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Industrial Sector's Energy Demand Projections and Analysis of Nepal for Sustainable National Energy Planning Process of the Country

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Abstract: The reliable future energy demand projection is an essential requirement for planning and formulating the policy to provide sustainable energy supply in the country. The purpose of this study is to project the sectoral energy demand up to 2030 under different anticipated growth scenarios of national economy. To project future energy demand, the end use industrial 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. Further, the study has illustrated that among the industrial sub-sectors, the energy demand of food beverage and tobacco, textile & leather, chemical rubber & plastics, mechanical engineering & metallurgy and wood products & papers will be increased while the electrical engineering and products subsector will be decreased. Among the anticipated scenarios, the BA scenario has been selected as a reference scenario for policy measures. In the policy scenario, it has been found that the total sectoral energy demand and electricity demand can be reduced from 1.78 and 2.42 times of the base year demand in BA scenario to 1.53 and 2.24 times of the base year demand in 2030 respectively. The projected sectoral energy demand along with demanding fuels will support the sustainable national energy planning process of the country for days to come.

Keywords: Industrial Sector, Energy Demand, GDP, GDP Growth, LEAP

1. Introduction

After the establishment of democratic government in 1991, Nepal adopted open economic policies and started promoting private sectors in the business [18]. To demonstrate the adopted policy, government privatized many public enterprises during 1990s. As a result, an accelerated economic growth was observed for some years but it could not be continued later [4]. The armed conflict, which began in 1996 in the country, caused political instability and therefore, the process of economic reforms became low priority of the nation due to the shift of its focus for addressing the solution of emerged new challenge of law and order situation across the country. The armed conflict ended through the comprehensive peace accord agreement between concerned stakeholders in the year 2006. In 2008, a new constitutional assembly was formed which abolished monarchy and established the country as a federal democratic republic. Unfortunately, the constitutional assembly also could not promulgate constitution thus, it was dissolved. After then, again a new constitutional assembly election was held in the year 2013, and the newly elected constitutional assembly is under the process of drafting the new constitution.

The main problems of industrial development in the country are political instability, industrial insecurity, unfavorable labor relation, minimal availability of energy, week industrial infrastructures, lack of competent human resources, lack of capacity to adopt new technology, low productivity, lack of diversification of exportable items and weak supply management [3]. In reflection of these problems; the sector is performing poorly in national economy. As a result, its contribution on Gross Domestic Product (GDP) reduced from 22.9% in 1997 to 15.3% in the year 2009.

To address the sectoral problems, the government of Nepal promulgated an industrial policy 2010, including measures to remove weakness of the sectoral development and to promote industrial environment within the country. The policy has taken the objective of increasing the exports of industrial products to make remarkable contribution in the national economy. However, it seems hard to achieve these targets in the near future as the contribution of industrial sector on GDP is declining each year. Some of the fundamental barriers in this regards are Nepal as a land lock country between India and China, small internal markets, lack of export oriented products and low efficiency of the sector in comparison with the two neighbors. In addition to this, exporting to third countries is delayed by the additional disadvantages of local infrastructure along with long transport route for accessing sea ports [4].

Out of the total national energy consumption, the share of the industrial sector was about 3.5% in 2009. In 1997, 34.2% % energy was supplied from coal followed by 21.2% from electricity, 19.6% from petroleum products, 16.5% from biomass and 8.5% from fuel wood to provide the energy need of industrial sector. But in 2009, the energy consumption statistics showed that about 57.9% % energy was supplied from coal followed by 23.5% from electricity, 10.2% from petroleum products, 5.5% from fuel wood and 2.9% from petroleum products respectively [17]. Thus during the period, the contribution of the coal and electricity has increased while the contribution of the other fuels has decreased.

The industrial sector of Nepal has been disaggregated into following seven sub sectors [15].

1. Food, beverage and tobacco
2. Textile and leather
3. Chemical, rubber and plastic
4. Mechanical engineering and metal products
5. Electric engineering products
6. Wood products and paper
7. Other manufacturing

There are five end uses in each industrial sub sector which are process heat, motive power, boiler, lighting and others. The Boiler end use application uses most of the energy. Therefore, coal is heavily consumed in the sector. Other main end uses for energy consumptions are power motive (31%), process heat (30%) and lighting (2%). Many traditional and small scale industries were closed due to due to shortage of reliable power supply [16, 17]. A study has shown that the electricity outage (i.e. planned and unplanned) has resulted in an economic losses to the tune of 4.43% of industrial sector GDP loss or 0.45% of the national GDP loss in the year 2001 [9]. In 2009, sixteen hours of planned electricity outage (February to March) was experienced [13]. Thus, the impact of the electricity outage on national economy has increased along with the prolongation in the outage periods.

Economic growth and energy demand are closely related [8]. In the Figure 1, the industrial sector energy consumption of Nepal has increased along with increase in an industrial value added amounts on national economy.

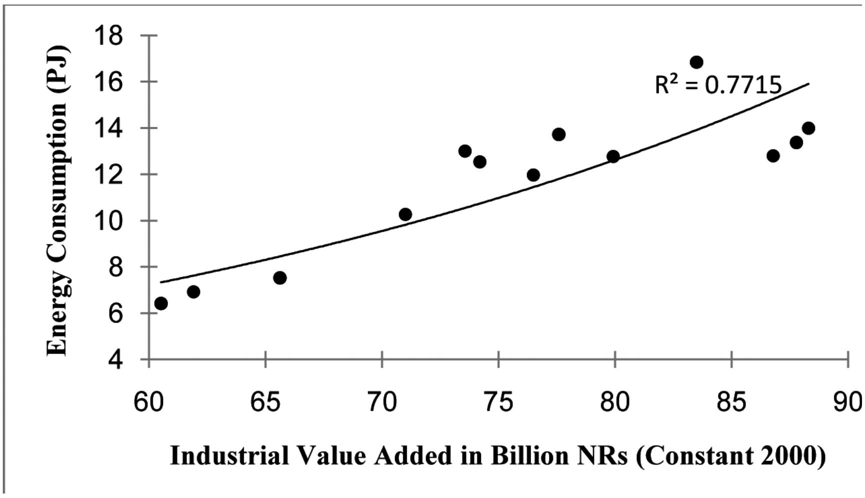

Figure 1: Relation between Industrial Energy Consumption and Industrial Value Added (1997-2009)

In literatures, Tripathy [12] used linear econometric demand model for the projection of electricity demand in the case of India from 1991 to 2007 by using sectoral value added approach. Mondal et al. [5] used the LEAP framework for industrial sector electricity demand projection of Bangladesh from 2005 to 2035 by using an anticipated overall sectoral contribution on national economy. Pokharel [8] used the econometric model to provide medium-range energy demand projections till 2012 for Nepal. Parajuli et al. [7] also used the econometric approach for energy consumption projections of the country from 2010 to 2030 under different anticipated growth scenarios. Shrestha et al. [11] analyzed the potential implications of adopting a policy of CO_2 emission reduction from Kathmandu Valley using Market Allocation (MARKAL) framework. Shakya et al. [10] analyzed the effects of different levels of road transport systems electrification over a long term horizon in Nepal using MARKAL framework. Both Shrestha et al. and Shakya et al. used the industrial value added approach for econometric projection of future industrial service demand.

The main aim of the present study is to project future energy demand of the industrial sector of Nepal by considering different industrial sub sectors for the period 2011 to 2030 under different growth scenarios of national economy. In addition to this, in a policy scenario, the energy saving opportunities in the sector has been discussed. This study has been done in Long – range Energy Alternative Planning (LEAP) framework.

2. Methodological Approach

The industrial energy demand model has been formulated for this study using LEAP framework [2]. End –use methodology combined with trend analysis has been used for energy demand projections. In the model, the data are assembled in a hierarchical order from sector level (industrial) to technology (fuel use) level. The sector level (industrial) consists of seven sub sector levels which are food beverage and tobacco, textile and leather, chemical, rubber and plastic, mechanical engineering and metal products, electric engineering products, wood and paper products and other manufacturing. In each sub- sector, there are five end uses (i.e., motive power, boiler, process heat, lighting and others). Finally, the data are arranged based on each end use according to the fuel use (i.e., coal, electricity, diesel etc). For the base year, the energy consumption has been calculated from end-use methodology. In formulated methodological framework, the energy demand has been calculated by multiplying the activities (energy services) by the 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 the sector's value added and energy intensities are mentioned on the section 3 and 4 of this study. The basis for industrial demand projections is based on the industrial value added and energy intensity approach. The energy intensity for industrial sector is calculated on the basis of quantity of energy used in particular year to the value added for the sector in that year. In this analysis energy intensity for each fuel used in the sector is in MJ/ $ (1 US $ equals 71 NRs in 2000).

In the model, the final energy demand has been calculated as the product of the total activity level A measure of social and economic activity. When used in LEAP's Demand analysis, activity levels are multiplied by energy intensities to yield overall levels of energy demand and the energy intensity The average energy consumption of some device or end-use per unit of activity. at each given technology branchAn item on the tree. Different types of branches are represented by different icons on the tree. The energy demand is calculated for the current year account The starting data for all scenarios. The Current Accounts can include data for just a single Base Year, or data for multiple historical years between the Base Year and one year before the First Scenario Year. and for each future year in each scenarioA self-consistent storyline of how a future energy system might evolve over time in a particular socio-economic setting and under a particular set of policy conditions..

Mathematically, (adopted from LEAP energy planning tool)

$$D_{b,s,t} = TA_{b,s,t} \, x \, EI_{b,s,t} \qquad (1)$$

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 yearThe first historical year of a LEAP analysis. [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:

$$D_{b,0} = TA_{b,0} \, x \, EI_{b,0} \qquad (2)$$

The energy demand calculated for each technology branch is uniquely identified with a particular fuelSomething combusted, or otherwise used to produce energy. 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,

$$TA_{b,s,t} = A_{b',s,t} \, x \, A_{b'',s,t} \, x \, A_{b''',s,t\,x} \qquad (3)$$

where A_b 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 [15]. The historical GDP and Initial Value Added (IVA) data are taken from the World Bank database [14].

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

3. Projection of GDP and Industrial Value Added (IVA)

3.1 Gross Domestic Product (GDP) Projection

The actual economic growth rate of the country is lower than the target set by government through its fiscal policies [1]. Hence, to project future economic growth of the country, its historical growth pattern has been considered. Figure 2 show the historical GDP growth trend of the nation. This figure shows that the GDP growth rate of Nepal is fluctuating. Thus, it is difficult to predict exact single value of the GDP growth for the future. The energy demand varies according to the GDP growth in the country. Therefore, if the projected growth is not followed in the future, there will be a high deviation on actual energy demand and supply from the projected value. To capture the future energy demand, different 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 (BA) (3.9%), low economic growth (LG) (4.4%), medium economic growth (MG) (5.6%) and high economic growth (HG) (6.5%). Among the growth scenarios, BA growth scenario has been taken as the reference scenario for analyzing energy saving opportunity (policy scenario) in the sector.

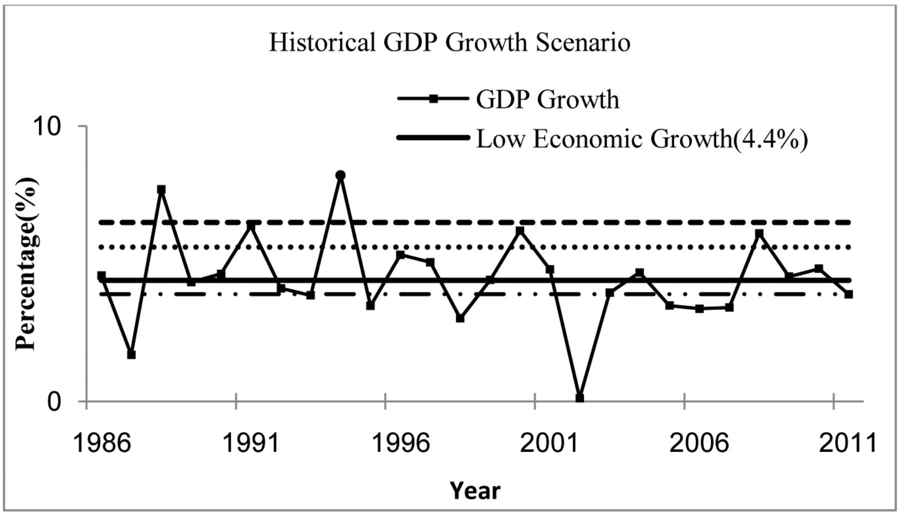

Figure 2: Historical GDP Growth Scenario of Nepal

In this study, the GDP growth rate up to 2010 has been taken as actual historical values. From 2011, four GDP growths scenarios are used. For the BA scenario, the GDP growth of the year 2011 has been considered and assumed that the growth will be continued during the study period. In the year 2030, projected value of GDP in the BA, LG, MG and HG will be NRs 1324 Billion, NRs 1450.99 Billion, NRs 1802.36 and NRs 2118.36 Billion respectively.

3.2 Industrial Value Added Projections

The historical industrial value added (IVA) trend of the country has been shown in the Figure 3. The trend has declining pattern. To capture the future energy demand in the sector, several IVA growth scenarios have been considered by analyzing the historical growth pattern. The IVA at 2005 was NRs 79.9 Billion. In this study, the actual observed IVA growth rates up to 2010 have been taken. From 2011, four GDP growths scenarios have been considered. For business as usual scenario, 2.9% industrial value added has been taken and projected the same growth rate up to

2030. 2.9% industrial value added was observed in 2011 when the overall GDP growth of the country was 3.9%.

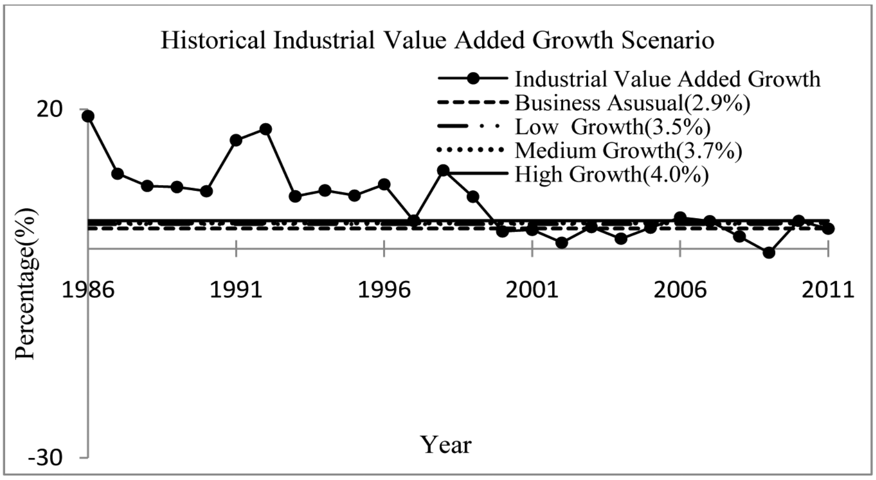

Figure 3: Historical Industrial Value Added Pattern of Nepal

For the low growth GDP projection, 3.5% annual growth of IVA has been taken from 2011 to 2030. The 3.5% IVA was Annual Average Growth Rate (AAGR) from 1997 to 2011 of the country. For high GDP growth rate, 4% IVA has been considered for the period. The 4% annual growth rate was observed in 1997, 2007 and 2010 respectively. For the medium GDP growth, 3.7% of the IVA has been considered. Figure 4 shows the projected scenarios of the IVA. Among the growth scenarios, the BA scenario has been taken as the reference scenario for projecting energy saving scenario (policy scenario).

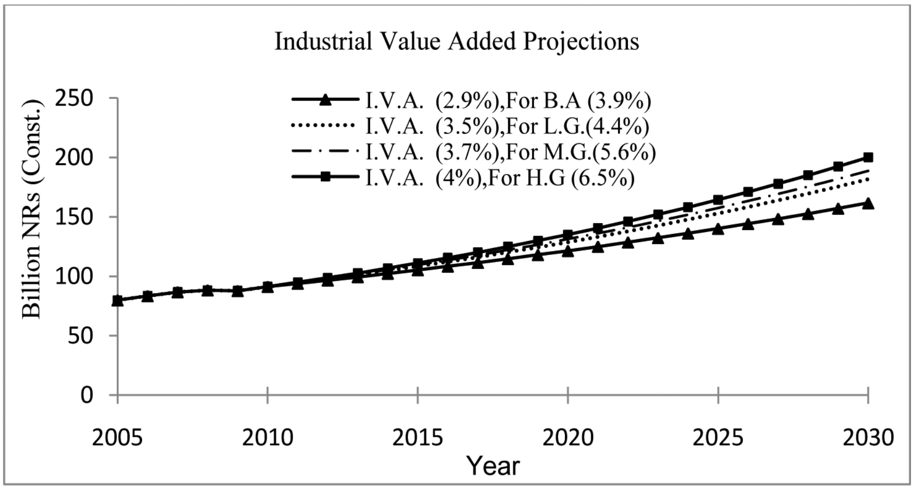

Figure 4: Projection of Industrial Value Added

4. Energy Intensity in Industrial Sector

Due to traditional approach, the energy intensity of Nepalese industry is quite high as compared to other developing countries [16, 17]. The overall sectoral energy intensity was 7.53 MJ/$ in 1997.

It went up to 10.81 MJ/$ in 2009 with AAGR of 6.28%. The maximum intensity of 15.71 MJ/$ was observed in the year 2000. Figure 5 shows the intensity and intensity growth rate of the sector since last 1997 to the year 2009.

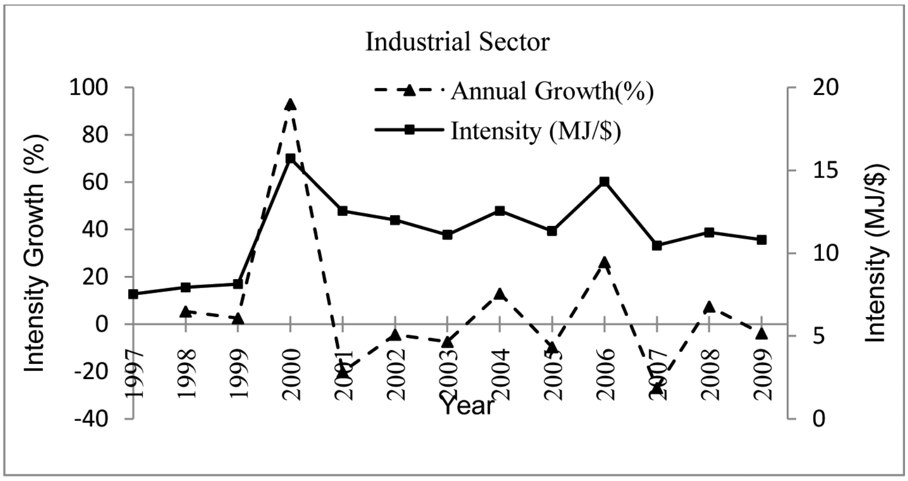

Figure 5: Intensity and Intensity Growth rate of Industrial Sector

The share of agriculture residue in 1997 was 16.53% of total industrial energy consumption which reduced to 10.09 % in 2009. The intensity of agriculture residue in 1997 was 1.244 MJ/$ which reduced to 1.092 MJ/$ in 2009. The trend of the agriculture residue intensity on the sector has been decreased. Figure 6 show the historical pattern of the intensity and its growth scenario from 1997 to 2009. The negative annual growth (- 4.2%) has been considered in the model for future intensity projection of the fuel.

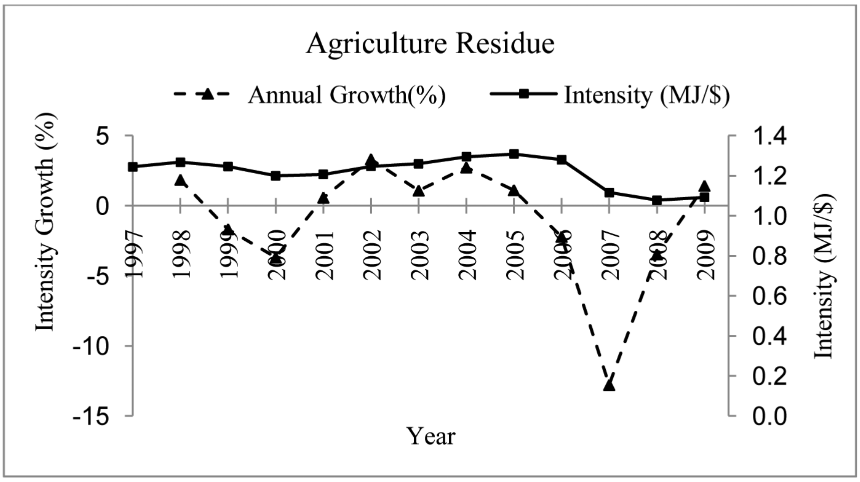

Figure 6: Agriculture Residue Intensity and Intensity Growth

The contribution of the fuel wood in the sector's energy consumption was 8.51% in 1997 and reduced to 5.39% in 2009. Figure 7 shows the historical pattern of intensity and its growth. In 1997, the share of the fuel wood intensity was 0.641 MJ/$ which reduced to 0.583 MJ/$ in 2009. The average intensity during the period was 0.637 MJ/$. The maximum intensity was 0.583 MJ/$

in 2005, while minimum was 0.577MJ/$ in 2008. The recent trend shows that the intensity of wood has decreased. For projection of intensity, the growth rate of -3.8% has been considered.

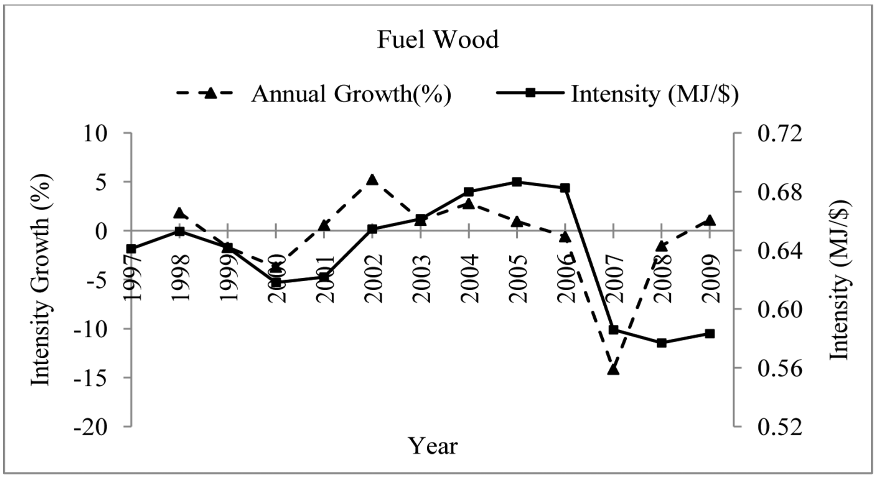

Figure 7: Fuel Wood Intensity and Intensity Growth

The share of electricity was 21.15% of the sectoral energy consumption in 1997 and increased slightly to 23.23% in 2009. As shown in Figure.8, the intensity has increased from 1.592 MJ/$ to 2.51 MJ/$ from 1997 to 2009. There was maximum intensity of 2.609 MJ/$ in 2008 while, the minimum intensity was only 1.592 MJ/$ in 1997. The trend of the intensity was gradually increased during the period. For future projection of it, 3.1% annual growth has been considered.

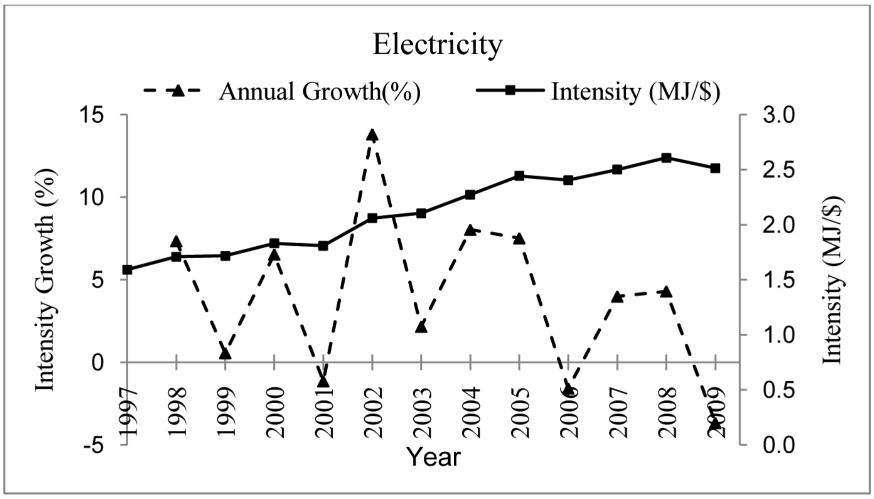

Figure 8: Electricity Intensity and Intensity Growth

The share of diesel was 5.33 % in 1997 but reduced to 1.8 % in 2009. In 1997, its intensity was 0.401 MJ/$ and reached to 0.193 MJ/$ in 2009. The average intensity during the period was 0.223 MJ/$. The maximum intensity was 0.475 MJ/$ in 1998, while in 2008 it was minimum to 0.133 MJ/$. In this study, annual growth of - 3.51% has been considered. Figure 9 shows the intensity and its growth from 1997 to 2009.

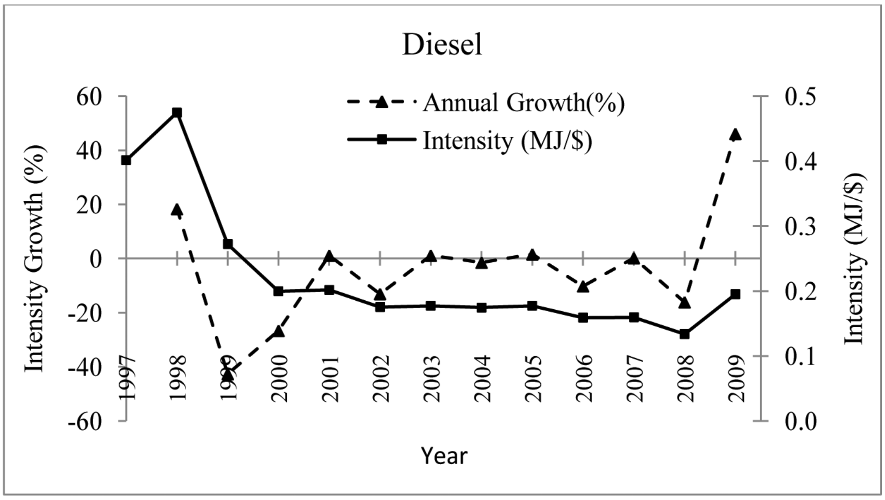

Figure 9: Diesel Intensity and Intensity Growth

In 1997, the share of kerosene was 5.74% of the sectoral energy consumption and sharply reduced to 0.83% in 2009. The energy intensity in 1997 was 0.432 MJ/$ which reduced to 0.090 MJ/$ in 2009. Its AAGR during the period was -9.58%, but the trend was observed negative from 2003 as shown in Figure10. The intensity growth of (-26%) has been consider for the future projection.

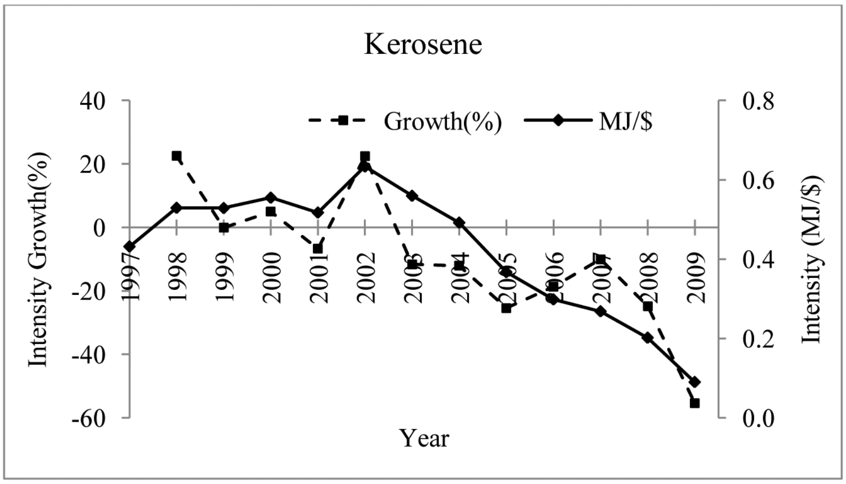

Figure 10: Kerosene Intensity and Intensity Growth

The intensity of coal was 2.576 MJ/$ in 1997 and reached to 6.242 MJ/$ in 2009 as shown in the Figure 11. In 1997, 34.2% of the industrial energy demand was supplied by coal and increased to 57.71% in 2009. The average intensity during the period was 5.89 MJ/$. For future projection of it, 0.8% annual growth has been considered.

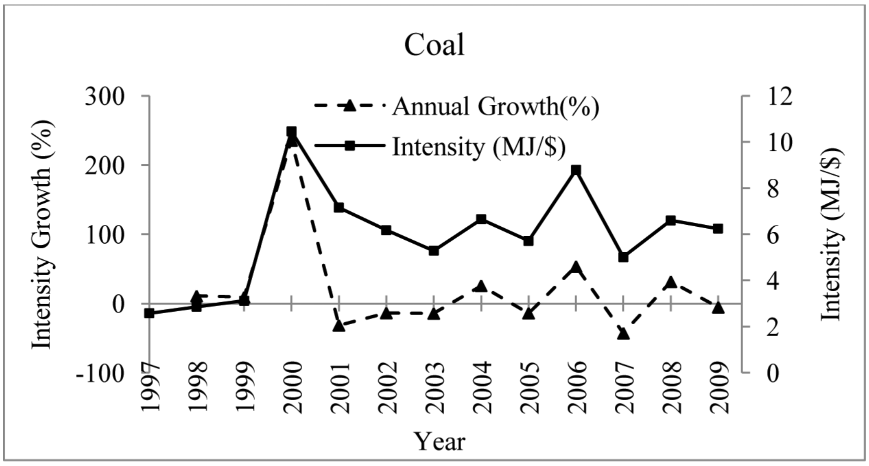

Figure 11: Coal Intensity and Intensity Growth

Figure 12 shows historical pattern of other petroleum and its growth from 1997 to 2009. In 1997, the intensity was 0.267 MJ/$ and reduced to 0.099 MJ/$ in 2009. The share of other petroleum was 8.33% of the sectoral energy consumption in 1997 and reduced sharply to 0.92% in 2009. The maximum intensity of 1.06 MJ/$ was observed in 2003 while minimum of 0.052 MJ/$ was observed in 2008. For future projection, -2.27% growths have been considered.

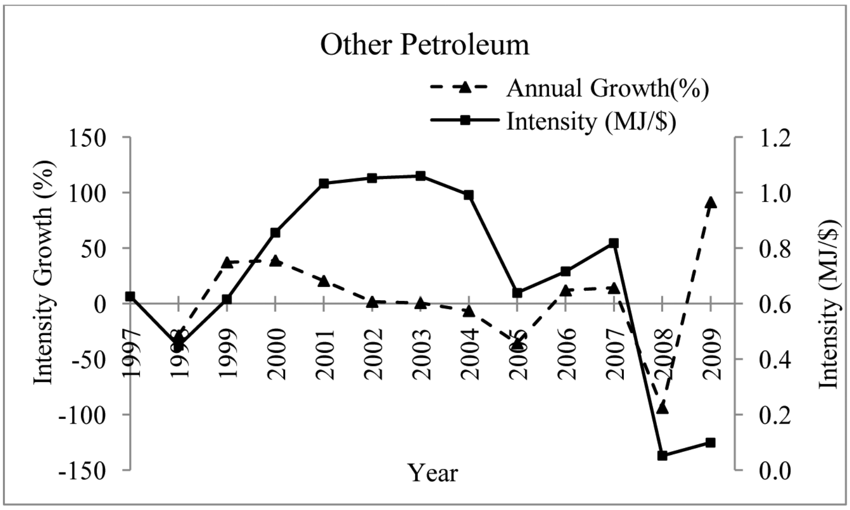

Figure 12: Other Petroleum Intensity and Intensity Growth

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 [16, 17]. Table 1 shows the actual and projected energy consumption during the period. It has been found that the percentage of deviations between actual and projected values are ranging from -1% to + 5% during the period. Thus, there is a close agreement between the model's output and actual consumption hence; the model has been used for further projections.

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

Year	2005	2006	2007	2008	2009
Model Output (PJ)	12.6	13.1	13.4	13.9	14.1
Actual Consumption(PJ)	12.7	12.8	12.8	14.0	13.4
Deviation from actual(PJ)	-0.1	0.3	0.6	-0.1	0.7
Deviation (%)	-1%	2%	5%	-1%	5%

Table 2: Projection of Total Energy Demand under Different Growths

Demand in PJ	Year						Ratio
Scenario	2005	2010	2015	2020	2025	2030	2030/2005
Business As usual (3.9%)	12.6	14.4	17.1	20.5	24.9	30.5	2.4
Low Growth (4.4%)	12.6	14.4	17.6	21.7	27.2	34.3	2.7
Medium Growth (5.6%)	12.6	14.4	17.8	22.2	28.0	35.7	2.8
High Growth (6.5%)	12.6	14.4	18.0	22.8	29.2	37.8	3.0

Table 2 shows the total industrial energy demands of the country under different scenarios. In 2030, the total demand of the country will reach to 30.5 PJ in the BA case. The final demand in 2030 will be increased by 2.4 to 3 times of the BA case in the HG scenarios. The projections of energy demand during the study period are shown in Figure.13.

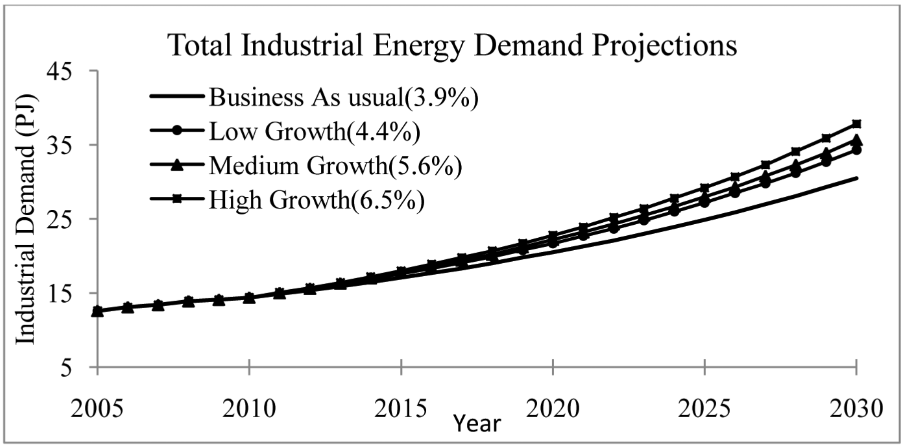

Figure 13: Projection of Energy Demand under Anticipated Growths

Table 3 shows fuels projections for various AAGR in the BA scenario. This also shows the projected end year values and ratio of end year to base year fuels in BA scenario. In future, the demand of coal, electricity and oil will increase whereas the demand of remaining fuels will decrease. The growth rate of the electricity demand will be maximum, followed by coal and oil. Although the demand of some fuels will decrease during the study period, the total energy demand of the sector will increase.

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
Coal	6.5	7.7	9.2	11.1	13.3	16	3.7%	2.5
Electricity	2.7	3.7	4.9	6.6	8.9	11.9	6.0%	4.4
Biomass	1.5	1.4	1.3	1.2	1.1	1.1	-1.3%	0.7
Wood	0.8	0.7	0.7	0.7	0.6	0.6	-1.0%	0.8
Oil	0.7	0.8	0.8	0.8	0.8	0.8	0.5%	1.1
Diesel	0.2	0.2	0.2	0.2	0.2	0.2	-0.8%	1.0
Kerosene	0.2	0.1	0	0	0	0	-23.9%	0.0
Total	12.6	14.6	17.1	20.6	24.9	30.6	3.6%	2.4

The energy demand projection for industrial sub sectors in the BA scenario has been shown in Table 4. It has been found that the growth rate of food beverage and tobacco sub sector will increase compared to other remaining sub sectors. However, the energy demand of electrical engineering and products sub sector will reduce and the total energy demand in the year 2030 will reach 30.54 PJ.

Table 4: Projection of Industrial Sub-Sector Demand for Business As usual Scenario

Demand in PJ	Year						AAGR	Ratio
Industry Sub-sector	2005	2010	2015	2020	2025	2030	2005-30	2030/2005
Other Manufacturing	4.13	4.89	5.87	7.03	8.44	10.13	3.7%	2.5
Food Beve.&Tobacco	3.59	4.29	5.25	6.53	8.21	10.44	4.4%	2.9
Mach Eng.& Metallurgy	2.05	2.16	2.37	2.66	3.06	3.60	2.3%	1.8
Textile and Leather	1.29	1.51	1.80	2.16	2.62	3.21	3.7%	2.5
Chemical Rub.& Plastics	0.89	0.90	1.02	1.20	1.45	1.78	2.8%	2.0
Wood Prod. & Papers	0.57	0.65	0.75	0.90	1.08	1.32	3.4%	2.3
Electrical Eng. Products	0.08	0.04	0.03	0.03	0.05	0.06	-1.1%	0.8
Total	12.61	14.43	17.08	20.51	24.91	30.54	3.6%	2.4

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 ratio will be 4.3, 4.9, 5.1 and 5.4 respectively under the BA, LG, MG and HG scenarios.

Table 5: Projection of Total Electricity Demand under Different GDP Growths

Electricity Demand in PJ			Year					Ratio
Scenario	2005	2010	2015	2020	2025	2030	2005-30	2030/2005
Business As usual (3.9%)	2.8	3.7	4.9	6.6	8.9	11.9	6.1%	4.3
Low Growth (4.4%)	2.8	3.7	5.1	7.0	9.7	13.4	6.5%	4.9
Medium Growth (5.6%)	2.8	3.7	5.1	7.1	10.0	13.9	6.7%	5.1
High Growth (6.5%)	2.8	3.7	5.2	7.3	10.4	14.7	7.0%	5.4

The electricity demand projections under anticipated growths are shown in Figure 14. According to study, the electricity demand of the country will increase by 6.1%, 6.5%, 6.7% and 7% respectively from 2005 to 2030 under the projected scenarios respectively.

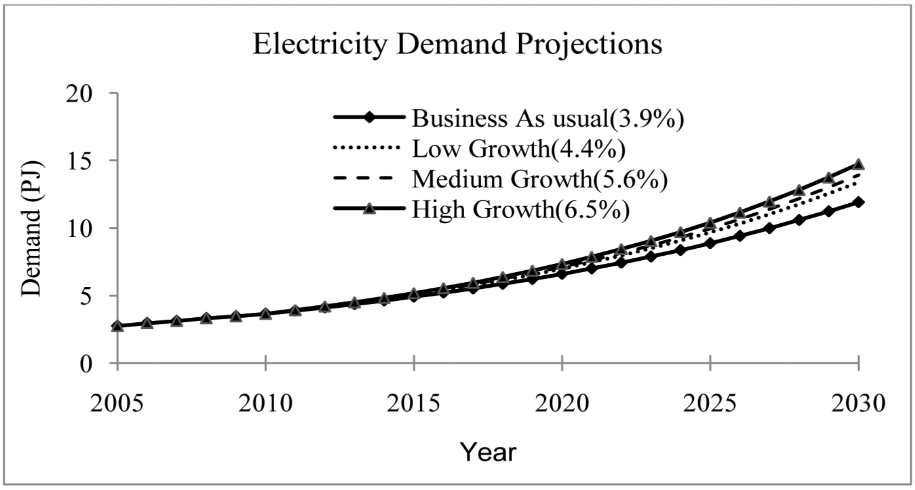

Figure 14: Electricity Demand Projections under Anticipated Growths

The five end-use applications are considered in the study. Among them, most of the energy is used in boiler, process heat and motive power. In base year 2005, boiler consumed largest share of sectoral energy supply followed by process heat, motive power, others and lighting applications as illustrated in Table 6. According to projections, the demand share of the motive power, boiler, process heat, lighting and others will reach to 35.8%, 35.2%, 24.6%, 2.1% and 2.3% respectively by the year 2030.

Table 6: Projection of End-Use Demand under Business As usual Scenario

End Uses	2005	Share (%)	2010	Share (%)	2020	Share (%)	2030	Share (%)
Motive Power	2.8	22.0%	3.6	24.9%	6.5	30.1%	12.2	35.8%
Boiler	5.2	40.9%	5.7	39.4%	8.3	38.4%	12	35.2%
Process Heat	3.5	27.6%	4.1	28.4%	5.7	26.4%	8.4	24.6%
Lighting	0.2	1.6%	0.3	1.7%	0.4	1.9%	0.7	2.1%
Others	1.0	7.9%	0.8	5.5%	0.7	3.2%	0.8	2.3%
Total	12.7	100%	14.5	100%	21.6	100%	34.1	100%

6. Energy Saving Policy Scenario

Although from national energy consumption perspective the share of total industrial sector energy consumption is low, there is a good potential for saving significant amount of energy in the sector. The detail study [6] on the 322 industries covering all industrial subsectors of the country has shown that there is a good opportunity for energy saving in these industries through implementation of energy saving measures. It has been pointed out that about 4.88% electrical energy in cement industry, 2.49% electrical & 22.52% thermal energy in pulp and paper industries, average 11.84% electrical & 15.28% thermal energy in food industry and 6.17% electrical & 22.97% thermal energy in metal industries can be saved.

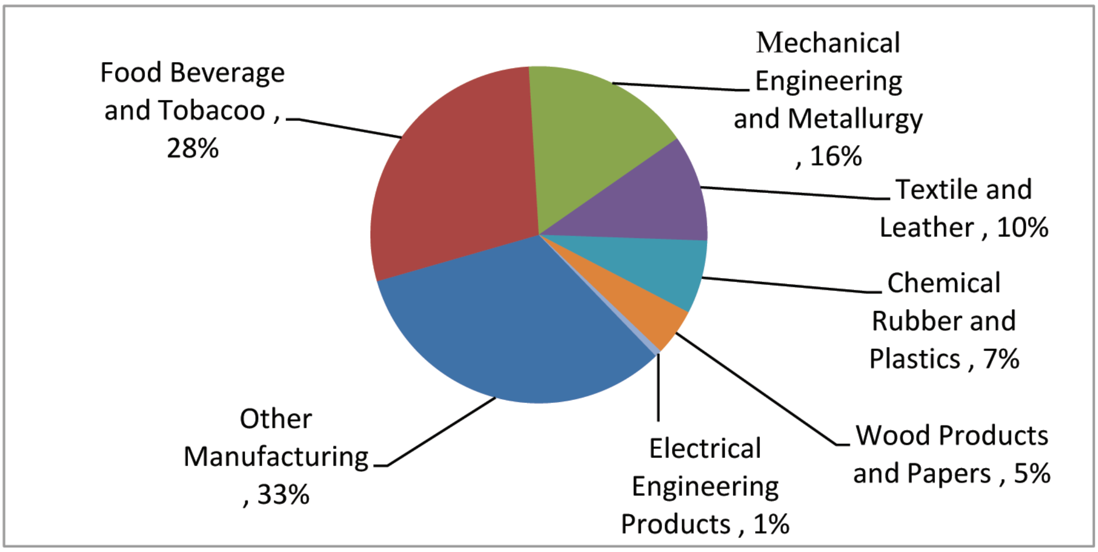

Figure 15: Contributions of End Use Applications in 2005

Similarly, in soap and chemical sub sector there is the possibility of saving 9.71% electrical & 39.46% thermal energy. The end use applications in 2005 have been shown in Figure 15. The three sub sectors, other manufacturing, food beverage and tobacco, mechanical engineering and metallurgy consumed about 77% of total energy consumption in the year. In energy saving policy scenario, saving potential of 11.84% electrical energy and 15.28% of thermal energy, in food beverage and tobacco sub sector, 6.17% electrical and 22.97% of thermal energy and 4.43% electrical and 25.56% of thermal energy in others sub sector have been analyzed. For the projection of energy demand in the scenario, the intensities of the fuels in end use applications are taken in such a way that by 2030 the potential saving in the subsectors can be achieved linearly from 2015 to 2030. In other manufacturing sub sector, the average saving potential of brick and cement industries has been considered. The average saving potential of biscuit, brewery, dairy, ghee and oil, industrial noodles and sugar has been considered in food beverage and tobacco sub sector and, finally, the metal industry saving potential has been taken for mechanical engineering and metallurgy sub sector.

Figure 16 shows the projection of total energy demand on the BA and energy saving policy scenario in the sector. Current study has shown that, if the policy scenario will be implemented, then the projected demand will be reduced from 30.5 PJ to 26.3 PJ in 2030. Thus in 2030, 4.2 PJ of energy can be saved, which will be 13.77% of the BA energy demand in the year 2030.

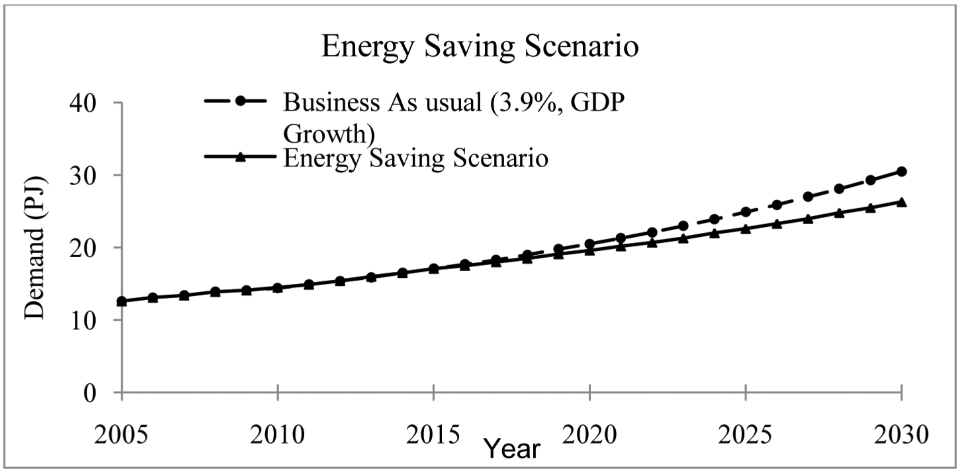

Figure 16: Projection of Energy Demand under Business As Usual and Energy Saving Scenarios

Table 7 shows energy demand values under business as usual and energy saving scenarios. It has been found that the energy demand of the country will reduce from 1.78 to 1.53 times of the base year demand by 2030, if the proposed policy scenario is implemented.

Table 7: Energy Demand under Business As usual and Energy Saving Scenarios

Energy Demand in PJ	Year						Ratio
Scenario	2005	2010	2015	2020	2025	2030	2015-30
Business As usual (3.9%, GDP Growth)	12.6	14.4	17.1	20.5	24.9	30.5	1.78
Energy Saving	12.6	14.5	17.1	19.6	22.6	26.3	1.53

The electricity demands under the BA and energy saving scenario have been shown in Figure 17. It illustrates the quantity of electricity that can be saved from applying the policy scenario.

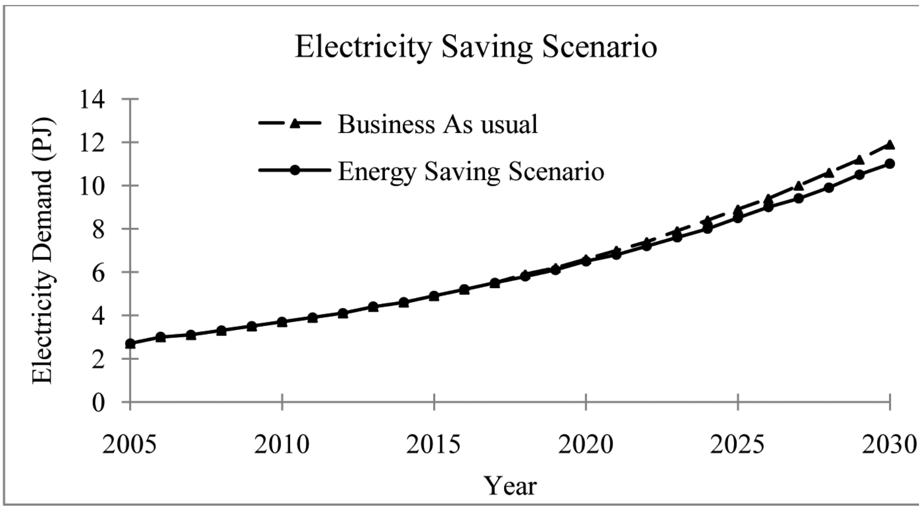

Figure 17: Projection of Electricity Demand under Business As usual and Energy Saving Scenarios

According to the study, after policy interference, the sectoral electricity demand will reduce to 11 PJ from 11.9 PJ in 2030. Thus, in year 2030, 0.9 PJ of electricity demand can be saved, which is 7.56% of the BA demand in the year 2030.

Table 8: Electricity Demand under Business As usual and Energy Saving Scenarios

Demand in PJ	Year						Ratio
Scenario	2005	2010	2015	2020	2025	2030	2015-30
Business As usual (3.9%, GDP Growth)	2.7	3.7	4.9	6.6	8.9	11.9	2.42
Electricity Saving	2.7	3.7	4.9	6.5	8.5	11.0	2.24

7. Conclusion

The industrial energy demand under the four anticipated growth scenarios of the national economy has been projected by formulating end use demand model using the LEAP energy planning framework. It has been found that the overall total energy demand of the country will increase from 2005 to 2030 by 2.4, 2.7, 2.8 and 3 times the base year demand and will reach to 30.5 PJ, 34.3 PJ, 35.7 PJ and 37.8 PJ on the BAU, LG, MG and HG scenarios respectively. The share of end use applications in the sector like motive power, boiler, process heat, lighting and others will reach to 35.8%, 35.2%, 24.6%, 2.1% and 2.3% of the total sectoral energy consumption in the year 2030.

Among the seven industrial sub sectors; six sub sectors energy demands will increase in future while one sub sector energy demand will decrease. The food beverage & tobacco, textile & leather, chemical rubber & plastics, mechanical engineering & metallurgy and wood products & paper sub sectors energy demand will increase with AAGR of 4.4%, 3.7%, 2.8%, 2.3% and 3.4% respectively from the year 2005 to 2030. The demand of electrical engineering and products sub sector will decrease by -1.1% AAGR during the period.

By formulating the policy scenario, we have shown that a policy intervention on the sector will reduce total energy demand including electricity demand in the coming years. Through application of the proposed policy intervention, the total energy demand and electricity demand of the sector in 2030 can be reduced by 13.77% and 7.56% of the projected BA energy demand. The outcomes of the study will contribute in the future energy planning process of the country to provide reliable energy supply .

References

[1] Dhungel KR (2008), A Causal Relationship between Energy Consumption and Economic Growth in Nepal. *Asia-Pacific Development Journal*, **15** : 137-150.

[2] LEAP (2011*), Long Range Energy Alternative Planning System, A tool for energy policy analysis and climate mitigation assessment*, Stockholm Environment Institute, USA.

[3] MoI (2010), Ministry of Industry (MoI), Government of Nepal, *Industrial Policy 2010*, Kathmandu, Nepal.

[4] MoICS, (2002), Ministry of Industry, Commerce and Supplies, Government of Nepal, *Industrial Development Perspective Plan: Vision 2020, Analytical Report*, Kathmandu, Nepal.

[5] Mondal MD, AH. Boie W, Denich, M. Future (2010), Demand Scenarios of Bangladesh Power Sector, *Science Direct, Energy Policy* **38**, 7416-7426.

[6] NEEP, (2012), *Nepal Energy Efficiency Programme, Final Report*, Baseline Study of Selected Industries to access the potentials for more efficient use of energy, Kathmandu, Nepal.

[7] Parajuli.R, Alberg.P, Dalgaard.T, Pokharel. GR. (2013) Energy consumption projection of Nepal: An econometric approach, *Science Direct*, 432-444.

[8] Pokharel S (2007), An Econometric analysis of energy consumption in Nepal. *Energy Policy*, 350-361.

[9] SARI/Energy, (2003), *South Asia Regional Initiative for Energy*, Economic Impact of Poor Power Quality on Industry, United States Agency for International Development, 2003,Nepal.

[10] Shakya SR, Shrestha RM (2011), Transport sector electrification in a hydropower resource rich developing country: Energy security, environmental and climate change co-benefits, *Science Direct*, 147-159.

[11] Shrestha RM and Rajbhandari S (2009) Energy and environmental implications of carbon emission reduction targets: Case of Kathmandu Valley, Nepal, *Science Direct*, 4818-4827.

[12] Tripathy SC (1997) Demand Forecasting in a Power System, *Energy Convers. Management* **38**, 1475-1481.

[13] USAID, (2009) United State Agency for International Development, *Impact Assessment of Load Shedding on Media and Access to Information in Nepal*, 2009, Kathmandu, Nepal.

[14] WB (2012), World Bank Data, Nepal, 2012. Accessed: September 5, 2012, *http://data.worldbank.org/country/nepal*.

[15] WECS, (1997), Water and Energy Commission Secretariat (WECS), *Update and Compilation of Energy Resources and Consumption Profile of Nepal, Final Report, Volume-I & II*, Nepal.

[16] WECS, (2006), Water and Energy Commission Secretariat (WECS), *Energy Synopsis Report: Nepal*, Ministry of Water Resources, 2006, Kathmandu, Nepal.

[17] WECS (2010), Water and Energy Commission Secretariat (WECS), *Energy Synopsis Report*, Ministry of Water Resources, Kathmandu, Nepal.

[18] WTO (2012), World Trade Organization, *Trade Policy Review Report by Nepal*.