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Commercial Sector Energy Demand Projections of Nepal for Sustainable Sectoral Energy Planning

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Abstract

Nepal's commercial sector consumed 1.3% of total national energy consumption in 2009. Although from national perspective, the sectoral energy consumption is low but reliable future energy demand is an essential requirement for sustainable utilization of available energy resources. The purpose of this study is to project the sectoral energy demand up to 2030 under selected anticipated growth scenarios of national economy. To project future energy demand, the end use commercial sector energy demand model based on Long –range Energy Alternative Planning (LEAP) framework has been formulated with four GDP growth scenarios namely business as usual (BA), low growth (LG), medium growth (MG) and high growth (HG) respectively. The output of the model has been validated from base year 2005 to 2009 with actual energy consumptions. It has been found that the overall total energy demand of the sector from 2005 to 2030 will be raised by 2.5, 3.1, 4.3 and 5.7 folds and will be reached to 13.2 PJ, 16.6 PJ, 22.9 PJ and 30.3 PJ on BA, LG, MG and HG scenarios respectively. Further, this study has illustrated that among commercial sub-sectors; restaurants, hotels, academic institutions, hospitals, institutions, cinema halls and water supplies will be increased with AAGR of 4.4%, 4.8%, 1.3%, 0.4% and 3.1%, 6.1% and 6% respectively from 2005 to 2030 while the demand of essential and non- essential shops sub sector will be decreased with -0.7% AAGR during the same period. During the period, it has also been found that the sectoral fuels demand of electricity, LPG and wood will be increased in one side whereas in other side the demand of kerosene will be decreased.

Keywords

Energy Scenarios, Commercial Sector Energy Planning, Nepal

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1. Introduction

The commercial sector is defined as an economic activity undertaken within the country organized as a registered (i.e. proprietorship, partnership, private limited, public limited etc.) or unregistered enterprises having an orientation towards profit or public services excluding the manufacturing and transportation sectors [7]. In 2009, the total energy consumption of the country was 400.5 PJ in which the most of the energy was consumed by residential sector, followed by transport, industrial, commercial and others as shown in Fig. 1 [8].

The total energy consumption on the sector in 2009 was 5.12 PJ while in 1996 it was only 2.84 PJ. During the period 5.01% of annual average growth of the energy demand was observed. In 1996, 0.96 PJ of fuel wood was consumed while in 2009 it was increased to 1.84 PJ. The average growth rate of fuel wood was 5.74% during 1996 to 2009. Similarly in 1996, 0.12 PJ of LPG was consumed and it increased to 2.29 PJ in 2009 with AAGR of 30.41%. During the period, the demand of electricity was increased with AAGR of 7.44% and reached to 0.56 PJ from 0.226 PJ. Among the fuels,

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kerosene was decreased from 1.09 PJ to 0.30 PJ with -6.4% AAGR during the same period. As in the residential sector, cooking is the major end use in commercial sector consuming (68.4%) of total sectoral energy consumption followed by lighting (19.3%), water boiling (0.3%), space heating & cooling (5.3%), and electrical services such as water pumping etc. (6.7%) [8,9].

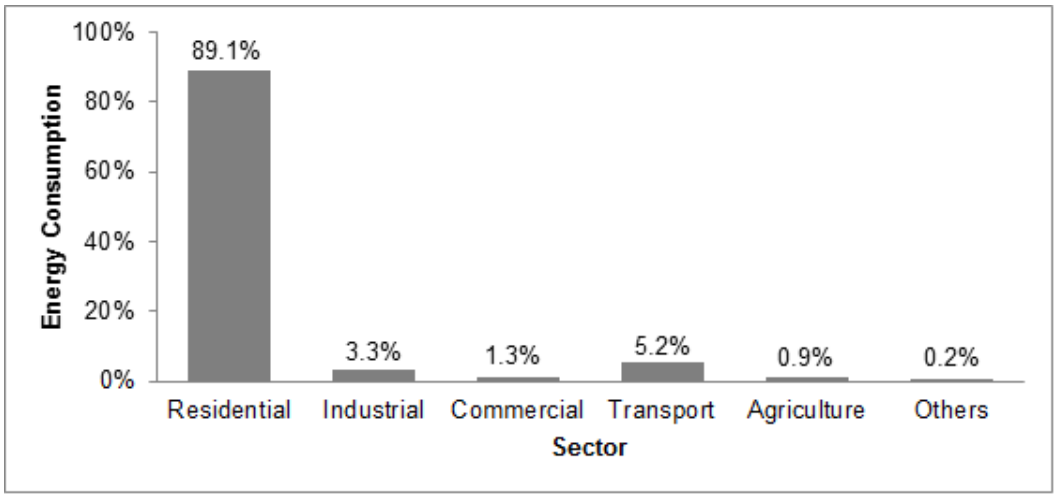

Fig. 1. Sectoral Energy Consumption in 2009.

Although, there are different ways for disaggregation of commercial sector, but the current study has adopted the disaggregation based on WECS. According to it, the commercial sector has been disaggregated into following eight sub-sectors [10].

1 Academic Institutions (School, boarding schools and colleges)

2 Health Services (Health posts and hospitals)

3 Institutions (Government, semi-government and private)

4 Retail shops (Essential retails and non-essentials retails)

5 Hotels (Star hotels, non-star hotels and lodges)

6 Restaurants

7 Cinema Halls/Video halls

8 Water Supplies

From 2001 to 2011, Nepal's service sector has been grown by an average of 3.9% per year, which was greater than growth in agriculture (3.4%) and industrial (2.6%) sectors during the same period. Among the biggest contribution to that growth were from wholesale and retail trade, transport storage and communications sub-sectors. Wholesale and retail tread has remained the biggest sub sector, sustained by strong remittance inflows and tourism earnings. [1]

The Himalayas, diverse landscapes, and rich cultural diversity provide Nepal with a natural advantage in the tourism industry. Nepal is a house to four world heritage sites. There are two cultural sites; one is Kathmandu Valley, where the capital of the country is located and other is in Lumbini where the birthplace of the Lord Buddha is located. In addition to the culture sites there are two natural sites called Royal Chitwan National Park and Sagarmatha National Park in the country [6]. Though the entire Nepal possesses potential for tourist destination, the country has not been able to develop this sector properly as desired. Despite the increasing number of tourists' arrival as a result of making the year 2011 as Nepal Tourism Year, contribution of this sector to GDP has not yet been appreciating [4].

In 2011, NRs 278.65 Billion value was added from service sector to the national economy [11]. As shown in Fig. 2, the major contributions were from wholesale and retail trade followed by transport, storage & communications, real estate renting & business activities, education, financial intermediations, other community social and personal service activities, public administration and defense and hotels and restaurants respectively [4].

Although, the quantity of sectoral value added from hotels and restaurants is low but, the energy consumption on them are high. In 1996, 67.2% of the sectoral energy was consumed on them, followed by remaining other sub sectors [10]. From 2001 to 2009, the average annual growth of value added in hotels and restaurants was 2.29%. Fig.3 and Fig.4 show the historical sub- sectors contribution on sectoral value added and their growth scenarios [3], [4]. The reason for service sector's comparative increase in the share of total value added is due to growth in outputs of wide ranging sub-sectors like wholesale and retail trades, hotels and restaurants, transport and communications, public administration and defense, education, health and other community social and personal services.

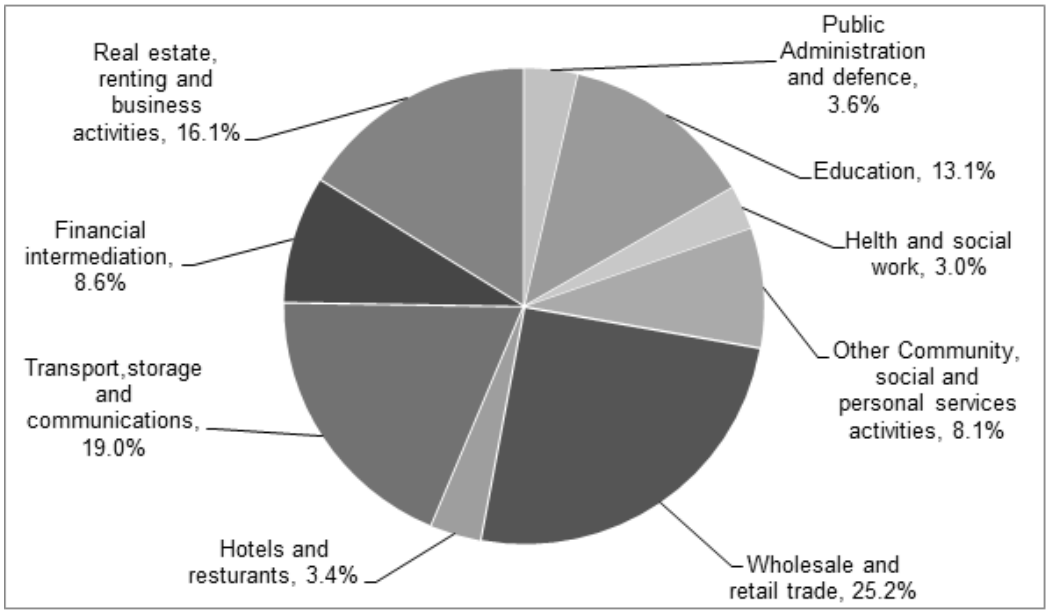

Fig. 2. Composition of Service Sector Value Added in 2011.

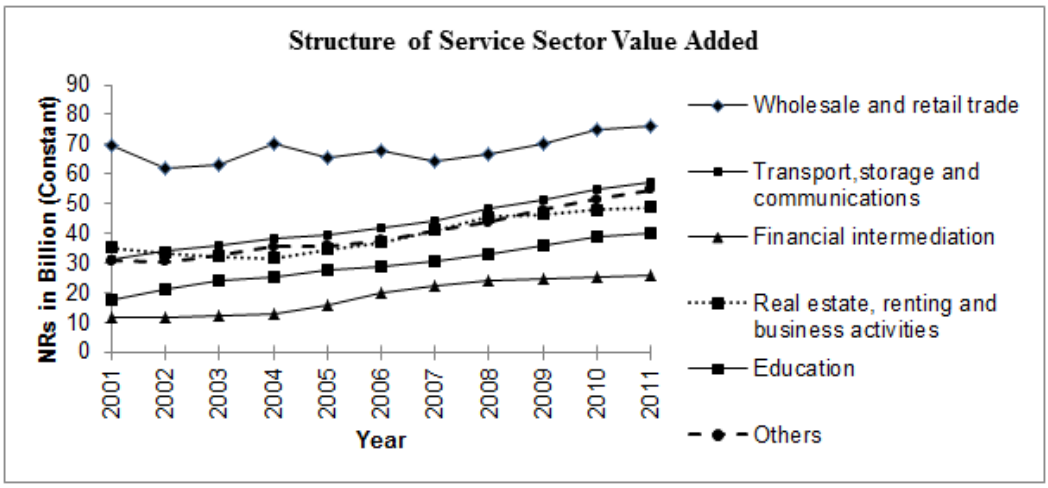

Fig. 3. Structural Scenario of Service Sub-sectors Value Added.

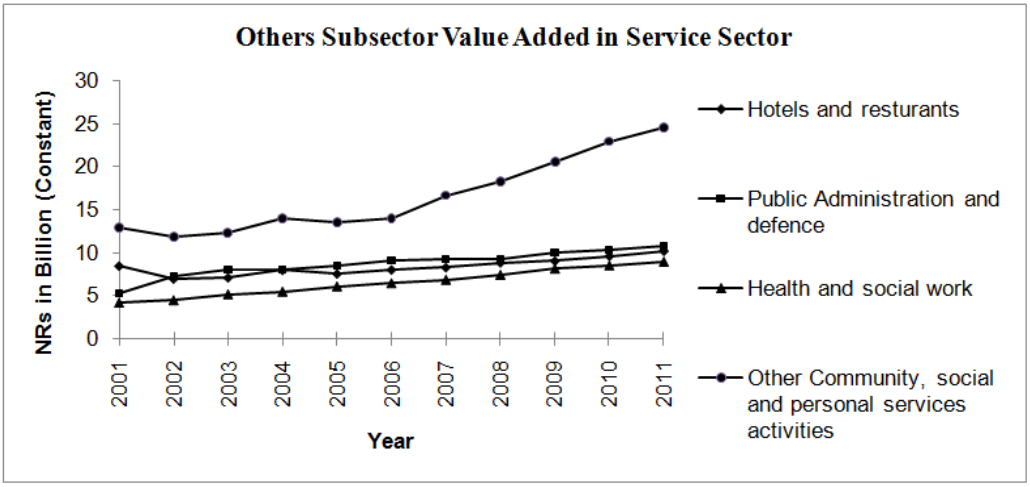

Fig. 4. Structural Scenario of other Sub-sectors.

Recent years, service sector is emerging as a robust sector for Nepalese economy. In the last few years, it has significantly grown. It accounts for around half of the GDP and absorbs around 18% of total employment in the country [12]. The service sector is largely composed of traditional activities but financial services are gradually gaining ground.

As of 2011, financial services accounted for 8.6 % of service sector value added up from 5.8 % in 2001 [3], [4]. The surge in telecommunication was also behind the rapid growth in the service sector. Telecommunication reached approximately 50% of the total population in 2011, up significantly from 8% in 2007 [1].

As shown in Fig.4, the contribution of hotel and restaurants on sectoral value added has been increased. The output of the sector is due to increase in per capita income, influence of urbanization, change in people's lifestyle and their food habits respectively [4].

Economic growth and energy demand are closely related [5]. It can be seen in Fig. 5 that the commercial sector energy consumption of the country has been increased along with increase in service sector value added.

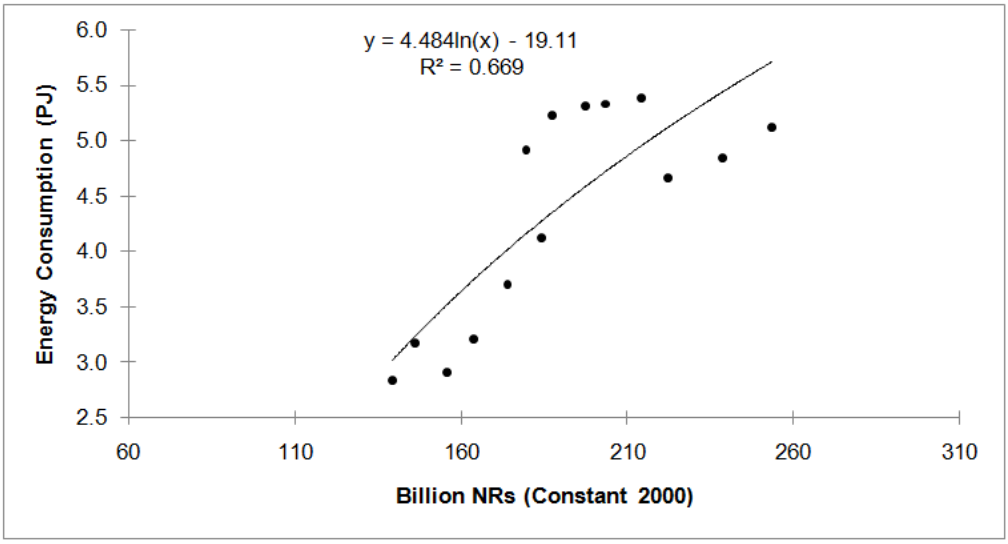

Fig. 5. Relation between Energy Consumption and Value Added (1996-2009).

2. Methodological Approach

A commercial sector energy demand model has been formulated for this study using LEAP framework. End –use methodology combined with trend analysis has been used for energy demand projections. In this model, the data are assembled in a hierarchical order from sector level (commercial) to technology (fuel use) level. Sector level (commercial), is followed by eight sub-sectors which are restaurants, hotels, academic institutions, essential and non essentials, hospitals, institutions, cinema halls and water supply. In each sub- sector, there are seven end uses (i.e., cooking, space heating, space cooling, water boiling, electric appliances, lighting and others). Finally, the data are arranged based on each end use according to fuel use (i.e., fuel wood, kerosene, electricity and LPG). For base year; the energy consumption is calculated from end-use methodology. In formulated methodological framework, the energy demand is calculated by multiplying the activities (energy services) by energy intensities (fuels intensities) of corresponding end uses. The prediction of growth rates of activities and energy intensities are exogenous to the model. The prediction of growth rates of value added and energy intensities are mentioned on section 3 and 4 of current study. The basis for the demand projections is based on service sector value added and energy intensity approach. The energy intensity for the sector is calculated on the basis of quantity of energy used in particular year to the value added for the sector in that year. Due to limitation of database, service sector value added has been considered instead of commercial sector. The energy intensity for each fuel used in the sector has been taken in MJ/ $ (1 US $ equals 71 NRs in 2000) in the study.

In the model, final energy demand is calculated as the product of the total activity level and energy intensity at each given technology branch. Energy demand is calculated for the current account year and for each future year in each scenario.

Mathematically,

$$D\,b,s,t = TA\,b,s,t \times EI\,b,s,t \quad (1)$$

Where D is energy demand, TA is total activity, EI is energy

intensity, b is the branch, s is scenario and t is year (ranging from the base year [0] to the end year). All scenarios evolve from the same current accounts data, so that when t=0, the above equation can be written as:

$$D\,b,0 = TA\,b,0 \times EI\,b,0 \quad (2)$$

The energy demand calculated for each technology branch is uniquely identified with a particular fuel. Thus, in calculating all technology branches, the model also calculates the total final energy demand from each fuel.

The total activity level for a technology is the product of the activity levels in all branches from the technology branch back up to the original demand branch. Mathematically,

$$TA\,b,s,t = A\,b',s,t \times A\,b'',s,t \times A\,b''',s,t \times \quad (3)$$

Where Ab is the activity level in a particular branch b, b' is the parent of branch b, b" is the grandparent, etc.

The final energy intensity for different end uses applications are taken from water and energy commission secretariat (WECS) report [10].The historical GDP and SSVA data are taken from world bank (WB) database [11].

In the model, the year 2005 has been considered for base year and 2011 has been taken for first projection year. The validation of the model has been carried out with actual energy consumption in the sector from 2005 to 2009.

3. Projection of GDP and Service Sector Value Added (SSVA)

3.1. Gross Domestic Product (GDP) Projection

The actual economic growth rate of the country is much lower than the target set by government through its fiscal policies [2]. Hence, to project future growth of the country, its historical growth pattern has been considered. Fig. 6 shows the historical GDP growth trend of the nation. From the trend, it has been observed that the country's GDP growth was varied up and down annually. Thus, it is difficult to predict exact single value of GDP growth for future. As the energy demand varies according to growth, and if the projected growth will not be followed in future, then there will be chance of deviation on energy demand and supply system. To capture the future energy demand several GDP growth scenarios have been considered by analyzing the historical macro - economic growth pattern of the country. The selected different growth scenarios are business as usual growth (3.9%), low economic growth (4.4%), medium economic growth (5.6%) and high economic growth (6.5%) respectively.

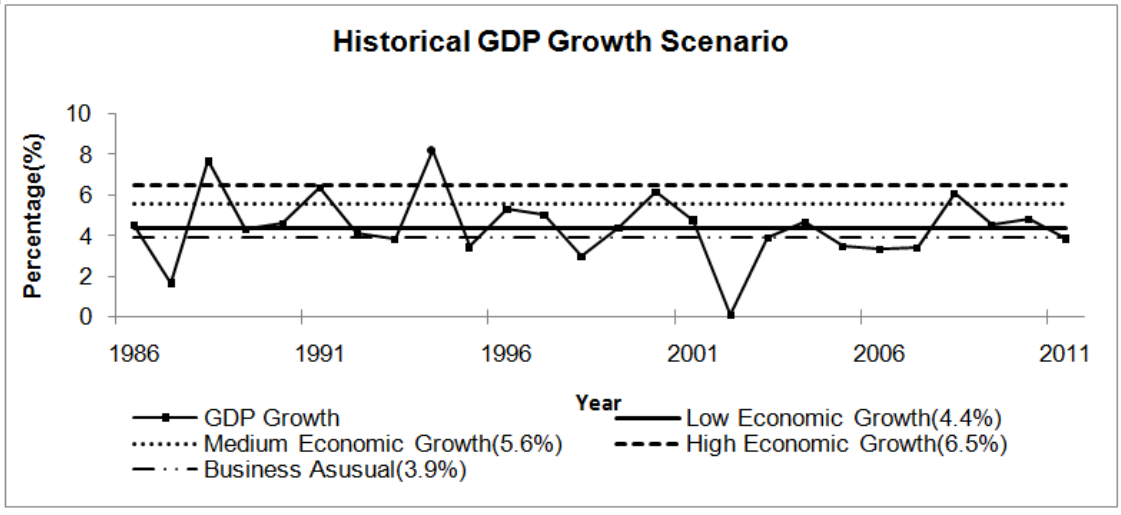

Fig. 6. Historical GDP Growth Scenario of Nepal.

The nation's GDP at 2005 was NRs 496.03 Billion. In this study, the GDP growth rate up to 2010 has been taken as actual historical values. From 2011, four GDP growths scenarios have been considered for analyzing purpose. For BA scenario, the growth of 2011 has been used and assumed the growth will be continued during the study period. In the year 2030, projected value of GDP in BA, LG, MG and HG will be NRs 1324 Billion, NRs 1450.99 Billion, NRs 1802.36 and NRs 2118.36 Billion respectively. The projected values of GDP are presented in Appendix.

3.2. Service Sector Value Added Projection

The historical service sector value added (SSVA) trend of the country has been shown in the Fig. 7. To capture future energy demand in the sector, several SSVA growth scenarios have been considered by analyzing the historical growth

pattern. The SSVA at 2005 was NRs 203.4 Billion. In this study, the actual observed SSVA growth rates up to 2010 have been taken. From 2011, corresponding values of SSVA for four GDP growths have been considered for analyzing purpose. For business as usual scenario, 3.6 % service sector value added has been considered and projected the same growth rate up to 2030. The 3.6 % SSVA was observed in 2011 when the overall GDP growth of the country was 3.9%.

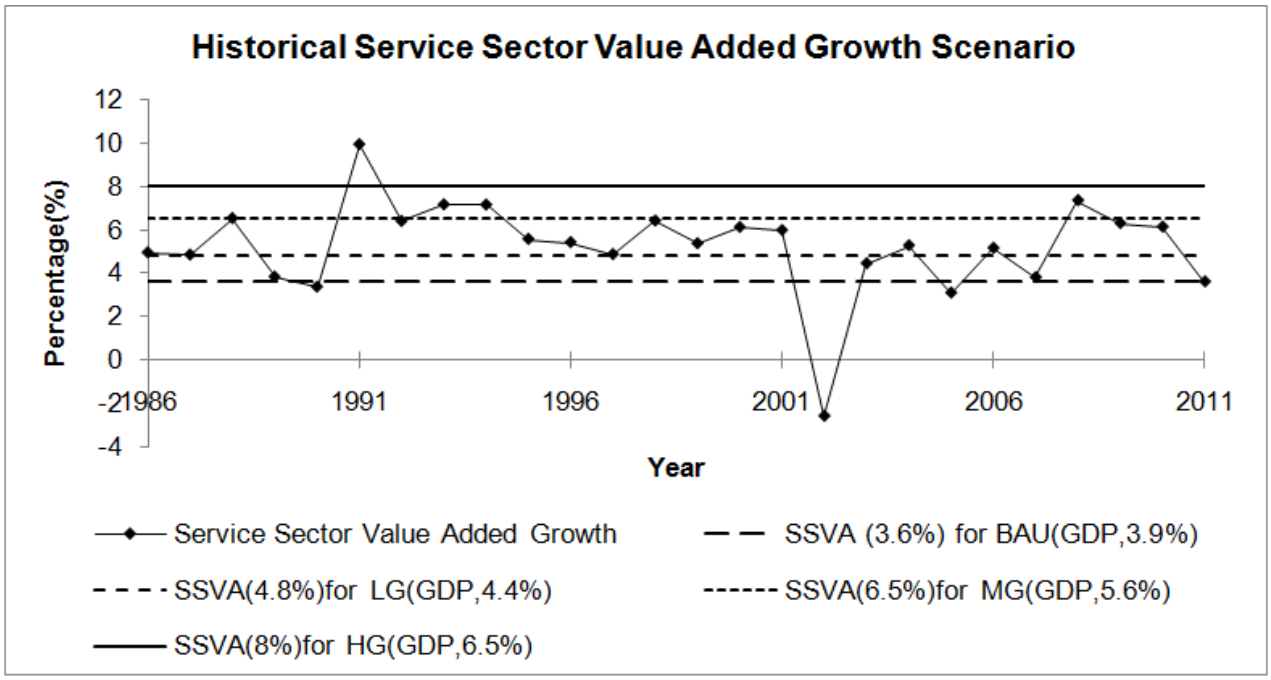

Fig. 7. Historical Service Sector Value Added Scenario of Nepal.

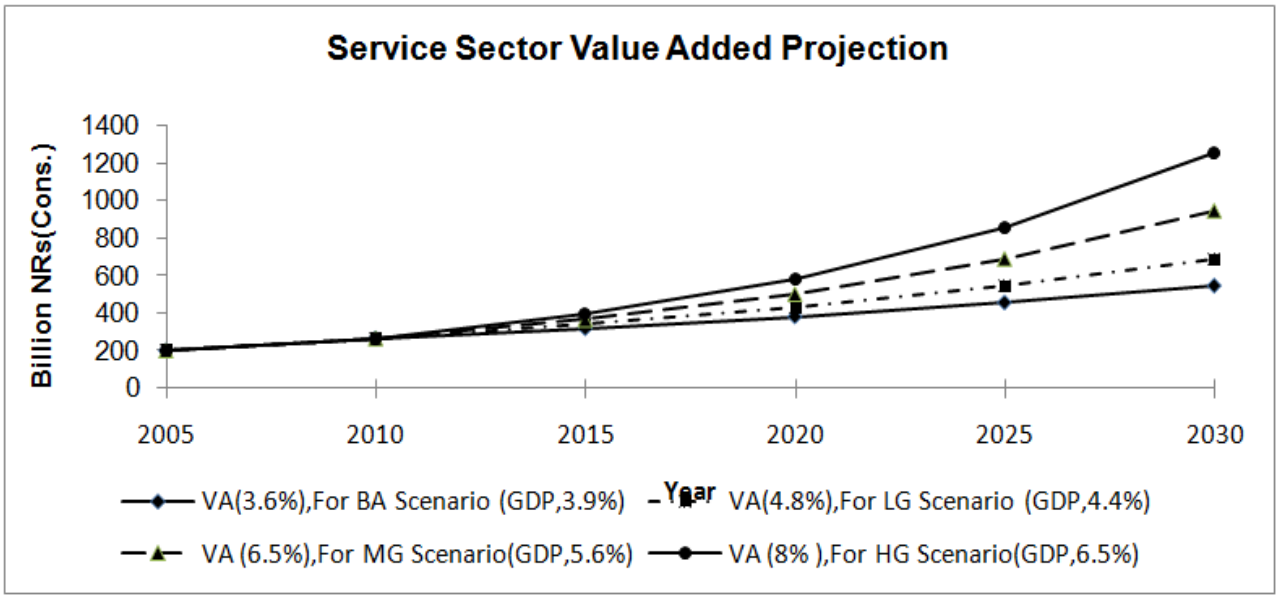

Fig. 8. Projection of Service Sector Value Added.

For low growth GDP projection, 4.8 % annual growth of SSVA has been used from 2011 to 2030. The selected 4.8 % SSVA was AAGR from 1997 to 2011 of the country. For medium GDP growth, 6.5 % of the SSVA has been considered. Historical data shows that country had achieved more than 6% SSVA repeatedly (i.e., 1991, 6.4%; 1994, 8.2%, 2000, 6.2% and in 2008, 6.1%). For high GDP growth of 6.5%, the 8% SSVA has been considered in this study. The 8% annual growth rate was needed for achieving the anticipated high economic growth of the country. The three year approach paper (2014 to 2016) prepared by government of Nepal has also considered the service sector growth rate to 6.42%, 7.11% and 7.7% for 2014, 2015 and 2016 respectively.Fig.8 shows the projected scenarios of the SSVA.

The projections of SSVA under selected anticipated GDP growths are presented in Appendix.

4. Energy Intensity in Commercial Sector

The historical commercial sector energy intensities values from 1996 to 2009 have been presented in Appendix. Overall sectoral energy intensity was 1.44 MJ/$ in 1996. It reduced to 1.43 MJ/$ in 2009 with AAGR of 0.381% during the period. The maximum intensity 1.98 MJ/$ was observed in 2003. Fig. 9 shows the energy intensity and the intensity growth rate of the sector since last 1996 to 2009.

The contribution of fuel wood in the sector's energy consumption was 33.66 % in 1996 and increased to 35.96 % in 2009. Fig.10 shows the historical pattern of fuel wood intensity and its growth. In 1996, the fuel wood intensity was 0.487 MJ/$ while in 2009 it was 0.516 MJ/$.The average intensity during the period was 0.602 MJ/$. The maximum intensity was 0.733 MJ/$ in 2006, while minimum was 0.487 MJ/$ in 1996. The recent trend shows that the intensity of wood has been decreased. For projection of intensity, from 2006 to 2009 actual intensity growth of the fuel and after then the AAGR of -1% has been considered.

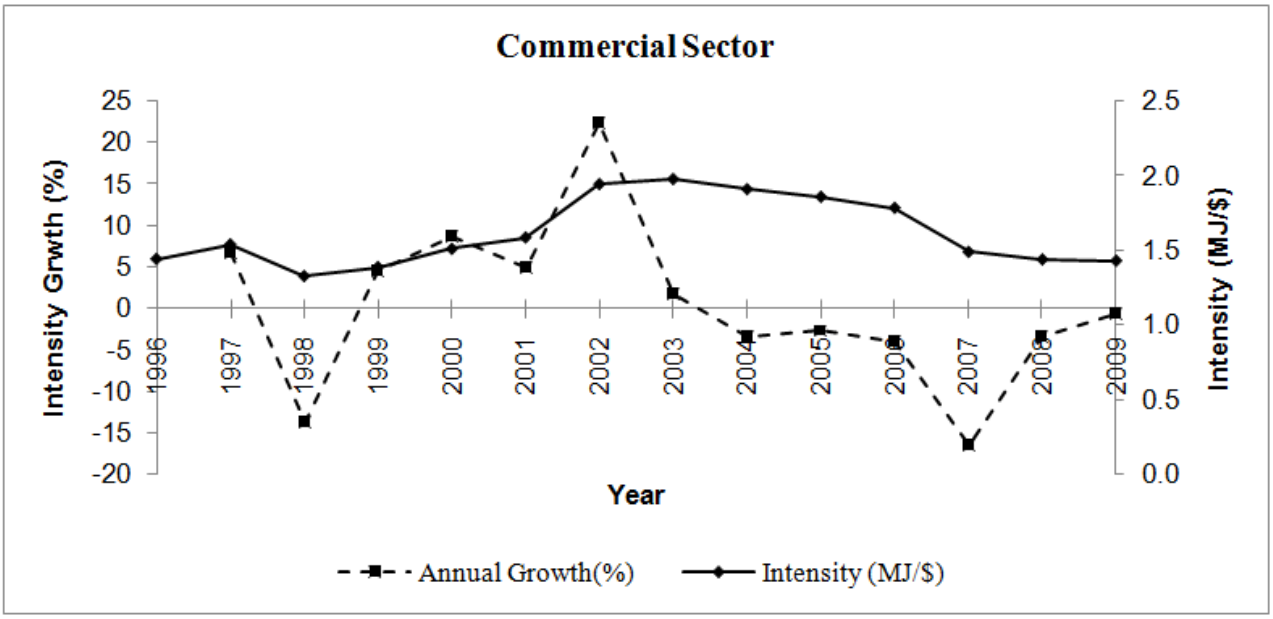

Fig. 9. Energy Intensity and Intensity Growth rate of Commercial Sector.

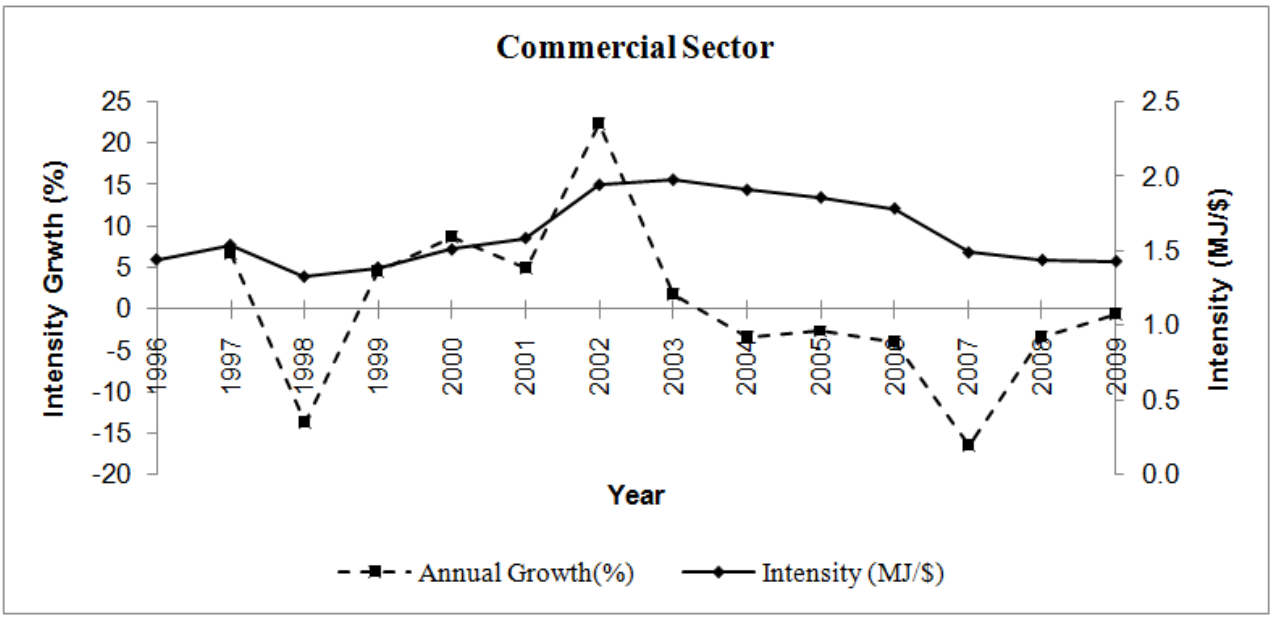

Fig. 10. Fuel Wood Intensity and Intensity Growth.

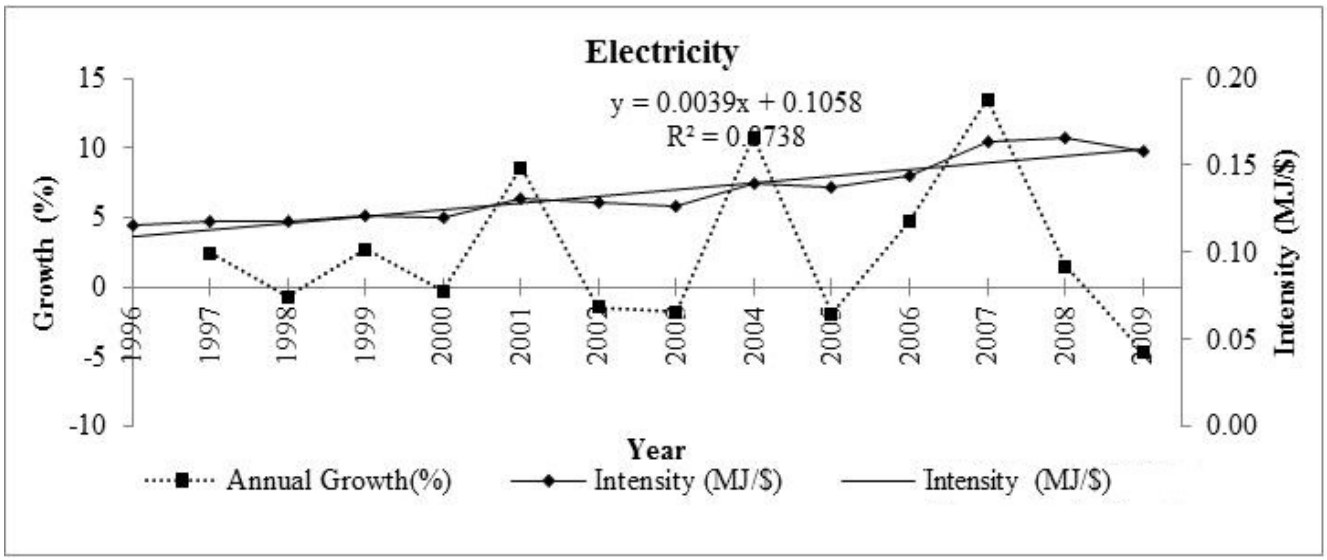

Fig. 11. Electricity Intensity and Intensity Growth.

The share of electricity was 7.97% of the sectoral energy consumption in 1996 and increased to 11% in 2009. As shown in Fig.11, the intensity had increased from 0.115 MJ/$ to 0.158 MJ/$ from 1996 to 2009. It has been found that the maximum intensity was 0.166 MJ/$ in 2008 while, the minimum intensity was only 0.115 MJ/$ in 1996.The growth of future electricity intensity has been projected using the growth as linear equation shown in Fig. 11.By 2030, the electricity intensity of the sector will be reached to 0.242 MJ/$ according to current projection.

In 1996, the share of kerosene was 38.61% of the sectoral energy consumption and reduced sharply to 5.93% in 2009. The energy intensity in 1996 was 0.559 MJ/$ while in 2009 it was reduced to 0.085 MJ/$. Its AAGR during the period was -10.35 %, and from 2003 the trend was observed always negative as shown in Fig.12. The intensity growth of -24.6% has been consider for future projection of this fuel.

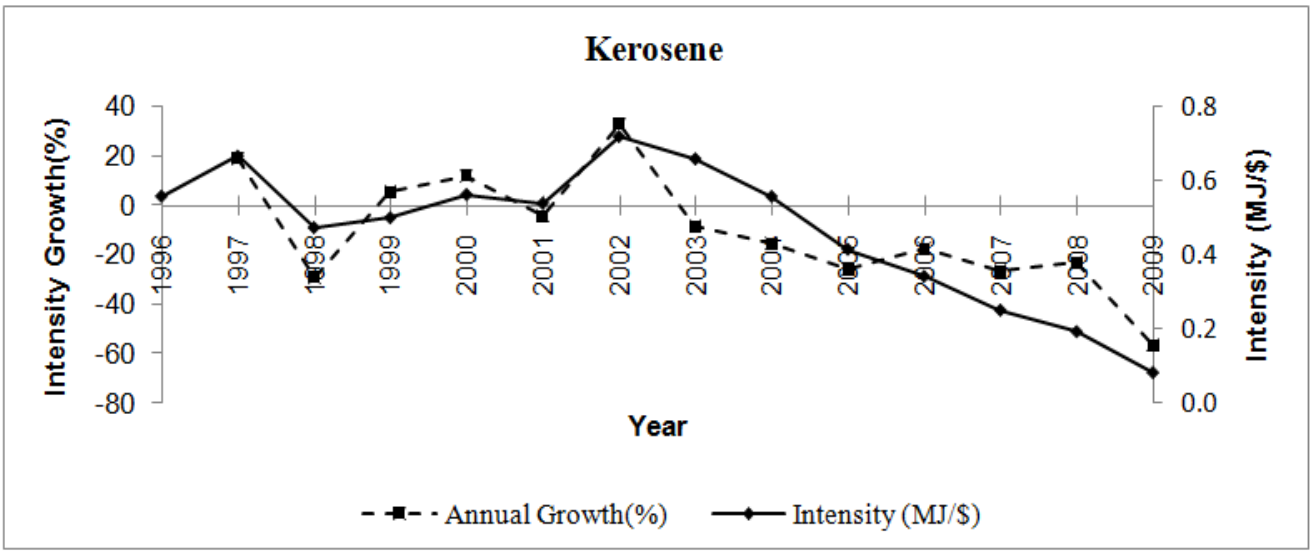

Fig. 12. Kerosene Intensity and Intensity Growth .

Fig. 13 shows historical pattern of LPG and its growth since 1996 to 2009. In 1996, the intensity was found 0.061 MJ/$ and increased to 0.642 MJ/$ in 2009. The share of this fuel was 4.22% of the sectoral energy consumption in 1996 and increased sharply to 44.72% in 2009. The maximum intensity 0.642 MJ/$ was observed in 2009 while minimum 0.061 MJ/$ was found in 1996. For projection purpose, the actual growth of fuel intensity from 2005 to 2009, and after then the annual growth of 2.3% has been considered.

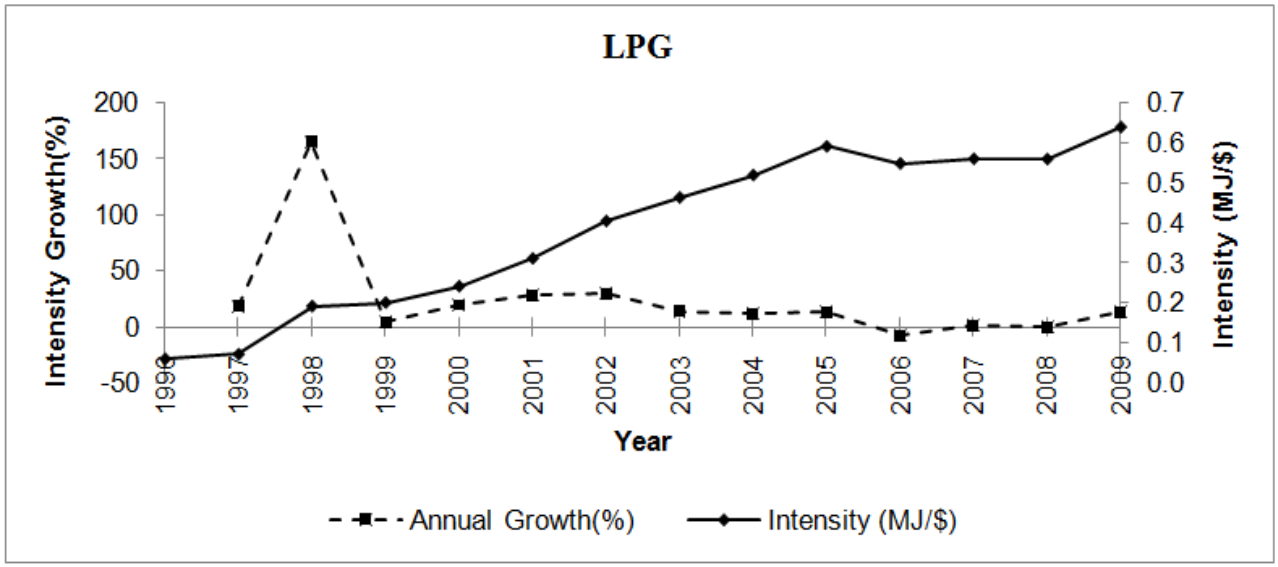

Fig. 13. LPG Intensity and Intensity Growth.

5. Model Validation and Result Analysis

After formulation of the model, its outputs are validated with historical energy consumption data. The model has been validated from base year 2005 to 2009 with actual energy consumptions [8], [9].Table 1 shows the actual and projected energy consumptions during the period. It has been found that the percentage of deviations between actual and projected values are ranging from -0.6% to + 2% during the period.

Table 1. Comparison of Model's Output Energy Demand and Actual Energy Consumption.

Year	2005	2006	2007	2008	2009
Model Output (PJ)	5.36	5.37	4.66	4.82	5.02
Actual Consumption(PJ)	5.33	5.38	4.67	4.84	5.12
Deviation from actual(PJ)	-0.03	0.01	0.01	0.02	0.1
Deviation (%)	-0.6%	0.2%	0.2%	0.4%	2.0%

Thus, there is a close agreement between the models's output and actual consumption hence, the model has been used for further energy projections.

Table 2. Projection of Total Energy Demand under Different Growths.

Demand in PJ	Year						Ratio
Scenarios	2005	2010	2015	2020	2025	2030	2030-2005
BA (3.9% GDP Growth)	5.4	5.3	6.5	8.1	10.3	13.2	2.5
LG (4.4% GDP Growth)	5.4	5.3	6.8	9.1	12.3	16.6	3.1
MG (5.6% GDP Growth)	5.4	5.3	7.4	10.7	15.6	22.9	4.3
HG (6.5% GDP Growth)	5.4	5.3	7.9	12.3	19.2	30.3	5.7

Table 2 shows the total service sector energy demands of the country under different anticipated growth scenarios of national economy. According to study, by 2030, the total energy demand of the country will be reached to 13.2 PJ in BA case. The final demand in 2030 will be increased 2.5 to 5.7 times from BA to HG scenarios as shown in the table. The projections of energy demand during the study period are shown in Fig.14.

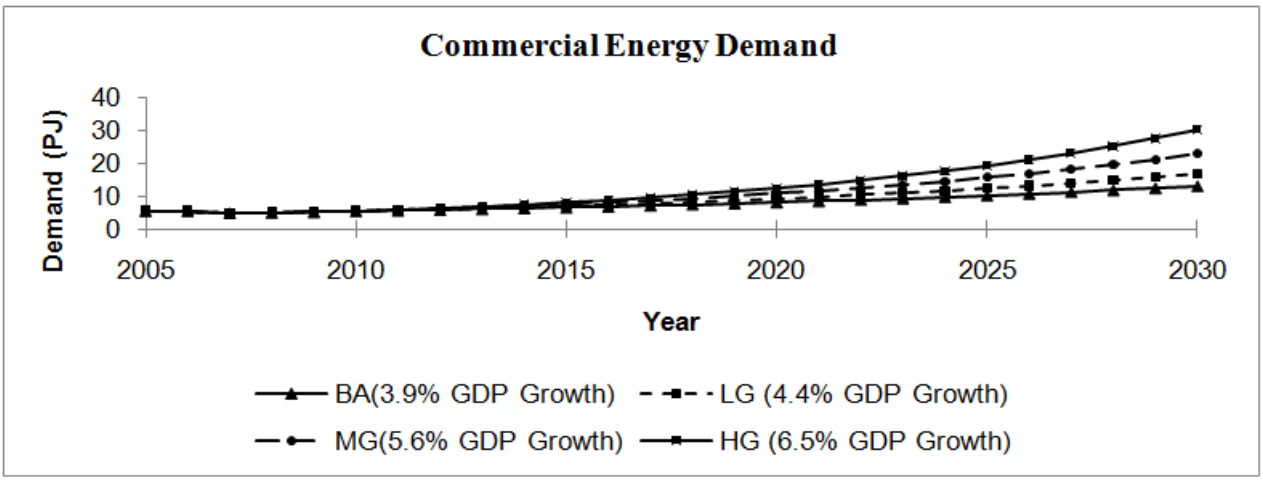

Fig. 14. Projection of Energy Demand under Anticipated Growths.

Table 3 shows various fuels projections, AAGR, along with final year to base year energy demand ratio. In future, the demand of electricity, LPG and wood will be increased in one side whereas in other side, the demand of kerosene will be decreased. The growth rate of LPG demand on the sector will be high followed by electricity and wood. The total energy demand of the sector will be increased with AAGR of 2.5% during the period although, sharply decreased (-22.5%) of kerosene demand during the period.

Table 3. Projection of Fuel types for Business As usual Scenario.

Demand in PJ	**Year**						**AAGR**	**Ratio**
Fuel	2005	2010	2015	2020	2025	2030	2005-30	2030/2005
Electricity	0.4	0.6	0.8	1.0	1.3	1.7	6.2%	4.5
Kerosene	1.2	0.2	0.1	0.0	0.0	0.0	-22.5%	0.0
LPG	1.7	2.5	3.4	4.6	6.2	8.3	6.5%	4.8
Wood	2.0	1.9	2.2	2.5	2.8	3.2	1.7%	1.5
Total	5.4	5.3	6.5	8.1	10.3	13.2	3.7%	2.5

The energy demand projections for commercial sub- sectors in BA scenario have shown in table 4. It has been found that, the growth rate of cinema halls sub - sector will be more in comparison with other remaining sub sectors. However, the energy demand of essentials and non essential sub sector will be reduced; the total energy demand of the sector will be reached to 13.2 PJ by the year 2030.

Table 4. Commercial Sub-Sectors Energy Demand in Business As usual Scenario.

Demand in Thousand GJ	**Year**						**A.A.G**	**Ratio**
Commercial Subsectors	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2005-30**	**2030/2005**
Restaurant	1969	2093	2619	3371	4383	5730	4.4%	2.9
Hotels	1198	1378	1750	2260	2944	3851	4.8%	3.2
Academic Institutions	110	85	93	108	128	152	1.3%	1.4
Essentials & Non Essential	672	380	378	421	485	567	-0.7%	0.8
Hospitals	94	65	69	78	89	103	0.4%	1.1
Institutions	1310	1293	1537	1853	2268	2788	3.1%	2.1
Cinema Halls	1	1	2	2	3	4	6.1%	4.1
Water Supply	1	1	2	2	3	4	6.0%	4.4
Total	5356	5296	6450	8095	10303	13199	3.7%	2.5

Table 5 shows the total sectoral electricity demand under anticipated macroeconomic situations of the nation from base year 2005 to end year 2030. It has been found that the projected end year to base year demand ratios will be 4.46, 5.61, 7.74 and 10.25 under BA, LG, MG and HG scenarios respectively.

Table 5. Total Electricity Demand under Different GDP Growth Scenarios.

Electricity Demand in PJ	Year						AAGR
Scenarios	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2005-30**
BA(3.9% GDP Growth)	0.39	0.6	0.8	1.02	1.34	1.74	6.18%
LG (4.4% GDP Growth)	0.39	0.6	0.84	1.15	1.59	2.19	7.16%
MG(5.6% GDP Growth)	0.39	0.6	0.91	1.35	2.02	3.02	8.55%
HG (6.5% GDP Growth)	0.39	0.6	0.98	1.55	2.5	4	9.77%

The electricity demand projections under the selected growths are shown in Fig. 15. According to the study, the electricity demand of the country will be increased with AAGR 6.18%, 7.16%, 8.55% and 9.77% from 2005 to 2030 in BA, LG, MG and HG scenarios respectively.

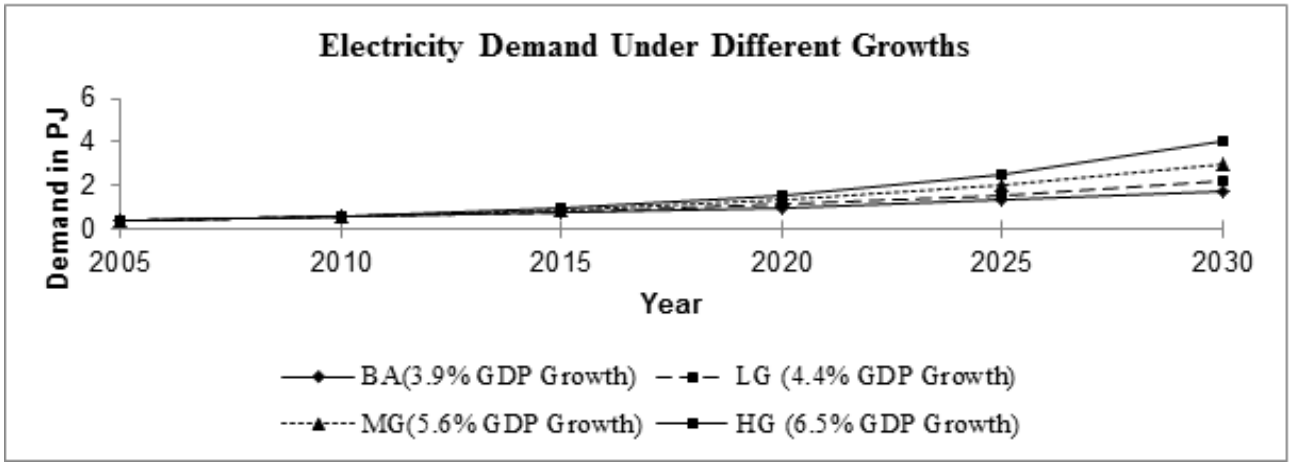

Fig. 15. Electricity Demand Projections under Selected Anticipated Growths.

Fig. 16 shows the selected sub sectors contribution on service sector value added in 2011. As shown in the figure, the share of hotels and restaurants was 3.4%, education 3.1% , wholesale and retail trade 25.2% and others remaining subsector (58.3%) respectively.

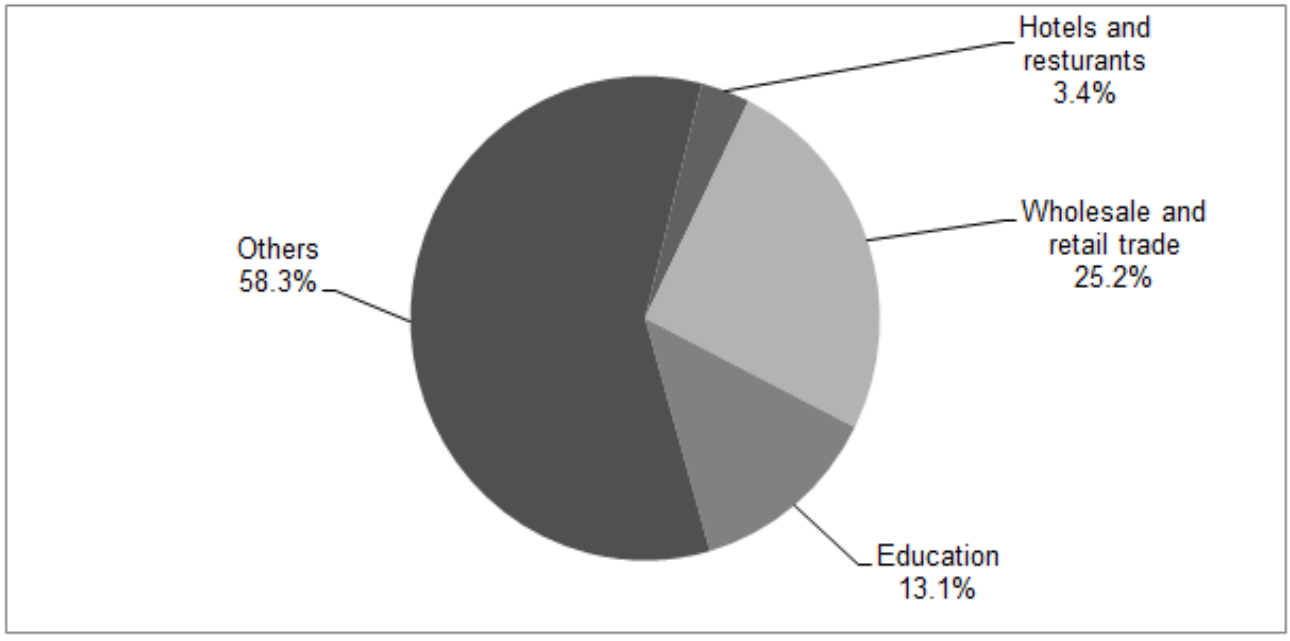

Fig. 16. Selected Sub - Sectors Contribution on Service Sector Value Added in 2011.

If we analyze the historical pattern, the contribution of hotel and restaurant sub sector on sectoral value added has not changed much since last decade, similarly the contribution of others and education sub sectors are also observed stable during the period, while the contribution of wholesale and retail trade has been decreased since 2001 to 2011 as shown in Fig 17.

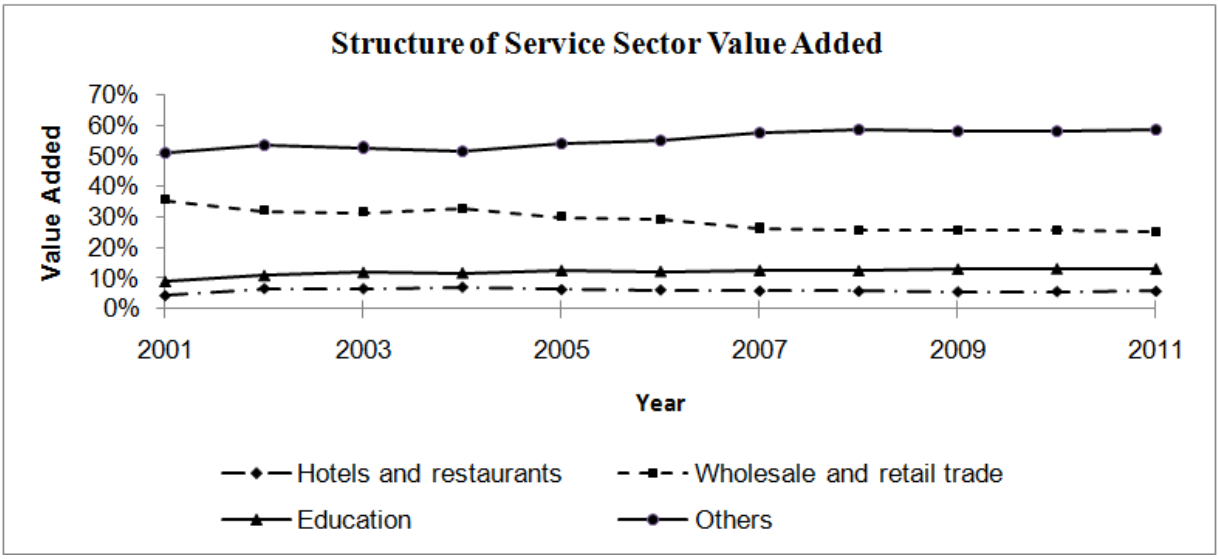

Fig. 17. Historical Scenario of Selected Sub- Sectors Value Added.

The projected share of energy demand under BA scenario has been shown in table 6. In the country, the contribution of the hotel and restaurant on the national economy is very low but, it has consumed maximum share of sectoral energy consumption. In 2005, about 59.1% of the total sectoral energy was consumed on the sector. The present analysis has shown that the sector will demand most of the energy in future too. It has been found that the sub-sector's energy demand will be reached to 72.6% of total sectoral energy demand by 2030.

Table 6. Sub Sector Contribution for Projected Energy Demand.

% Contribution in BA Scenario	Year					
Sub Sectors	2005	2010	2015	2020	2025	2030
Hotels and Restaurants	59.1%	65.5%	67.7%	69.6%	71.1%	72.6%
Academic Institutions	2.1%	1.6%	1.5%	1.3%	1.2%	1.2%
Essentials and Non Essential	12.6%	7.2%	5.9%	5.2%	4.7%	4.3%
Others(Remaining Subsectors)	26.3%	25.7%	25.0%	23.9%	22.9%	22.0%
Total	100%	100%	100%	100%	100%	100%

Followed by hotel and restaurant, sub-sectors like academic institutions, essential and non essentials and others shares on the sectoral energy demand will be decreased in the future. According to this study, the sectoral contribution of the academic institutions, essential & non essentials and others remaining sectors will be reached to 1.2%,4.3% and 22% respectively by 2030 as shown in table 6.

6. Conclusion

The commercial sector energy demands under four anticipated growth scenarios of national economy are projected by formulating end use demand model. It has been found that the overall total energy demand of the sector from 2005 to 2030 will be raised by 2.5, 3.1, 4.3 and 5.7 folds, and will be reached to 13.2 PJ, 16.6 PJ, 22.9 PJ and 30.3 PJ on BA, LG, MG and HG scenarios respectively. Among eight commercial sub-sectors, seven sub-sectors energy demands in future will be increased while one - sub sector energy demand will be decreased. Restaurants, hotels, academic institutions, hospitals, institutions, cinema halls and water supplies will be increased with AAGR 4.4%, 4.8%, 1.3%, 0.4% and 3.1%, 6.1% and 6% respectively from 2005 to 2030 under BA scenario. The demand of essential & non- essential shops sub- sector will be decreased by -0.7% AAGR in the same duration.

Although, the contribution of hotels and restaurants on sectoral economy is low but the sector is consuming most of the sectoral energy consumption. The study has also shown that in future too, most of the energy will be needed in the sub sector.

It is greatly expected that the outcomes from this study will support for future sustainable energy planning process of the country through proper utilization of available energy resources within the country.

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