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SUSTAINABLE ENERGY PLANNING FOR NEPAL IN THE FEDERAL STRUCTURE

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Abstract

This paper examined the energy planning in each province, sustainable technology policy interventions in the energy demand and social cost benefit analysis in energy sector for Nepal in the federal structure over the period 2017 -2050 using LEAP-IBC modelling framework.Four scenarios were developed, reference, Low economy, accelerated economy and sustainable scenario, former three are based on socioeconomic assumption and later is technology intervention case. In reference scenario, energy consumption will increase by 3 folds from 544 PJ to 1645 PJ during 2017-2050, whereas in sustainable scenario the value expected to increase to 866 PJ by 2050.In the base year 2017, emission is 69 million metric tons of Co2 equivalents whereas per capita emission is 2.36 metric tons. In the reference scenario the carbon emission increases to 178 million Metric tons of CO_2 equivalent in 2050 whereas per capita carbon emission increases to the 4.06 metric ton in the year 2050. In sustainable scenario the carbon emission increases to 21.95 million Metric tons of CO_2 equivalent in 2030 whereas per capita carbon emission reduces to the 0.64 metric ton in the year 2030 due to the technological policy intervention.The calculated NPV shows that SED scenario is most economically viable with NPV value 7899 million NRS.In sustainable policy scenario efficient as well as new and improved technologies has been considered as a result of which substantial amount of reduction in energy intensities and per capita final energy consumption is achieved. In reference scenarioper capita energy consumption 18GJ is increase to 40 GJ and in sustainable scenario is expected to 19 GJ by 2050.

Keywords: *Energy Planning; LEAP-IBC; Emission*

1. Introduction

Energy is a crucial element for sustainable development of country. Unless the energy sector is geared up for efficient, secure and indigenous sustainable resources, the economy cannot move forward on higher growth path. Access to reliable and affordable energy services has become fundamental in reducing poverty, increasing productivity, enhancing competitiveness and promoting economic growth. Sustainable energy planning and management is a method of research, development and promotion of rationality in planning and policy making that optimizes the benefits for global as well as local societies by making use of cost-effective energy technologies and clever policy strategies.

Table 1: Energy balance of Nepal for base year 2017 in TJ[1],[5],[6],[8],[9],[10],[11],[18][19]

Base Year (2017) Energy Balance (TJ)							
Particulars	Petroleum Products	Coal	Hydro	Electricity	Biomass	Modern Renewables	Total
Primary Supply							
Indigenous production	-	-	18371	-	391532	17159	427062
Imports	81464	38836	-	7830	-	-	128130

Exports	-	-	-	(10)	-	-	(10)
Stock changes	(964)	-	-	-	-	-	(964)
Total Primary Supply	80,500	38,836	18,371	7,820	391,532	17,159	554,218
Transformation							
Inputs	(1434)	-	-	-	-	-	(1434)
Electricity generation	-	-	14,697	15200	-	-	439
T & D losses	-	-	-	(4,763)	-	-	(3,078)
Other losses, own-use etc.	-	-			-	-	(3,200)
Net supply to consumers	79,066	38836	0	18,257	391532	17,159	544850
Final Consumption							
Industry	737	35,938	0	6,442	9,417	-	52,534
Residential	9533	93		9127	372592	17,159	407,939
Commercial	4930	2804		2,254	9,524	-	19512
Transport	56021	-		24	-	-	56045
Agriculture	7,846	-		407	-	-	8,253
Total	79067	38835	0	18254	391,533	17,159	544,848
Statistical error	1	(1)	-	(3)	(0)	-	

The main energy resource base in the Nepal are fuel wood, hydropower, petroleum products and other fuels like crop residues, livestock manure, biogas technology, micro- hydro turbines, coal, solar energy and wind energy etc. The resources are scarce and demand is increasing. The petroleum products supply is interrupted time to time so for the sustainability there is the need of the Sustainable Energy Planning and Management. The population and the GDP of the Nepal are increasing which forces the increase in the life standard and energy demand. To meet the high energy demand with the scarce available sources, there arises the policy problem and management problem. So to meet this scenario we need the energy planning.

2. Literature Review

Nepal is divided in three ecological region Himalayan, Hill and Terai. Before reconstruction of province Nepal is divided into 5 development regions and 75 districts. Eastern development region (EDR) contain 16 districts, Central development region (CDR) contain 19 districts, western development region (WDR) contain 16 districts, mid-western development region (MWDR) contains

15 and far western development region contains 9 districts [2]. The energy balance is disaggregated using disaggregation ratio according to WECS energy demand survey 2011/12 [22][23]. Energy data were depicted in WECS survey report by development and ecological region. So energy in each province calculated accordance with below table:

Table 2: Relation between province, district and development region

Description	Relation between province ,district and development region
Province1	Province 1=EDR-Saptari-siraha
Province2	Province 2=CDR Terai+saptari+siraha-Chitwan
Province3	Province 3= CDRHill +CDR Mountain+Chitwan
Province4	Province 4=WDR Hill+WDR Mountain-Arghakhanchi-Gulmi-palpa
Province5	Province5=MWDR Hill+MWDRTerai +WDR Terai+Arghakhanchi+Gulmi+palpa-Surkhet- salyan
Province6	Province6=MWDR mountain + Surkhet+ Salyan
Province7	PROVINCE 7=FWDR

Seven districts Saptari, Siraha, Chitwan, Arghakhanchi, Gulmi ,Palpa ,surkhet ,Salyan energy consumption calculated with respect to proportion of Population and GDP.

Energy Consumption in Each Province:

Seven provinces are reconstructed on the basis of demographical, ecological and political structures such as population, geographical area, the human development Index, per capita income, agriculture production, roads, revenues, etc. On the basis of agriculture and other variables Province 3 comes out on top, Province 2 comes in second. Table 3 illustrates energy consumption by different economic sectors in each province. Total energy consumption in Nepal is 544.28PJ.The energy consumption in province 3 is 131.56 PJ which is higher than other provinces. Province 2 contain most of industry and only Terai districts so energy consumption is higher than other Provinces one, four, five, six, seven. The consumption of energy in Province six is 16.53 PJ which is lowest energy consumption than other provinces.

Table 3: Sectorial energy consumption in provinces fiscal year (2016/17) [1], [3],[18],[19]

Energy consumption (PJ)						
Province	**Residential**	**Commercial**	**Transportation**	**Industrial**	**Agricultural**	**Total**
Prov.1	72.66	2.30	5.41	6.33	1.21	87.90
Prov.2	80.98	3.93	12.24	15.24	2.92	115.30
Prov.3	75.95	7.48	27.54	19.79	0.80	131.56

Prov.4	31.55	1.51	2.50	1.27	0.19	37.03
Prov.5	85.97	2.98	6.53	8.61	2.43	106.53
Prov.6	15.81	0.32	0.23	0.14	0.04	16.53
Prov.7	45.02	0.98	1.59	1.16	0.67	49.41
Total	407.94	19.51	56.04	52.53	8.25	544.28

LEAP Energy Modelling Framework

LEAP (Long-range Energy Alternatives Planning System) was originally created in 1980 for the Beijer Institute's Kenya Fuel wood Project, to provide a flexible tool for long-range integrated energy planning. LEAP provided a platform for structuring data, creating energy balances, projecting demand and supply scenarios, and evaluating alternative policies, the same basic goals as the current version of LEAP [13].LEAP follows an end use, demand driven approach, which means that the analysis starts from the end use of energy. Because LEAP is a very general purpose software tool, which can be used to build a wide variety of different models of energy systems, it is impossible to definitively describe its data requirements.

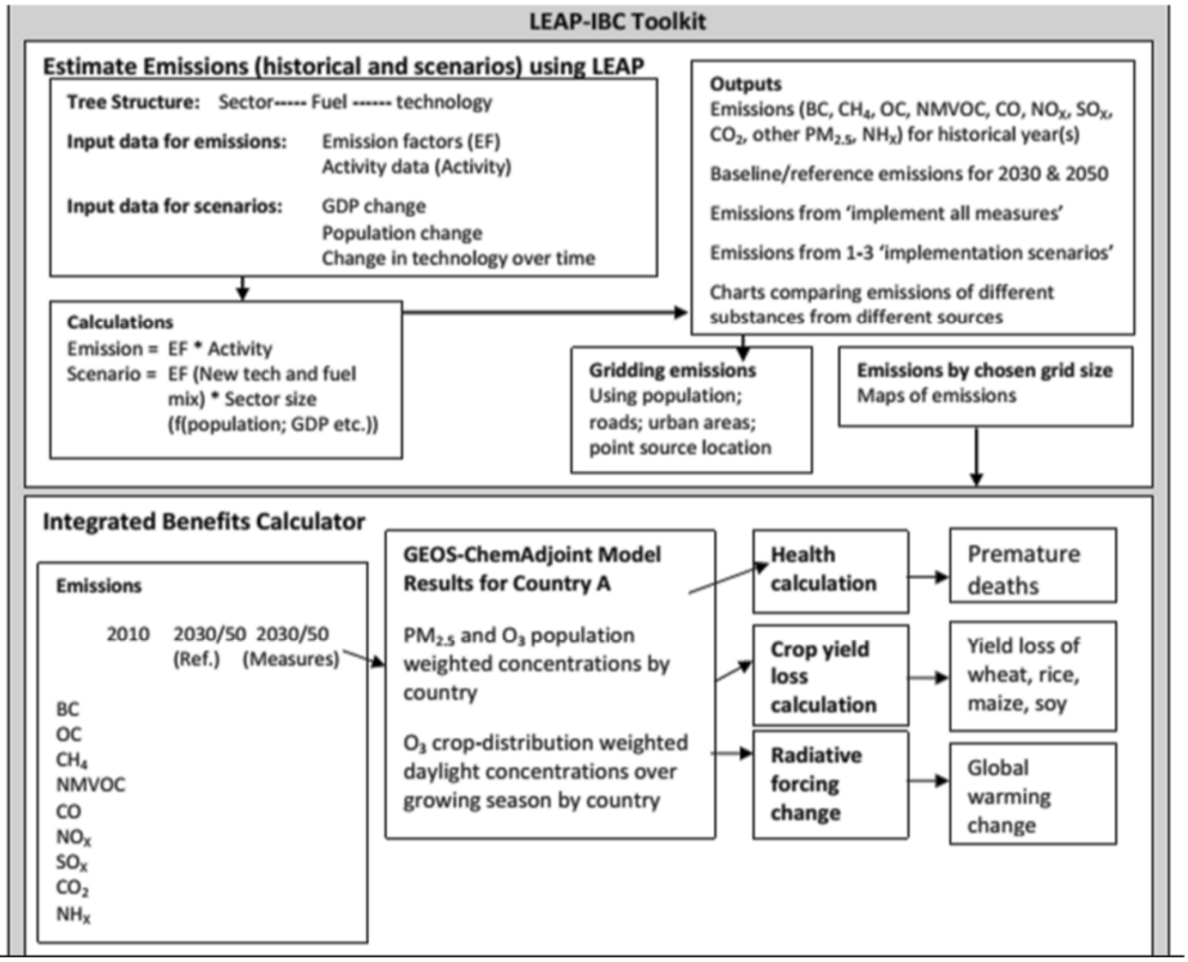

Fig1: LEAP-IBC modelling framework

(Zhao, Liu, & Zhao, 2011)Provides an important reference for the Chinese government to develop low-carbon economy using LEAP model. Four critical factors, the per capita GDP, energy consumption, energy structure, and CO2 emissions, are mainly considered as the indicators to measure the level of low-carbon economic development [21].

(Shakya, Kumar, & Shrestha, 2012)Analyses the co-benefits of introducing a time variant carbon (C) tax scheme in Nepal, a hydropower resourceful country, by using a bottom up integrated energy system model based on the MARKetALlocation (MARKAL) framework with time horizon of 2005–2050 [26].

(Parajuli, Østergaard, Dalgaard, & Pokharel, 2014) Assess the future primary energy consumption of Nepal, and the projection is carried out along with the formulation of simple linear logarithmic energy consumption models [12].

(Shakya, 2012)Studies the economy-wide consequences of introducing different levels of electrified mass transport systems in Nepal on the long term basis [14].(Shakya & Shrestha, 2011) analyses the co-benefits of transport sector electrification in terms of reductions of greenhouse gas and local environmental emissions, improvement in energy security and employment generation during 2015–2050 in the case of Nepal—a developing country with large hydropower potential. A bottom up energy system model of Nepal based on the MARKAL framework was developed to assess the effects of meeting a part of the land transport service demand through electrified mass transport system and electric vehicles [15].

(Lund, 2007)Discusses the perspective of renewable energy (wind, solar, wave and biomass) in the making of strategies for a sustainable development using Energy Plan modelling framework [4].

(Nakarmi, Mishra, & Banerjee, 2014) employs an integrated model for analysis of energy demand and MARKAl Allocation modelling framework for assessing different pathways for the development of energy systems of Nepal and this is the first attempt to integrate the MAED energy demand model with the MARKAL supply model for assessing and analysing energy systems and their implications in Nepal [7].

(Shrestha & Rajbhandari, 2010)analyses the sectorial energy consumption pattern and emissions of CO_2 and local air pollutants in the Kathmandu Valley, Nepal. It also discusses the evolution of energy service demands, structure of energy supply system and emissions from various sectors under the base case scenario during 2005–2050 [17].

3. Methodology

Modelling Framework and Data input

Out of the different energy modeling tools the LEAP modeling framework is being picked up for this thesis work due to its compatibility with published energy demand data. The Long-range Energy Alternatives Planning system (LEAP) is a widely-used software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute (SEI). It has been adopted by hundreds of organizations in more than 150 countries worldwide.

Fig 4: Key assumption, and disaggregation of residential and industrial sector.

The final energy demands of each economic sector are obtained from the prepared energy balance of base year 2017. Then each sector are disaggregated into the different development region, each development region is disaggregated into different physical region. For residential sector each physical region is disaggregated into rural and urban and is further disaggregated to end-use service demand. Similarly in the other economic sector each physical region is disaggregated into end-use service demand. According to the disaggregation branching was developed in the LEAP model as in the figure.

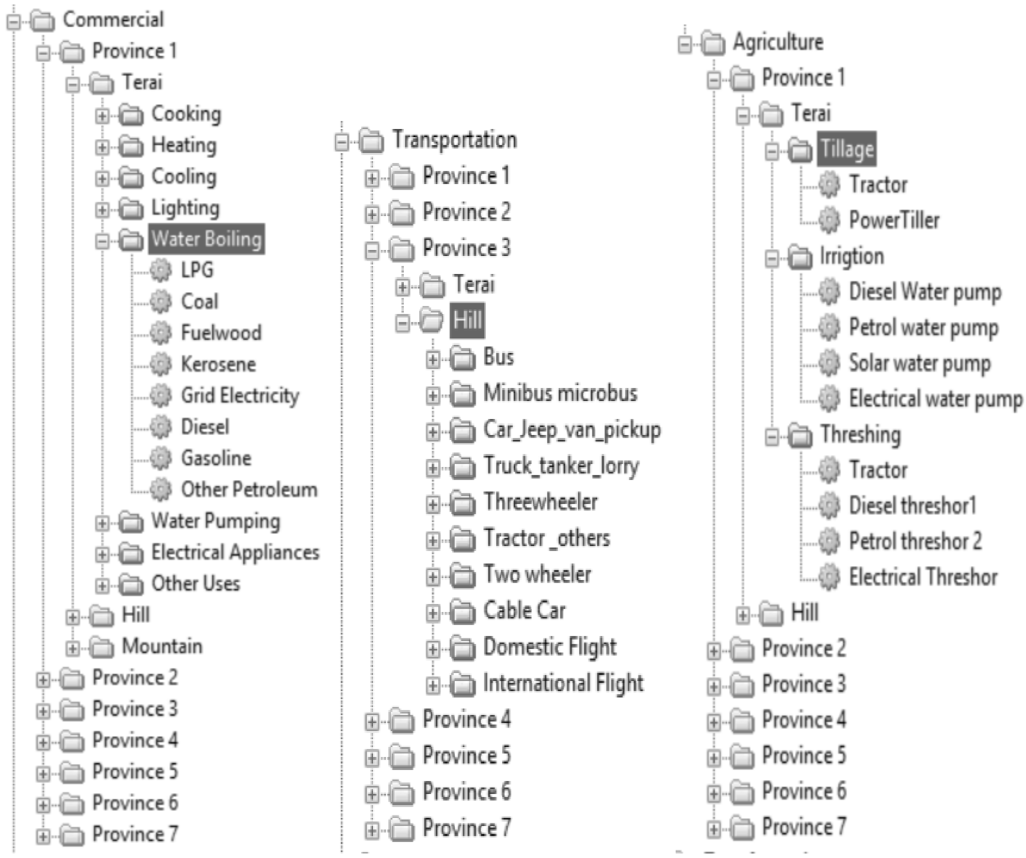

Fig 5: Key assumption, and disaggregation of Commercial, Transportation, and Agricultural sector.

Elasticity Calculations

The historical data of sectorial energy consumption, GDP, industrial VA, Commercial VA, and Agricultural VA are collected and different log linear regression models are developed to find the elasticity's for sectorial energy consumption.

The regression model is developed between following variables;

Dependent Variable	Independent Variable
Residential Energy Consumption (Y1)	Total Population (P1)
Industrial Energy Consumption (Y2)	Industrial VA (X2)
Commercial Energy Consumption (Y3)	Commercial VA (X3)
Transportation Energy Consumption (Y4)	Total GDP (X4)
Agricultural Energy consumption (Y5)	Agricultural VA (X5)

And the following results are obtained from the regression analysis.

Table 4: Results from regression analysis

Variables	R square	t value	P value	Elasticity
log(Y1) & log(P1)	0.588	4.14	0.00137	1.250
log(Y2) & log(X2)	0.444	3.09	0.00928	0.944
log(Y3) & log(X3)	0.122	2.29	0.22050	1.064
log(Y4) & log(X4)	0.526	3.65	0.00335	0.818
log(Y5) & log(X5)	0.742	5.88	0.00007	1.070

The model validity needs t-value grater or equal to 2.25 and corresponding p-value must be less than 5%. According to that, Five models are accepted.

Demand Forecasting

LEAP model uses the econometric method to forecast the energy demand of the country on the basis of base year calibrated data input in the model.

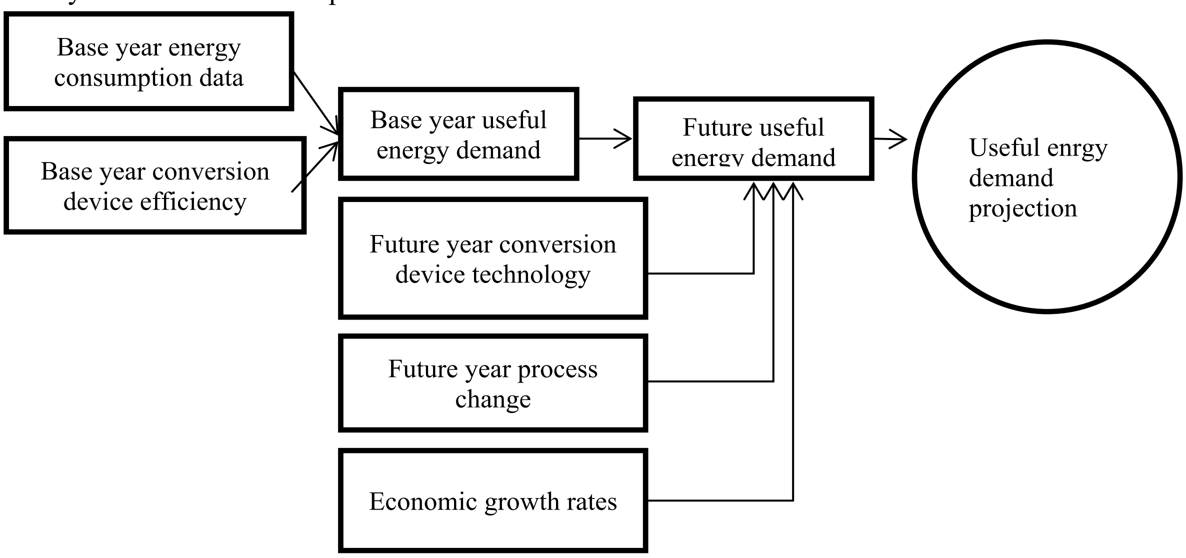

Figure 6: Energy demand projection flow chart

Scenario Development

Along with the REF scenario with other scenarios will be developed which helps in sustainable energy planning in each province.

Low Economic Growth Scenario

This scenario assumes a past 10 years average GDP growth rate of 4.5 % relative to the 7% GDP growth rate assumed in the reference scenario. All other underlying assumptions with respect resource availability, technology and other parameters are similar to those in the reference year.

High Economic Growth Scenario

This scenario assumes that high GDP growth rate according to high developing countries GDP growth rate 9.2 %.It further assumes that the share of each demand technology in the energy supply in future years will be the same as in the reference year.

Sustainable Energy Development Scenario

Technology intervention in Residential sector:

This Sustainable scenario is developed in order to make electricity consumption per households targeted to meet TIER 5 as in "Beyond Connection: Energy Access Redefined". The Multi –Tier Matrix for electricity consumption is depicted following table.

Table 5: Multi –Tier Matrix for electricity Consumption per households [22]

	TIER0	TIER1	TIER2	TIER3	TIER4	TIER5
Annual consumption level(KWh)	<4.5	≥4.5	≥73	≥365	≥1250	≥3000
Daily consumption levels (WH)	<12	≥12	≥200	≥1000	≥3425	≥8219

In this scenario the total energy consumption is targeted to more 3,000KWh per household and meets TIER 5. As stated above target to achieve TIER 5 by 2030 various technological interventions in different Rural and Urban sector have been considered. The technological interventions are depicted below table.

Table 6: Technological interventions in rural households

End uses	Descriptions
Cooking	By 2030, 85% of penetration of Electricity in cooking along with 15% Biogas and 10% improved Cooking stove.
Heating	Replacement of Traditional fuel with electricity by 70% in Terai ,50% in Hill and 50% in Mountain by Electricity .
Cooling	100% electricity access by 2030.
Lighting	100% electricity access by 2030.
Water Boiling	By 2030, 35% of penetration of Electricity in water boiling along with 15% solar water heater
Electrical Appliances	100% electricity access by 2030.

Table 7: Technological Interventions in Urban Households

End uses	Descriptions
Cooking	100% of penetration of Electricity by 2030
Heating	100% of penetration of Electricity by 2030
Cooling	100% electricity access by 2030.
Lighting	100% electricity access by 2030

Water Boiling	By 2030, 75% of penetration of Electricity in water boiling along with 25% solar water heater
Electrical Appliances	100% electricity access by 2030.

Technology Intervention in Industrial Sector:

Industrial Sector is second most energy consuming sector after residential. In 2017 energy consumption took up 10% of total energy consumption share (52.5PJ). The energy demand increases at an average 7% per annum to 120PJ in reference case. In sustainable energy development scenario the major intervention taken which are depicted below table:

Table 8: Technological interventions in industrial sector

End Uses	Descriptions
Power Motive	100% of penetration of Electricity by 2030
Process Heating	Replacement of traditional fuel ,coal, diesel and other oil used in process heat with electricity by 50% until 2030
Boiler	Replacement of traditional fuel ,coal, diesel and other oil used in boiler with electricity by 50% until 2030
Lighting	100% of penetration of Electricity by 2030
Other Equipment	100% of penetration of Electricity by 2030

Due to electrification in process heat, boiler and motive power, there is clear shift from imported petroleum products to clean renewable energy, especially hydropower.

Technology intervention in Transportation sector:

Transport sector energy consumption in 2017 was 56 PJ i.e. 10% total energy consumption. In transport sector, efficient means of transportation, electrification and promotion of mass transport are major strategic options for policy intervention. The EV30@30 campaign, launched at the Eighth Clean Energy Ministerial in 2017, redefined the EVI ambition by setting the collective aspirational goal for all EVI members of a 30% market share for electric vehicles in the total of all passenger cars, light commercial vehicles, buses and trucks by 2030 [23]. Electric train is introduced in freight transport in 2020 and its share 13% by 2030 and 30% by 2050. Introduction of electric train in intercity transport is expected only by 2020 and its share is supposed to increase to 30% by 2050.In case of intracity transport, the strategic option undertaken are high penetration of electric bus i.e. nearly 37% of total intracity transport share is electric (electric car, mono rail, ropeway, two-wheeler , electric bus) by 2030. Electric car, electric train, electric bus and mono rail are introduced to shift conventional mode of transport to clean and sustainable transport system. Increase of electricity use from 0.5% in reference case to around 30% indicates sustainable path of transportation sector.

Technology Intervention in Commercial Sector:

Commercial sector consumes only about 3.5 % of the total energy consumption in Nepal where as it accounts for 49% in Gross value added in the country. 41% of energy demand in the commercial sector is met by petroleum products and 12% by electricity. Traditional fuels meet about 48%of the commercial sector energy demand. With gradual increase in the penetration of electricity in the end uses in the service sector, most of the energy demand is expected to be fulfilled with electricity by 2030 and onwards. Petroleum fuel, traditional fuel used for cooking, heating, lighting and water heating replaced with electricity by 2030.

Technology Intervention in Agriculture Sector

The interventions of efficient technologies and fuel switching to clean energy in sustainable development scenario is done by electrifying 25% of farm machinery and 100% in water pumping by 2030.Electricity and solar power are used for water pumping. Increase of electricity use from 2% in reference case to around 15% indicates sustainable path of agricultural sector.

4. Results and Discussion

Total energy consumption in each province in the reference scenario:

The total final energy demand is 544.3PJ in base year 2017. With the assumed population and economic growth rates, the overall final energy demand is projected to increase 3 times over the study period 2017- 2050.The projected final energy consumptions in each province have illustrated in figure below:

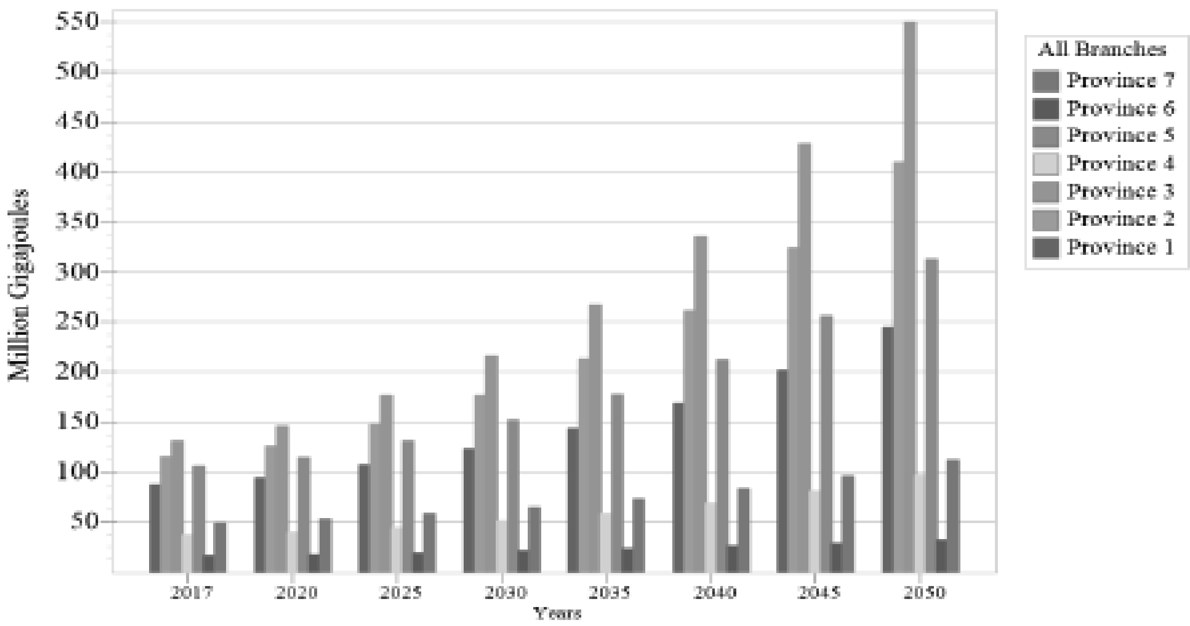

Fig 7: Energy demand projection in each province Reference Scenario

The energy demand in province 3 is rapidly increases than other Provinces. The energy demand in province 3 increase to 422 PJ by 2050 from base year value of 132PJ in 2017.The energy Province 2 contain most of industry and only Terai districts so energy consumption is higher than other Provinces 1, 4, 5, 6, 7. The energy demand in province 6 very low which increase to 33.56 PJ by 2050 from base year value of 16.5 PJ in 2017.

Energy Demand projection at different economic scenario

The comparative study of all scenarios reveals the changing energy consumption pattern .Energy consumption is increased with increase in GDP which correspond to increase in economic activities

and also signify improving living standard of people. However sustainable energy development policy scenario at reference GDP case brings reduction in energy consumption due mainly to shift in efficient and modern from traditional technologies. The figure 3 shows that The total energy consumption is 544.23 PJ in base year 2017 which increased to 1200.25 PJ by 2050 in low economic growth rate scenario, 2713.31 PJ by 2050 in accelerate economic scenario and 866PJ by 2050 in sustainable economy scenario. This energy reduction in sustainable scenario is achieved due to increase in the efficient electric energy penetration system.

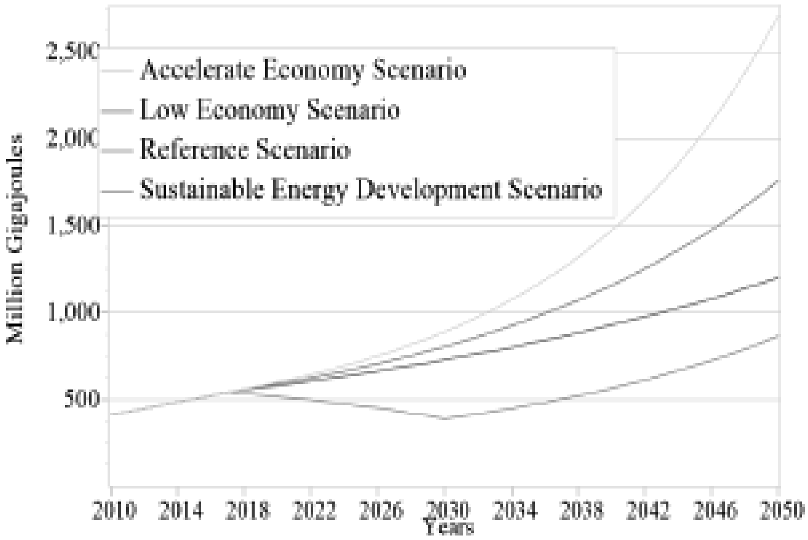

Fig 8: Energy demand projection at different economic scenario

Fuel Mix in Sustainable Development Scenario:

In Sustainable energy development Scenario fuel wood consumption will be below sustainable limit by 2030. With the policy intervention to promote commercial and renewable energy , traditional energy fuel wood share will be 28% of total energy mix by 2030.To reduce dependence on imported and promote indigenous energy resource, electrification in possible sector is incorporated that will substantially reduce import of petro products. As a result, electricity consumption grows rapidly in 2030. The share of electricity in 2017 is 3%which is increase to 49% by 2030. It is clear that quantitatively the total primary energy demand would be as much as halved. The demand for electricity would nearly double while demand for petroleum and coal would be nearly halved as well.

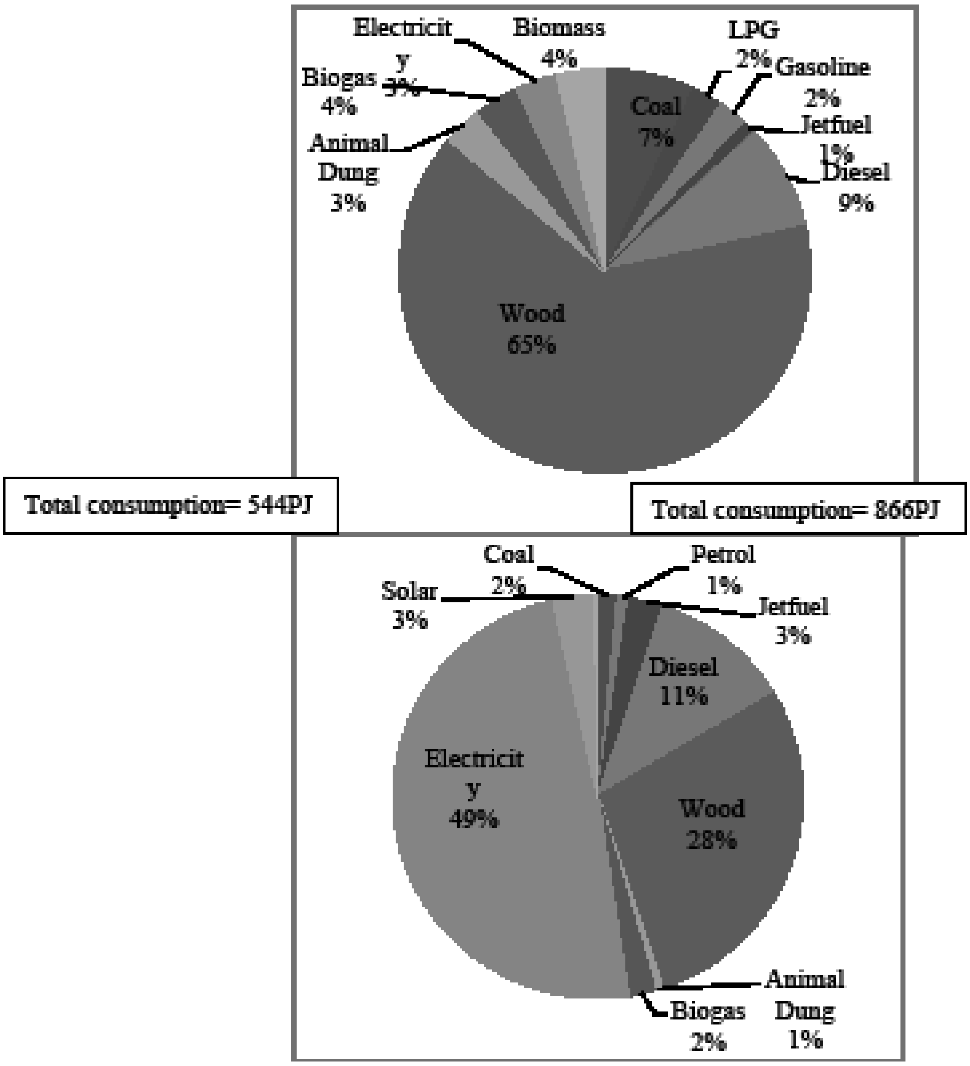

Fig 9: Fuel portfolio in year 2017 and 2050 in sustainable scenario.

Comparative analysis between REF scenario and sustainable scenario

i. Energy intensities

Energy intensity is a measure of energy efficiency of national economy .It is a indicative of unit energy per unit of GDP. High energy intensity refers to high cost of converting energy in to GDP. It implies mix of energy services in economics .Efficient and improved technology reduces energy intensity .In sustainable policy scenario efficient as well as new and improved technologies is considered as a result of which substantial amount of reduction in energy intensities is observed eventually saving energy useful energy stated in figure 7.Decrease in intensities in energy in sustainable energy policy is than reference case. The reason behind this is the penetration of component technologies and phasing out of outdated technologies.

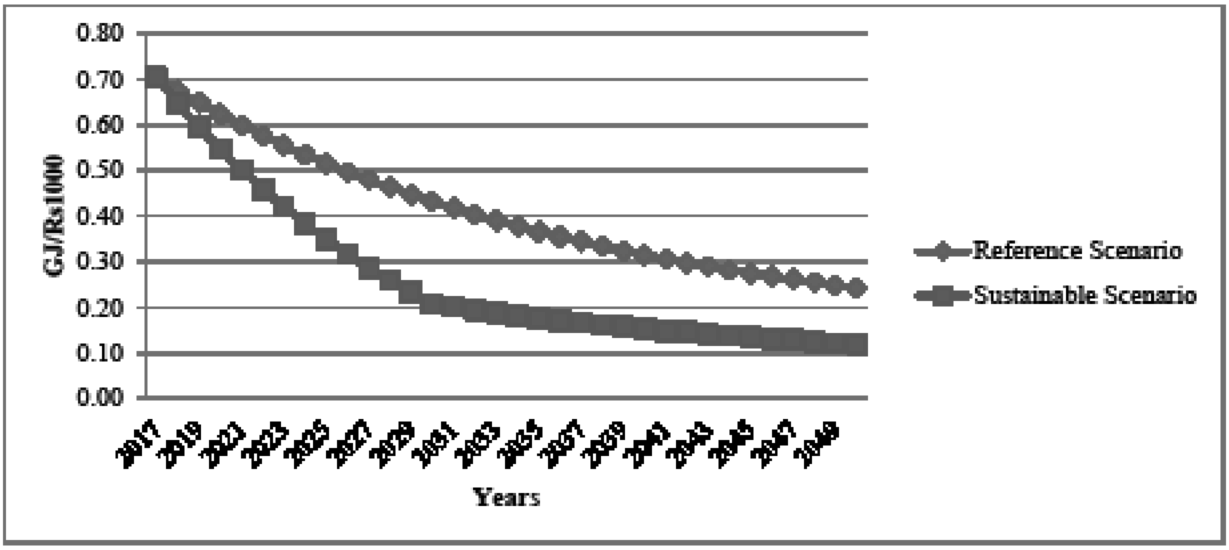

Fig 10: Comparison of energy intensities in reference and sustainable scenario.

ii. Per capita energy consumption

In base year 2017 per capita final energy consumption which is 18GJ is likely to increase 40 GJ in reference case but in sustainable energy policy it is expected to 19GJ. The disparity in figure owes chiefly the availability of efficient energy eventually leading to improved economic status.

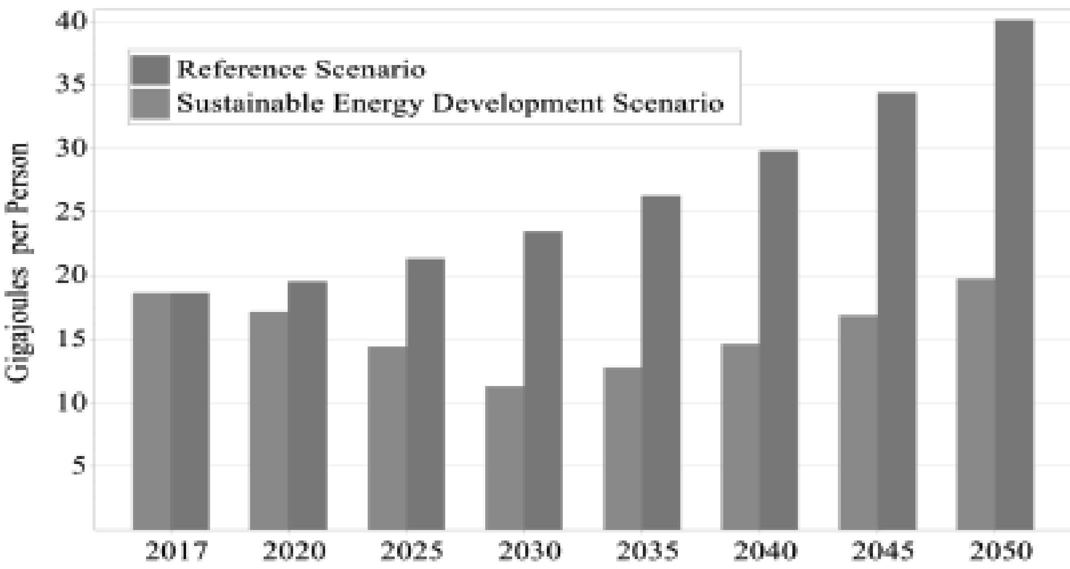

Fig 11: Energy consumption per capita

Emissions and Mitigation Potential

In the base year 2017, emission is 69 million metric tons of Co_2 equivalents whereas per capita emission is 2.36 metric tons. In the reference scenario the carbon emission increases to 178 million Metric tons of CO_2 equivalent in 2050 whereas per capita carbon emission increases to the 4.06 metric ton in the year 2050.In sustainable scenario the carbon emission increases to 21.95 million Metric tons of CO_2 equivalent in 2030 whereas per capita carbon emission reduces to the 0.64 metric ton in the year 2030 due to the technological policy intervention.

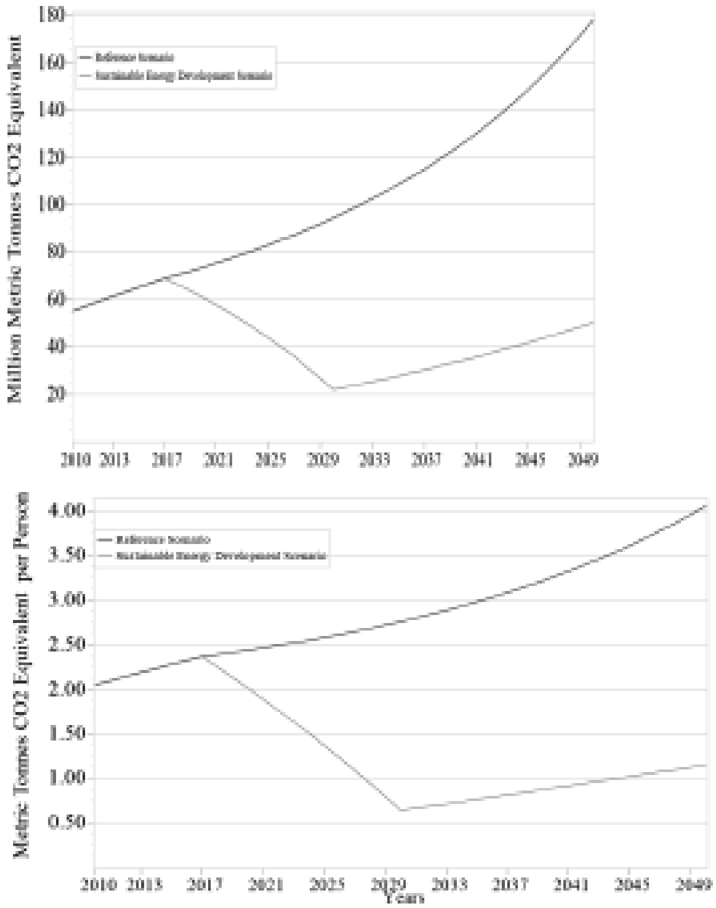

Fig 12: Emission and per capita emission projection in reference and sustainable scenario

$PM_{2.5}$ concentration and loss of life mitigated

Fine particulate matter ($PM_{2.5}$) is an air pollutant that is a concern for people's health when levels in air are high. $PM_{2.5}$ **is Due to increase of consumption of petroleum products and increase the energy demand in industrial and transportation sector the value of** $PM_{2.5}$ was found to be53.12**microgram/m3 in base year 2017** which may above WHO standard of **10 microgram/m3 [24]**. The figure shows that the concentration of $PM_{2.5}$is about **which decrease to 45.57microgram/m3 in 2030 in sustainable scenario.**

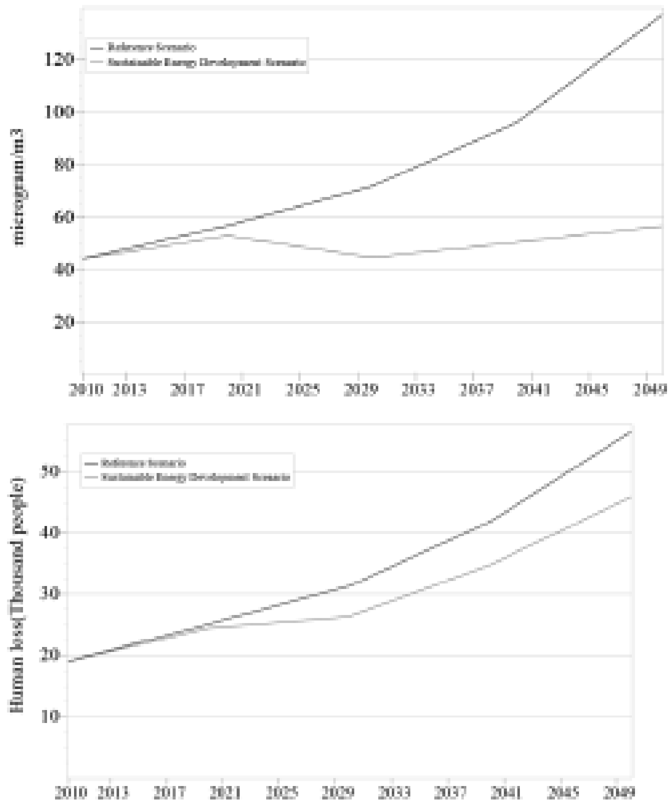

Fig 13: $PM_{2.5}$ concentration and human loss projection in reference and sustainable scenario

Among the most visible and significant impact of pollution on health and human well-being, mortality rate is taken as a major indicator to show the effect. Figure shows the effect of $PM_{2.5}$and ozone as lives lost due to exposure to these pollutants.

Due to increase of concentration value of $PM_{2.5}$ and depletion of Ozone layer the number of loss of people is twenty two thousand at the base year 2017 Which is increase to 56 thousand people loss by 2050.

Social Benefit -Cost Analysis in Energy Sector:

The benefit cost analysis when mitigation options are implemented only in energy sector. The benefit cost analysis is conducted based on present value analysis at social discount rate 6%.In scenarios , the resources production and import shows less amounts , because of fuel switching to electricity . The most important part of cost benefit analysis is net present value(NPV), which is one of the criteria to select the scenario. The NPV is lower in all scenarios which means that sustainable energy development are economically viable. Table 3 shows the shows the summary of cost of each scenario. From NPV value , it is found that SED scenario is most economically viable with NPV value 7899 million NRS.

Table 9: Cost Analysis of Scenario (in million in NRs.)

Cumulative Costs && Benefits	Reference Scenario	Low Economy Scenario	Sustainable Energy Development Scenario	Accelerate Economy Scenario
Demand	894.3	801.4	939.6	1,027.7
Residental	**567.3**	**567.3**	**656.3**	**567.3**
Industrial	**82.5**	**61.0**	**90.2**	**112.1**
Commercial	**75.5**	**52.4**	**122.2**	**109.6**
Transportation	**37.1**	**29.0**	**14.8**	**47.5**
Agriculture	**131.9**	**91.7**	**56.1**	**191.3**
Transformation	280.2	231.7	1,667.4	375.5
Transformation and Distribution	-	-	-	-
Grid Electricity	**265.0**	**216.5**	**1,594.6**	**360.0**
Off Grid Electricity Generation	**15.3**	**15.2**	**72.8**	**15.5**
Resources	9,194.5	8,234.4	5,292.8	10,540.6
Production	**6,070.3**	**5,916.9**	**3,748.0**	**6,289.8**
Imports	**3,124.2**	**2,317.5**	**1,544.9**	**4,250.7**
Exports	-	-	-	-
Unmet Requirements	-	-	-	-
Environmental Externalities	-	-	-	-
Non Energy Sector Costs	-	-	-	-
Net Present Value	10,369.0	9,267.4	7,899.9	11,943.8
GHG Emissions (Mill Tonnes CO2e)	**4,192.6**	**3,765.8**	**1,762.7**	**4,828.8**

5. Conclusion

The study has examined energy planning in each province, sustainable technology policy interventions in the energy demand and social cost benefit analysis in energy sector for Nepal in the federal structure over the period 2017 -2050. The analysis shows that in reference scenario, energy consumption will increase by 3 folds from 544 PJ to 1645 PJ during 2017-2050,whereas in sustainable scenario the value expected to increase to 866 PJ by 2050.The reason behind reduction is

the penetration of high electricity in the energy system, penetration of competent technologies and phasing out of out-dated technologies. Electricity has high end use efficiency as compared to other technologies presently being used that consume traditional and fossil fuel. The total energy consumption is increased to 1200 PJ by 2050 in low economic growth rate scenario and 2713 PJ by 2050 in accelerate economic scenario.

In the base year 2017, emission is 69 million metric tons of Co2 equivalents whereas per capita emission is 2.36 metric tons. In the reference scenario the carbon emission increases to 178 million Metric tons of CO_2 equivalent in 2050 whereas per capita carbon emission increases to the 4.06 metric ton in the year 2050.In sustainable scenario the carbon emission increases to 21.95 million Metric tons of CO_2 equivalent in 2030 whereas per capita carbon emission reduces to the 0.64 metric ton in the year 2030 due to the technological policy intervention.

Due to increase of consumption of petroleum products and increase the energy demand in industrial and transportation sector the value of $PM_{2.5}$ was found to be 53.12**microgram/m3 in base year 2017** which may above WHO standard of **10 microgram/m3(WHO, 2006).** Due to technology policy intervention it is decreased to**45.57 microgram/m3 by 2030 in sustainable development scenario.**

The NPV in sustainable energy development is lower than other scenarios. From NPV value , it is found that SED scenario is most economically viable with NPV value 7899 million NRS.In sustainable policy scenario efficient as well as new and improved technologies has been considered as a result of which substantial amount of reduction in energy intensities and per capita final energy consumption which is 18GJ is likely to increase 40 GJ in reference case but in sustainable energy policy it is expected to 19GJ. We can thus conclude that without tangible amendment in policy, energy consumption scenario is less prone to shift from traditional to commercial and renewable resources. Sustainable policy scenario is thus assumed to envisage conceivable energy scenario of Nepal. Electricity is most sought after technology as per the scenario. Within 30 years, Nepal will need hydropower resources and traditional fuel phased out and replaced by renewable and commercial resources. Penetration of electricity to meet the national demand in all commercial sector so as to completely substitute the imported fossil fuel .Energy intensities and per capita energy consumption seems to deviate positively that eventually improved energy statistics. GHG emission calculation also shows discernible reduction in sustainable energy policy scenario.

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