energy demands

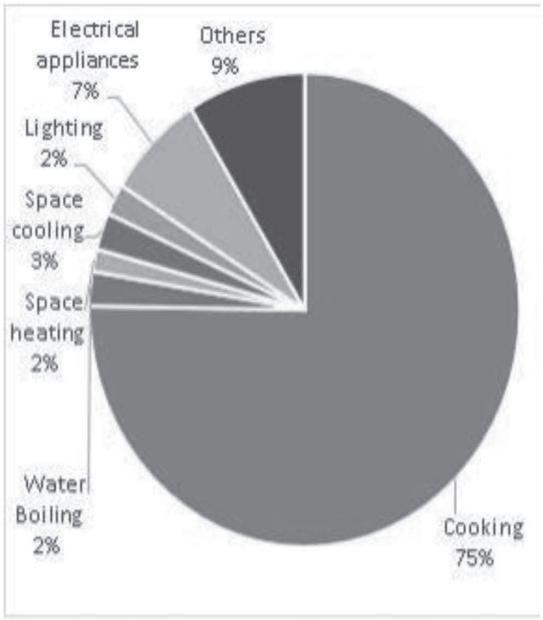


Figure 4-22 Urban energy demand 2030 end use wise

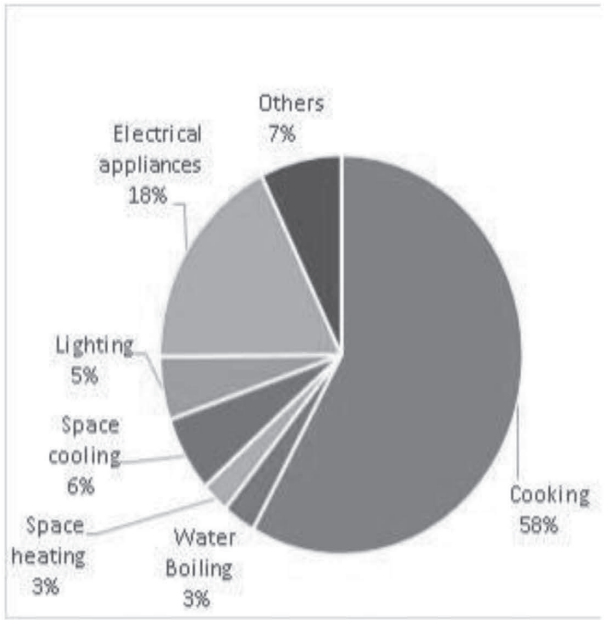


Figure 4-23 Urban energy demand 2050 end use wise

Rural sector

In the rural sector, significant changes in energy consumption are driven by population shifts to urban areas and adoption of energy-efficient technologies: Cooking Fuel Transition: Firewood use for cooking decreases from 136,373 TJ to 49,095 TJ by 2030, reaching zero by 2050 with full electrification. Electricity Demand: Despite a decrease in rural population, electricity consumption rises from 160 TJ to 7,943.135 TJ by 2050 due to increased adoption of energy-efficient technologies. Water Boiling: Shift to electric water boilers reduces solid fuels, LPG, and biogas use, increasing electricity demand to 298 TJ by 2050. Space Heating: Firewood use declines from 1,535.8 TJ to zero by 2050; electricity demand for heating increases to 206 TJ. Space Cooling: Electricity becomes primary for cooling, reducing demand to 267 TJ by 2050 with urbanization. Lighting Transition: Kerosene use ends, electricity demand for lighting decreases to 305 TJ by 2050. Electrical Appliances: Electricity demand for appliances decreases to 392 TJ by 2050 as population shifts to urban areas. Other End Uses: Reduced solid fuels, biogas, and LPG use increases electricity demand to 1,337 TJ by 2050.

The rural sector experiences a significant shift away from traditional solid fuels and other sources toward electricity, driven by the adoption of energy-efficient technologies and the target of achieving full electrification by 2050 according to the LTS. This transition results in changes in energy consumption patterns and a notable increase in electricity demand across various end uses.

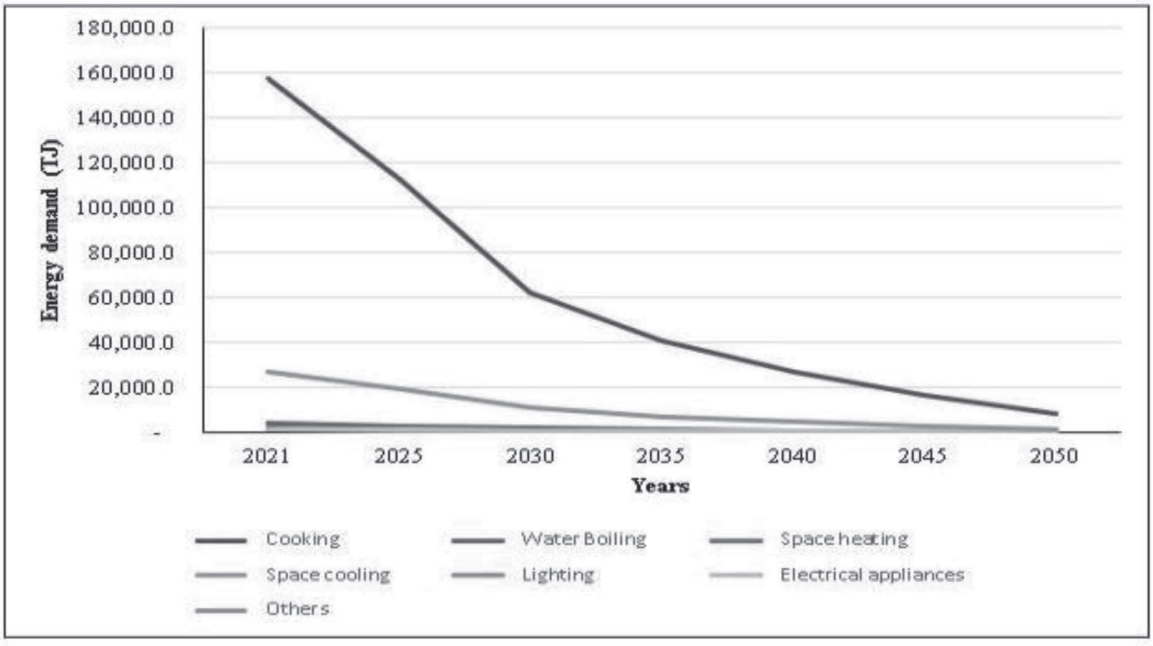


Figure 4-24 LTS Rural energy demand

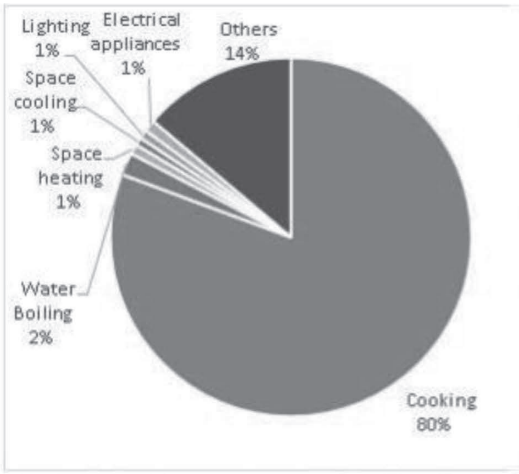


Figure 4-25 Rural energy demand 2030 end use wise

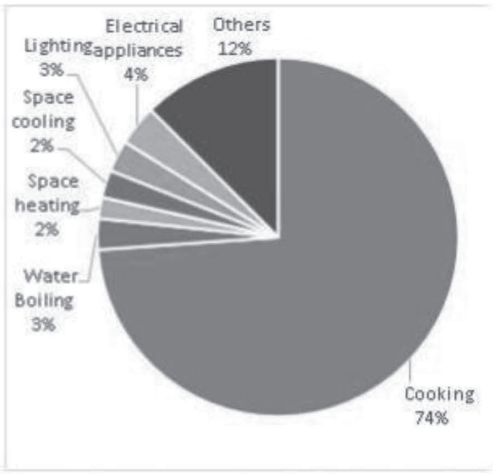
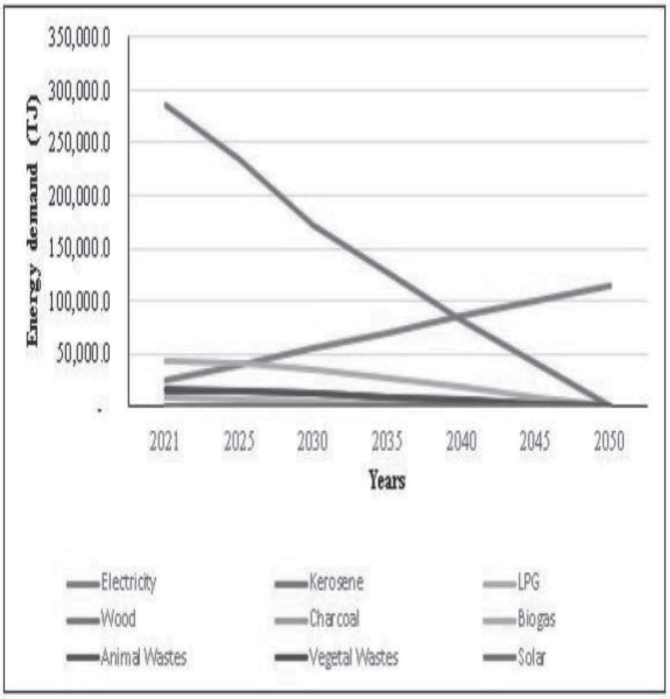


Figure 4-26 Rural energy demand 2050 end use wise

Fuel-wise LTS scenario

According to the data, there is c lear trend of decreasing reliance on firewood as s ource of fuel, with the goal of reaching 100% electrification by 2050 as outlined in the LTS. By 2030, the use of firewood is projected to represent only 73% of total energy usage, and it is expected to drop to 0% by 2050. This shift away from traditional fuels is accompanied by an increase in electricity demand driven by the adoption of energy efficient technologies, leading to a change in the energy consumption landscape as all fuel types decrease in use while electricity demand rises in accordance with the LTS scenario



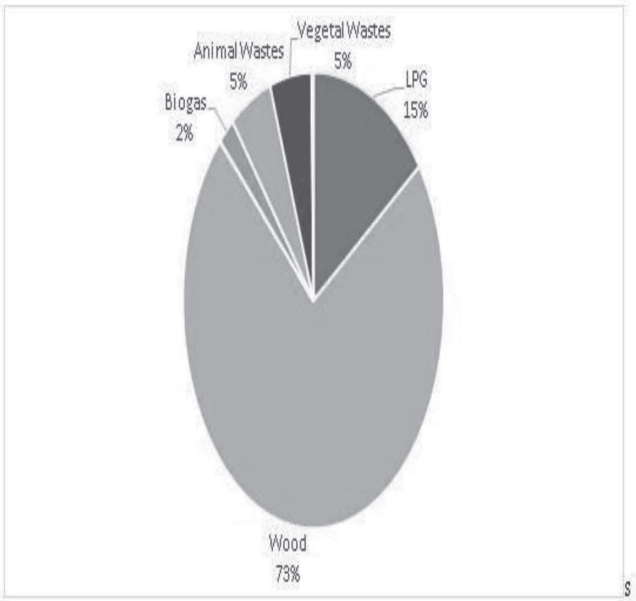


Figure 4-28 Fuel wise demand 2030 LTS

Fuel-wise LTS scenario

Total Energy in different scenarios

In 2021, the residential sector's total energy demand was 395.7 petajoules (PJ). However, different growth and policy scenarios are expected to influence this demand. In a low-growth scenario, energy demand is projected to decrease to 353.3 PJ. In a medium-growth scenario, it is expected to rise slightly to 356 PJ. In a high-growth scenario, energy demand may increase to 359.7 PJ. The energy demand trajectory also varies based on policy orientations: Under a low growth policy, demand is predicted to reach 111.3 PJ. In a medium-growth policy scenario, it could increase to 112.3 PJ. In a high-growth policy scenario, energy demand might reach 119.4 PJ. In the baseline or Business-As-Usual (BAU) scenario, a slight decline in total energy demand is anticipated. This is due to prevailing trends favoring electric appliances over traditional wood fuel sources, resulting in lower energy intensity. Conversely, policy scenarios aimed at promoting energy efficiency and sustainability are expected to significantly reduce energy demand by 2030. This reduction is attributed to the adoption of energy-efficient practices and technologies driven by these policies. This trend is expected to continue, albeit at a slower pace, until 2050. These reductions are primarily due to the consistent implementation of electrification and the integration of energy-efficient electrical equipment, both central to the policy strategies. In summary, while the baseline scenario suggests a modest decline in energy demand based on current trends, policy scenario offer promising avenue for substantial energy reduction through electrification and the promotion of energy-efficient practices in the residential sector.

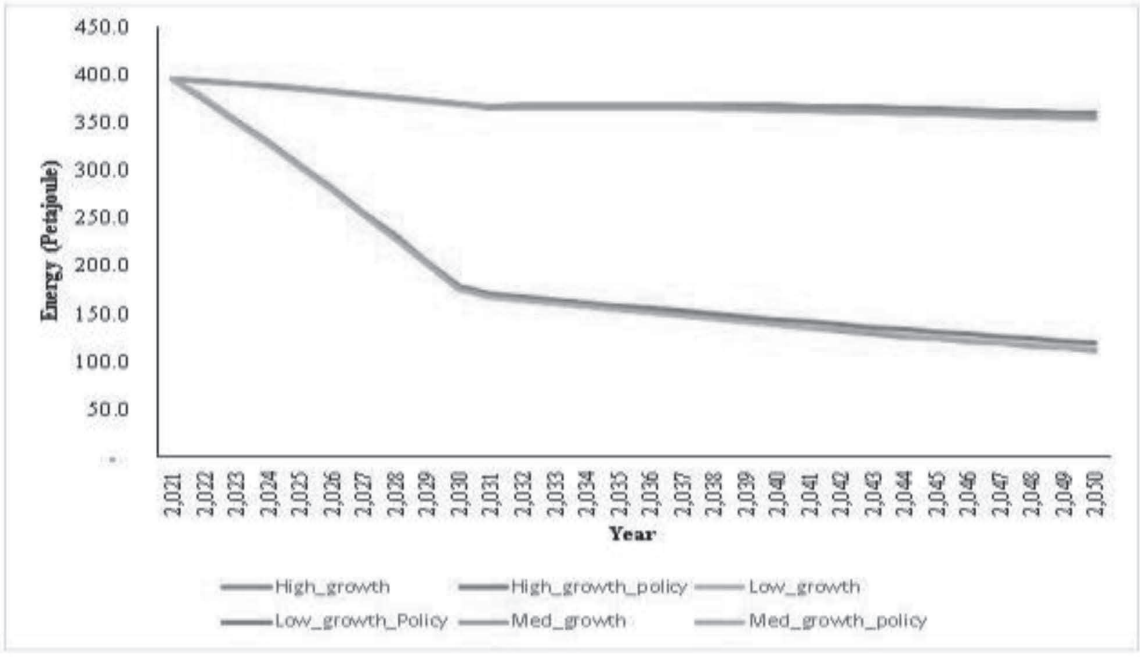


Figure 4-29 Total energy in different scenarios

Power generation requirements

In order to meet the electricity requirements for various scenarios:

Sustainable Development Goals (2030/2050): In the Sustainable Development Goal (SDG) scenario for 2030, a total electricity production of 9643.972 MW is required. The urban sector needs 8009.155 MW, while the rural sector needs 1634.817 MW in 2030. In 2050, the total electricity production requirement under SDG rises to 14831.98 MW. The urban sector requires 13428.49 MW, while the rural sector requires 1403.499 MW by 205

Table 4-43 Power generation requirement according to Sustainable development Goals (SDG)

End-use/year	2030			2050		
	Urban	Rural	Total	Urban	Rural	Total
Cooking	2248.151	951.0502	**3199.201**	3776.575	668.7671	**4445.342**
Water boiling	718.3562	147.3973	**865.7534**	2290.137	226.8493	**2516.986**
Space Heating	498.4127	61.26984	**559.6825**	1129.524	90.95238	**1220.476**
Space Cooling	764.95	74.7	**839.65**	884.85	37.1	**921.95**
Lighting	975.1076	120.2348	**1095.342**	1127.906	65.59687	**1193.503**
Electrical appliances	2419.726	120.4384	**2540.164**	2799.014	59.78082	**2858.795**
Others	384.4521	159.726	**544.1781**	1420.479	254.4521	**1674.932**
Total	**8009.155**	**1634.817**	**9643.972**	**13428.49**	**1403.499**	**14831.98**

Second Nationally Determined Contribution (2030/2050): For the Second Nationally Determined Contribution (NDC) scenario in 2030, 2540.164 MW of electricity production is required. In this scenario, the urban sector needs 2419.746 MW, and the rural sector requires 120.4384 MW in 2030. By 2050, the total electricity production requirement for NDC is 2858.795 MW. The urban sector needs 2799.014 MW, while the rural sector requires 59.78 MW in 2050.

Table 4-44 Power generation requirement according to Second Nationally Determined Contribution (NDC)

End-use/year	2030			2050		
	Urban	Rural	Total	Urban	Rural	Total
Cooking	2459.178	761.0959	**3220.274**	8950.342	1208.082	**10158.42**
Water boiling	494.7945	114.2466	**609.0411**	1801.37	181.3699	**1982.74**
Space Heating	501.4286	61.26984	**562.6984**	1141.111	90.95238	**1232.063**
Space Cooling	764.95	74.7	**839.65**	884.85	37.1	**921.95**
Lighting	953.5812	118.8258	**1072.407**	1127.906	63.24853	**1191.155**
Electrical appliances	2419.726	120.4384	**2540.164**	2799.014	59.78082	**2858.795**
Others	384.4521	159.726	**544.1781**	1420.479	254.4521	**1674.932**
Total	**7978.11**	**1410.303**	**9388.413**	**18125.07**	**1894.986**	**20020.06**

Nepal's Long-Term Strategy for Net Zero Emissions (LTS) (2030/2050): In the Nepal Long-Term Strategy (LTS) scenario for 2030, a total electricity production of 11112.06 MW is needed. The urban sector's requirement is 8991.418 MW, and the rural sector needs 2120.638 MW in 2030. In 2050, the total electricity production requirement for LTS is 23974.73 MW. The urban sector requires 21063.04 MW, while the rural sector requires 2911.693 MW by 2050.

Compared to the SDG and NDC scenarios, the LTS scenario envisions higher electricity production requirements, emphasizing the use of electricity over other renewable sources. This is driven by targets like per capita GDP reaching 7% and achieving 100% electrification by 2050

Table 4-45 Power generation requirements according to LTS strategy

End-use/year	2030			2050		
	Urban	Rural	Total	Urban	Rural	Total
Cooking	3243.288	1274.338	**4517.626**	11378.56	2014.977	**13393.54**
Water boiling	718.3562	147.3973	**865.7534**	2290.137	226.8493	**2516.986**
Space Heating	501.4286	142.963	**644.3915**	1141.111	212.2222	**1353.333**
Space Cooling	764.95	74.7	**839.65**	884.85	37.1	**921.95**
Lighting	959.2172	120.7828	**1080**	1148.885	66.45793	**1215.342**
Electrical appliances	2419.726	200.7306	**2620.457**	2799.014	99.6347	**2898.648**
Others	384.4521	159.726	**544.1781**	1420.479	254.4521	**1674.932**
Total	**8991.418**	**2120.638**	**11112.06**	**21063.04**	**2911.693**	**23974.73**

Electricity forecasting

Total electricity demand in different scenarios

In 2021, the cumulative electricity demand in the residential sector was 6782.3 GWh. Projections for the future show various potential scenarios: In the low growth scenario, electricity demand is expected to increase to 9173.3 GWh. In the medium growth scenario, it could reach 9294.4 GWh. Under the high growth scenario, the demand may rise to 9343.5 GWh. Low growth policy, medium growth policy, and high growth policy scenarios anticipate electricity demand at 30928.7 GWh, 31183.7 GWh, and 30668.3 GWh, respectively. Comparatively, the Business-AsUsual (BAU) scenario predicts a modest increase in electricity demand due to ongoing trends and urbanization. However, introducing various policy interventions leads to different demand trajectories, emphasizing the role of proactive energy management and policy design in influencing residential electricity consumption. In summary, while the BAU scenario suggests a gradual increase in demand, different growth and policy scenarios present a range of potential outcomes shaped by trends, demographics, and policy actions, highlighting the importance of informed decision-making in managing residential energy demand.

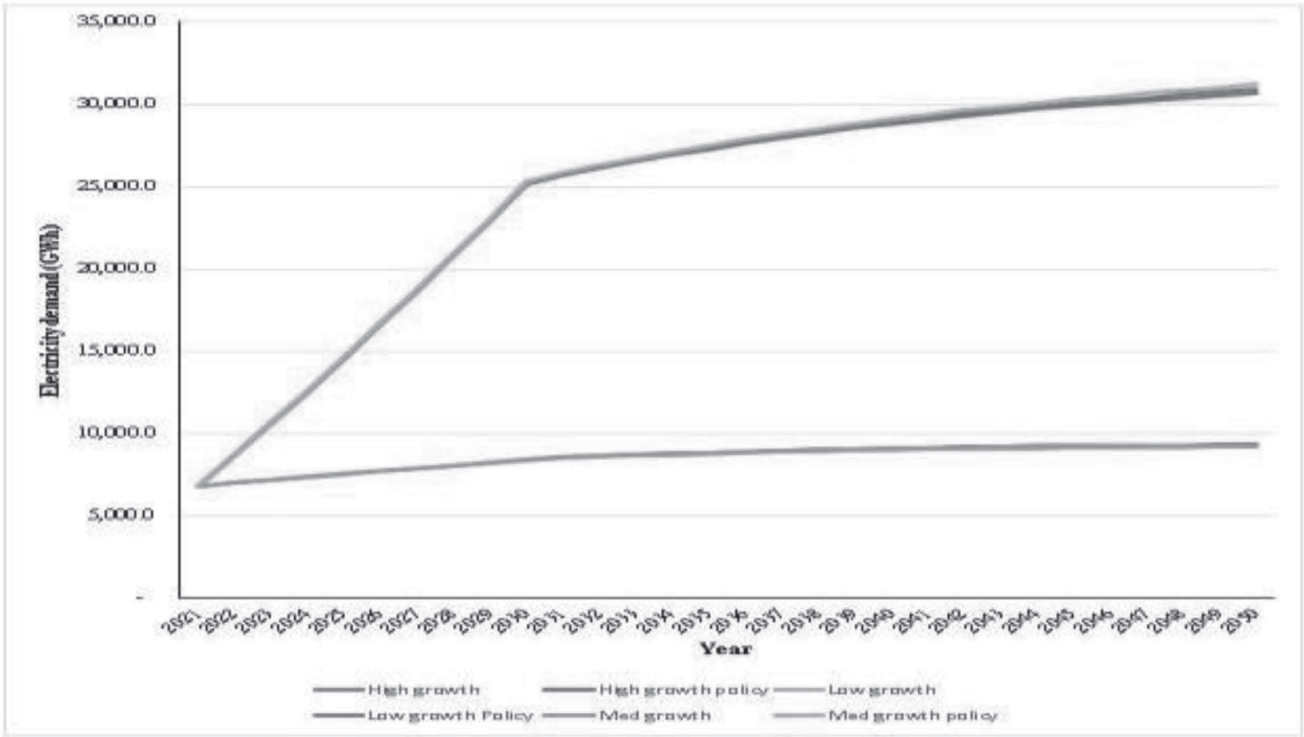


Figure 4-30 Total electricity demand in different scenarios

Conclusion

This research aims to provide practical strategies for promoting sustainable power demand, enhancing energy efficiency, and ensuring reliable access to electricity in Nepal's residential sectors. Currently, residential families consume 43.3% of the electricity, making the transition to electrical appliances a crucial research topic with limited existing literature. The research emphasizes the overall electricity and energy consumption trends in the residential sector, highlighting a Compounded Annual Growth Rate (CAGR) of 9.586% in electricity consumption, with the fastest growth observed in this sector. Peak-hour demand is projected to increase significantly by 2030. Various scenarios, including Sustainable Development Goals (SDG), Second Nationally Determined Contribution (NDC), and Long-Term Strategy for Zero Emissions (LTS), were considered to forecast energy consumption patterns. These scenarios show a shift away from solid fuels like wood towards electricity and LPG, indicating a strong demand for electrically powered devices in homes. Additionally, the study explored growth scenarios such as Low Growth, Medium Growth, High Growth, and Policy Scenario, using publicly available data from Nepali government organizations. These scenarios were input into the LEAP model to estimate energy demand in various residential subsectors. In summary, the research projects an increase in electricity demand in the overall residential sector, from 6844.6 GWh in the base year to varying levels in different growth scenarios by 2050. This underlines the importance of planning for increased energy consumption and the transition to cleaner energy sources in Nepal's residential sector.

Recommendations

To ensure a sustainable and resilient energy future in Nepal's residential sectors, the following key strategies and initiatives have been proposed:

- Investment in Infrastructure: Upgrade and expand electricity generation, transmission, and distribution infrastructure.
- Technology Transformation: Promote the use of electric appliances over traditional fuel based ones.
- Energy Efficiency Programs: Launch campaigns to encourage energy-conscious behavior, set energy-efficient standards, and provide incentives for adoption.
- Renewable Energy Integration: Increase the installation of solar panels and wind turbines, with incentives and subsidies.
- Grid Modernization: Upgrade the electrical system to accommodate distributed energy resources, smart grids, and microgrids.
- Energy Storage Solutions: Promote household energy storage systems, like batteries, for backup power and stability.
- Public Awareness Campaigns: Educate the public about sustainable energy practices.
- Incentive Mechanisms: Provide financial incentives and tax breaks for energy-efficient appliances and renewables.
- Policy and Regulatory Frameworks: Create and enforce policies that encourage energy management, renewables, and private sector involvement.

These initiatives aim to meet rising energy demand sustainably and ensure a resilient energy landscape for Nepal.

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