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# Energy and Environmental Implications of Graduating Nepal from Least Developed to Developing Country

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**Abstract**

Energy is a vital input for social and economic development of any nation. With increasing agricultural and industrial activities in the country, the demand for energy is also increasing. Formulation of an energy system planning model will help in the proper allocation of widely available indigenous energy resources such as solar, wind, bioenergy and hydropower and imported fossils fuels in meeting the future energy demand. As Nepal is a least developed country and aims to graduate to developing country by 2022 proper energy planning is essential for the sustainable development. This research is done to give the overview of primary energy mix, expected future energy demand in different scenario and its impact on graduation of Nepal. In reference scenario the future energy consumption of Nepal is expected to increases from 420 PJ in the base year 2013 to 566 PJ in 2022 and is expected to increases to 630 PJ in vision scenario. To graduate the Nepal from Least Developed Country category by 2022 the estimated per capita energy consumption must be 20.5 GJ and the per capita commercial energy consumption must be 6.5 GJ. In addition per capita electricity consumption must be 225 kWh at the end year. If Nepal moves through a different economic growth rate of 7%, 5.5% and 4 %, country will graduate from LDC category by 2023, 2026 and after 2030 respectively. Similarly in the base year 2013, green house gas (GHG) emission is 12 million metric tons of $CO_2$ equivalents. In the reference scenario the GHG is estimated to increase to 20 million metric tons of $CO_2$ equivalents and in vision scenario the value is estimated to increase to 27 million metric tons of $CO_2$ equivalents in 2022.

**Keywords**

Energy – Energy System Planning – Greenhouse Gas Emission – Least Developed Country

## 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 is fundamental to reducing poverty increasing productivity enhancing competitiveness and prompting economic growth[1].

Energy is a vital input for social and economic development of any nation. With increasing agricultural and industrial activities in the country, the demand for energy is also increasing. Formulation of an energy system model will help in the proper allocation of widely available indigenous energy sources such as solar, wind, bioenergy, hydropower and imported fossils fuels in meeting the future energy demand. As Nepal is a least developed country (LDC) and heading to become the developing country proper energy planning is essential for the sustainable development.

The LDCs represent the poorest and weakest segment of the international community. They are characterized by constraints such as low per capita income, low level of human development, and economic and structural handicaps to growth that limit resilience to vulnerabilities.

Nepal is a least developed country, which in a sense tells that its energy demand is in ever growing trend. Nowadays a concept is that more the energy demand more developed the country is. A strong relationship between index values and energy consumption is observed for the majority of the world. But Nepal being a landlocked country without any exploitable fossil fuel reserves, it fully depends upon other petroleum exporting countries. With increasing cost of fossil fuels, and uncertainty in supply, the development of the country is as dependent as dependency on those fuels, unless alternatives action is taken. It is well publicized that Nepal is rich in water resources and has a high hydro energy potential. So the proper energy system planning and implementation of different strategies is needed for the sustainable development and energy security.

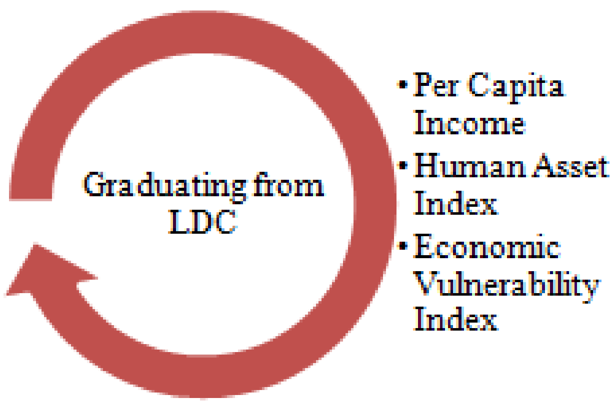


**Figure 1:** Criteria for graduating from LDC[2]

The Nepalese economy is agriculture dominated; the 39% of the GDP is produced from the agriculture [3]. Unfortunately, only 2.1% of the total energy consumption is associated with the agriculture sector of Nepal [4]. Nepal is being ravaged by the electricity crisis. At present, the peak load demand is 1094.6 MW, [5] but at that time total electricity supply is only 650 MW. Load shedding brings in the remaining 545 MW. Power outages are in effect ranging from 12 to 15 hours per day. The NEA is unable to expand its grid-based electricity system because of technical, environmental, and most importantly, financial constraints. The country's mountainous terrain and complex geology alone make the extension of grid-based electricity nearly impossible [6].

The population census 2011 found out 26.5 million populations with an annual rate of growth equal to 1.35% which is still high when compared with the international level. If this growth rate continues, Nepal's current population will double in the next 25 years. Population distribution is very unequal in terms of physiographic areas. Only about 7% people lives in Mountain region. This region occupies about 35% of the total land area. Hilly region occupies about 43% of the total land and support about 44% people to live in. Terai region of the country is more fertile and plain. Only 23% of the country's land is located in this region. However, this region supports 50% of the population [7].

## Problem Statement

For the first time, Nepal was included in the LDC category among 25 other countries in 1971. The list expanded to 48 countries in 2014, out of which 34 are in Africa, 13 in Asia and the Pacific and one in Latin America. Since the inception of the categorization, only four countries to date have been graduated from the LDC category, viz. Botswana in 1994, Cape Verde in 2007, Maldives in 2011 and Samoa in 2014. Equatorial Guinea and Vanuatu are scheduled to graduate by 2017. As a signatory to the Declaration of Istanbul Program of Action (IPoA), Nepal committed to seeking graduation from an LDC category by 2022 [8]. This is reflected in the Approach Paper to the Thirteenth Plan (2013-16). But the problem is every year the gap between graduation threshold and Nepal's position is increasing in terms of Gross National Income. GNI per capita is a directly proportional to the energy consumption per capita. So the energy consumption of the country needs to be increased in a planned way to get the required economic growth rate.

**Table 1:** Nepal's position and threshold for graduation

| Details | 2006 | 2009 | 2012 |
|---|---|---|---|
| **Gross National Income (GNI) Per Capita (in US $)** | | | |
| Graduation Threshold | 900 | 1086 | 1190 |
| Nepal's Position | 243.33 | 320 | 420 |
| Gap | -656.67 | 766 | 770 |
| **Human Assets Index (HAI)** | | | |
| Graduation Threshold | 64 | 66 | 66 |
| Nepal's Position | 56.03 | 58.34 | 59.83 |
| Gap | -7.97 | -7.66 | -6.17 |
| **Economic Vulnerability Index (EVI)** | | | |
| Graduation Threshold | 38 | 38 | 32 |
| Nepal's Position | 37.4 | 33.6 | 27.8 |
| Gap | 0.6 | 4.4 | 4.2 |

**Table 2:** Energy balance of Nepal for base year 2013 in TJ [3, 4, 5]

| BASE YEAR (2013) Energy Balance (TJ) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Particulars** | **Petroleum Products** | **Coal** | **Hydro** | **Electricity** | **Biomass** | **Modern Renewables** | **Total** |
| **Primary Supply** | | | | | | | |
| **Indigenous production** | - | - | 15,521 | - | 335,656 | 9,710 | 360,887 |
| **Imports** | 48,028 | 17,375 | - | 1,205 | - | - | 67,608 |
| **Exports** | - | - | - | (13) | - | - | (13) |
| **Stock changes** | (189) | - | - | - | - | - | (189) |
| **Total Primary Supply** | **47,839** | **17,375** | **15,521** | **1,192** | **335,656** | **9,710** | **427,293** |
| **Transformation** | | | | | | | |
| **Inputs** | (1,254) | - | - | - | - | - | (1,254) |
| **Electricity generation** | - | - | (12,417) | 12,856 | - | - | 439 |
| **T & D losses** | - | - | - | (3,078) | - | - | (3,078) |
| **Other losses, own-use etc.** | - | - | (3,104) | (96) | - | - | (3,200) |
| **Net supply to consumers** | **46,584** | **17,375** | **0** | **10,874** | **335,656** | **9,710** | **420,200** |
| | | | | | | | |
| **Final Consumption** | | | | | | | |
| **Industry** | 5,062 | 16,275 | 0 | 4,364 | 7,925 | - | 33,627 |
| **Residential** | 6,855 | - | | 5,072 | 319,715 | 9,710 | 341,352 |
| **Commercial** | 3,423 | 1,100 | | 1,155 | 8,015 | - | 13,693 |
| **Transport** | 26,974 | - | | 23 | - | - | 26,997 |
| **Agriculture** | 4,270 | - | | 261 | - | - | 4,531 |
| **Total** | **46,584** | **17,375** | **0** | **10,875** | **335,656** | **9,710** | **420,200** |
| | | | | | | | |
| **Statistical error** | **0** | **0** | - | **(0)** | **(0)** | - | **(0)** |

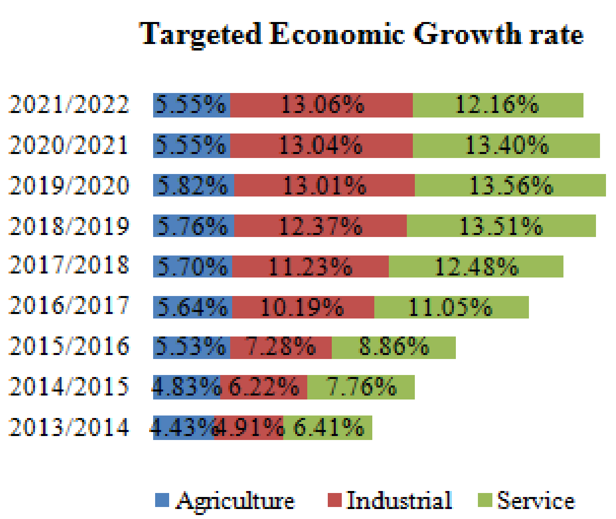


**Figure 2:** Targeted economic growth rate for graduating Nepal from LDC category by 2022

As one of the least developed country scheduled to be graduated by 2022, Nepal needs to focus in all the indicators (viz. Gross National Income (GNI) Per Capita, Human Assets Index (HAI) and Economic Vulnerability Index (EVI)) for graduation. The value of HAI and EVI is improving in each period of three years but GNI per capita is not going high as required for the graduation by 2022. Hence the proper energy system planning will help to move the GNI per capita in the direction of achieving goal and opens all the doors for implementing different strategies in a sustainable way. On the other hand the government of Nepal had projected different sectorial economic growth rate to achieve the goal.

## 2. Review on energy models

The different studies have been done in energy system planning using different modelling framework. LEAP, E-Views, MARKetALlocation (MARKAL), Model for

Analysis of Energy Demand (MAED), MESSAGE, AIM-ENDUSE, are some widely used modelling frameworks.

Shrestha and Rajbhandari (2010) analysed the sectorial energy consumption pattern and emissions of $CO_2$ and local air pollutants in the Kathmandu Valley, Nepal. A long term energy system planning model of the Kathmandu Valley based on the MARKAL framework is used for the analyses[9].

Zhao et al. (2011) provided 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 $CO_2$ emissions, are mainly considered as the indicators to measure the level of low-carbon economic development [10].

Shakya et al. (2012) analysed 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 MARKAL framework with time horizon of 2005–2050[11].

Parajuli et al. (2014) assessed 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 (2014) studied the economy-wide consequences of introducing different levels of electrified mass transport systems in Nepal on the long term basis [13]. Shakya and Shrestha (2011) analysed 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[14]. 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.

Lund (2007) discussed the perspective of renewable energy (wind, solar, wave and biomass) in the making of strategies for a sustainable development using Energy Plan modelling framework[15].
Nakarmi et al. (2014) employed an integrated model for analysis of energy demand and MARKAL 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[16].

Shrestha and Rajbhandari (2010) analysed 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[9].

## 3. Methodology

### Formulation

The significant work is not being done in the issues related to Nepal's graduation from LDC to developing country from the academic sector. This research was formulated as a problem to be addressed.

### Literature Review

The extensive literature review was conducted with the help of internet, national libraries, governmental reports, books, research papers and journals available. The literature related to LEAP and how it is used to analyse data was studied. The literature related to previous energy consumption pattern of all sectors was collected from the different sources and journals published by Water and Energy Commission Secretariat (WECS).Other energy related data was collected from various publications from ministry of finance, Nepal Electricity Authority (NEA) and Nepal Oil Corporation (NOC). The energy consumption demand situations of all sectors Residential, Industrial, Commercial, Transport, are collected from WECS report. Social data were collected from the census report published by Central Bureau of Statistics(CBS). Likewise, for all energy conversion units, data were collected from IEA's report. Continuous literature review was done throughout the research period related to energy, energy planning, energy policy, least developed countries, sustainable development, energy security etc.

### Data Collection and Generation

The data collection is done from the recent WECS report and from other NEA, MOF, CBS, etc. And the energy balance for the base year 2013 is developed. And multiplying the sectorial energy consumption data with appropriate desegregation ratios, the input energy data is generated for LEAP model.

### 1. Consumption Data

This research compiles and manipulates the primary energy data collected by WECS for the year 2011/12. Energy consumption pattern varies as per the ecological belt: Terai, Hill and Mountain, hence the energy consumption data are taken for each ecological belt within different developmental region under the following heading.

1. Residential sector: Rural and urban
2. Industrial sector: Big and medium and cottage
3. Commercial sector
4. Transportation sector
5. Agriculture sector

The energy data are arranged in bottom-up approach i.e the final energy consumption is estimated from the sum total of energy consumed in the end-use devices in different sectors.

### 2. GDP

The constant price GDP at 2005 market value is taken from the (UN, 2014) and the sectorial value addition is taken from Asian Development Bank [17].

### 3. Population

The population data is extracted from the census report 2011 at growth rate 1.35% [7].

## Modeling Framework and Data input

Out of the different energy modeling tools the LEAP modeling framework is being picked up for this research work due to its compatibility with published energy demand data.

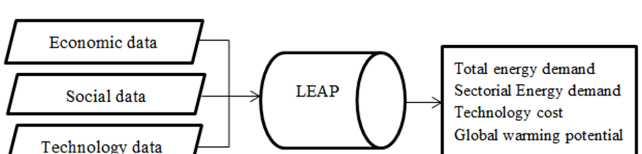


**Figure 3:** LEAP modeling framework

LEAP is a widely-used software 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.

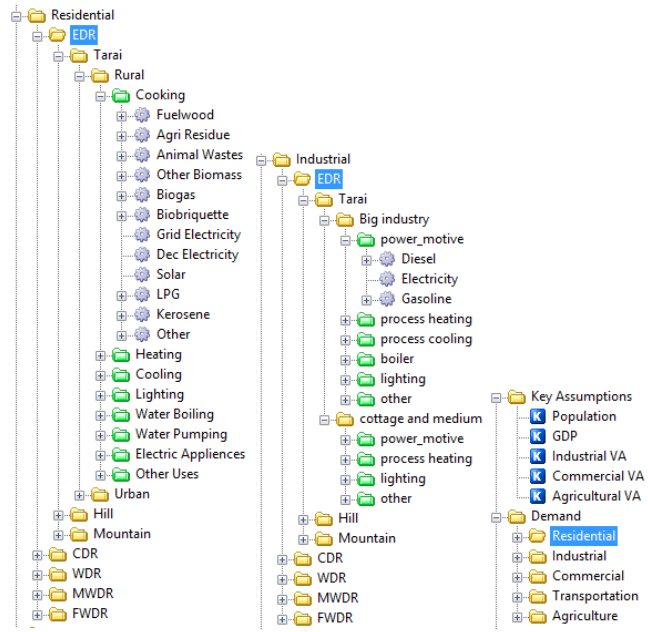


**Figure 4:** Key assumptions and demand disaggregation of residential and industrial

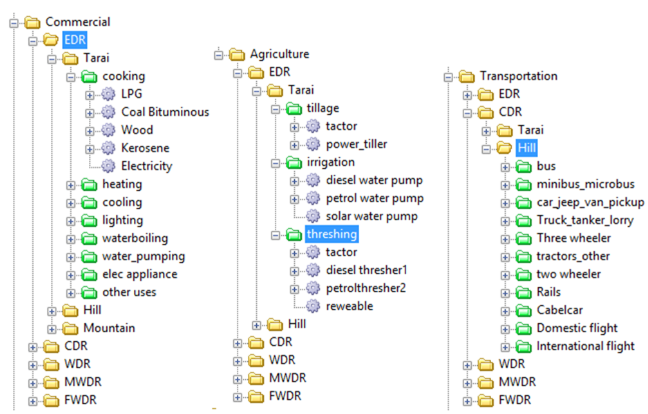


**Figure 5:** Demand disaggregation tree of commercial, agriculture and transportation sectors

The final energy demands of each economic sector are obtained from the prepared energy balance of base year 2013. 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.

## Base year data calibration

The base year data results in LEAP is calibrated accordingly with the detailed energy balance of base year 2013. The output data is calibrated according to fuel wise below 5% error.

## 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.

Demand elasticity is a measure of how much the quantity demanded will change if another factor changes. Here the Elasticity is defined as the increase in energy demand with per unit change in respective value addition.

The regression model is developed between following variables:

**Table 3:** Energy consuming sector and driving variable

| Dependent Variable (Energy Consumption) | Independent Variable |
|---|---|
| Residential (D1) | Total Population(P1) |
| Industrial (D2) | Industrial VA(X2) |
| Commercial (D3) | Commercial VA(X3) |
| Transportation (D4) | Total GDP(X4) |
| Agricultural (D5) | 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(D1) and log(P1) | 0.558 | 4.14 | 0.00137 | 1.417 |
| log(D2) and log(X2) | 0.444 | 3.09 | 0.00928 | 1.437 |
| log(D3) and log(X3) | 0.122 | 1.29 | 0.22050 | 1.064 |
| log(D4) and log(X4) | 0.526 | 3.65 | 0.00335 | 0.818 |
| log(D5) and log(X5) | 0.742 | 5.88 | 0.00007 | 4.889 |

The model validity needs t-value grater or equal to 2.25 and corresponding p-value must be less than 5%. According to that, four models are accepted but the regression model between commercial energy consumption and commercial VA is not valid so we take elasticity 1 as a standard for commercial energy demand projection and corresponding elasticity's are taken for respected sectorial energy demand projection.

## 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.

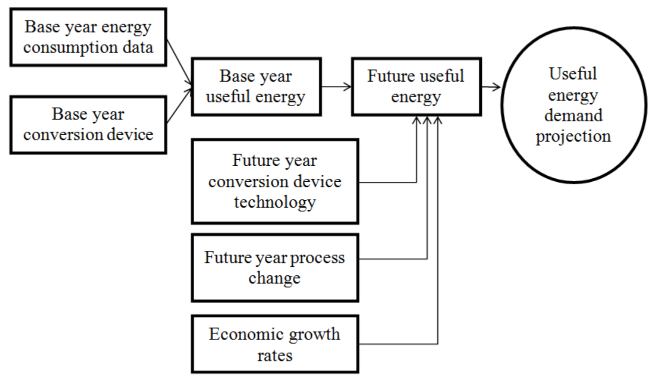


**Figure 6:** Energy demand Projection flow chart

## Scenario development

### 1. Reference Scenario

The reference scenario developed for the expected growth rate of the driving variable from the respective source: Annual GDP growth rate: 5.5%; Annual population growth rate: 1.35%. This is the base case scenario which is developed considering the existing situation will continue in future without any policy intervention. Following GDP growth rate is used for analysis period.

**Table 5:** Sectorial GDP growth in reference scenario

| Sector | GDP Growth Rate, % |
|---|---|
| Industrial | 3.8 |
| Commercial | 4.8 |
| Agricultural | 3.4 |

The transport sector energy consumption changes with GDP.

#### 2. Vision Scenario

The vision scenario is developed as per the vision document, An Approach to the Graduation from the Least Developed Country by 2022 [8]. Following GDP growth rate is used for Vision Scenario.

**Table 6:** Sectorial GDP growth in vision scenario

| Sector | GDP Growth Rate, % |
|---|---|
| Industrial | 3.8 |
| Commercial | 4.8 |
| Agricultural | 3.4 |

#### 3. Other scenarios

Besides reference and vision scenario other two scenarios were developed under reference scenario. The scenarios developed are Medium Economic Growth Scenario (MEG) with average GDP growth rate 7% and Low Economic Growth Scenario (LEG) with the average GDP growth rate of 4%. In these scenario sectorial GDP contributions are maintain as in the reference scenario for the projection years.

## 4. Results and Analysis

### 4.1 Scenario Development

The different economic scenarios are developed with the different economic growth rate to project the energy demand and the GHG emission of the country.

#### Reference Scenario(REF)

The final energy demand is 420 PJ in base year 2013. In REF scenario the final energy demand is projected to be 566 PJ in the year 2022. While going from base year to end year, 2013-2022, total energy consumption per capita increases from 15.4 GJ to 18.4 GJ whereas the commercial energy consumption per capita increases from 2.8 to 4.8 GJ.

The one hundred year global warming potential is estimated to be 12 million Metric tons of $CO_2$ equivalent in base year 2013. In REF scenario, the carbon emission is projected to about 20 million Metric tons of $CO_2$ equivalent in the year 2022. In the base year per capita carbon emission is about 0.43 metric ton which increases to 0.73 metric ton in the year 2022. This shows the per capita carbon emission also increases with economic growth.

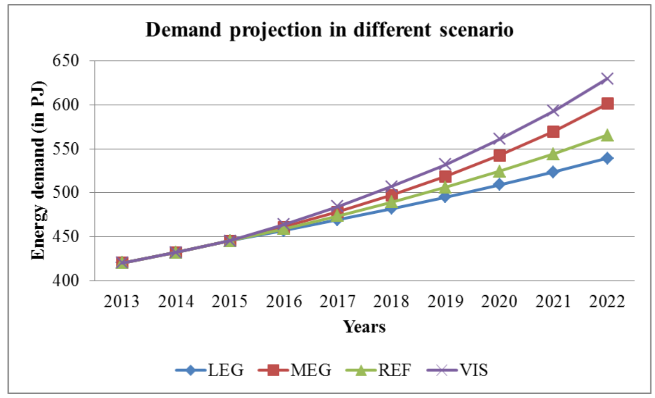


**Figure 7:** Demand Projection in different LEG, MEG, REF and VIS scenario

#### Vision Scenario (VIS)

In the Vision scenario the final energy demand increases to 630 PJ in 2022 which is 64 PJ more than in REF scenario. The per capita total energy consumption increases to 20.5 GJ whereas the per capita commercial energy consumption increases to 6.5 GJ in the year 2022. This data suggests, Nepal in order to graduate from least developed to developing country, per capita total energy consumption and Per capita commercial energy consumption should exceed 20.5 GJ and 6.5 GJ respectively.

In the VIS scenario the carbon emission increases to 27 million Metric tons of $CO_2$ equivalent in 2022 whereas per capita carbon emission increases to 0.99 metric ton in the year 2022. This shows, in the year 2022, the per capita carbon emission in vision scenario is 0.26 metric ton more than in reference scenario.

#### Medium Economic Growth Scenario (MEG)

In the MEG scenario, with GDP growth rate of 7%, the final energy demand increases to 601 PJ in 2022. The per capita total energy consumption increases to 19.6 GJ whereas the per capita commercial energy consumption increases to 5.84 GJ in the year 2022. It shows according to the per capita total energy consumption and per capita commercial energy consumption if we go through the MEG scenario Nepal won't be able to graduate from least developed to developing country by the year 2022.

In the MEG scenario the carbon emission increases to 23 million Metric tons of $CO_2$ equivalent in 2022 whereas per capita carbon emission increases to the 0.83 metric ton in the year 2022.

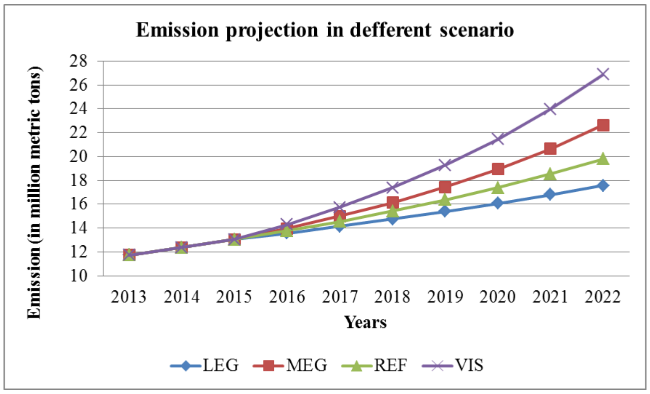


**Figure 8:** Emission forecasting in different LEG, MEG, REF and VIS scenario

### Low Economic Growth Scenario (LEG)

In the LEG scenario, with the GDP growth rate of 4%, the final energy demand increases to 539 PJ in 2022. The per capita total energy consumption increases to 17.56 GJ whereas the per capita commercial energy consumption is increases to 4.04 GJ in the year 2022. It shows, according to the per capita total energy consumption and per capita commercial energy consumption if we go through the LEG scenario Nepal won't be able to graduate from least developed to developing country by the year 2022.

In the LEG scenario the carbon emission increases to 18 million Metric tons of $CO_2$ equivalent in 2022 whereas per capita carbon emission increases to the 0.56 metric ton in the year 2022.

## 4.2 Potential area for mitigation of GHGs

Potential area for mitigation of GHG, based on energy consumption in 2013, GHG emission from different economic sectors are evaluated and shown in Figure 9. The use of efficient energy conversion technology might save tremendous amount of energy as well as reduces the GHG emission. Saving energy is equivalent to reducing GHG emissions. Some potential areas of mitigation are discussed below.

Industrial sector has largest carbon contribution in national carbon emission which is also due to the large share of fossil fuels in its total energy consumption. In 2008/09, industrial sector contributed only 25% of total emission 835738.6 tons [18]. Improving energy efficiency in industrial sectors (basically on boilers, furnaces, lighting and electric motors etc.) can reduce huge amount of carbon emission but the detail investigation of associated economic cost per unit of emission reduction should be identified in order to formulate an action plan of carbon mitigation strategy [19]. Residential sector is also another heavy emission sector it is due to the high consumption of traditional biomass. Industrial, residential and transportation sectors have the major contribution in carbon emission.

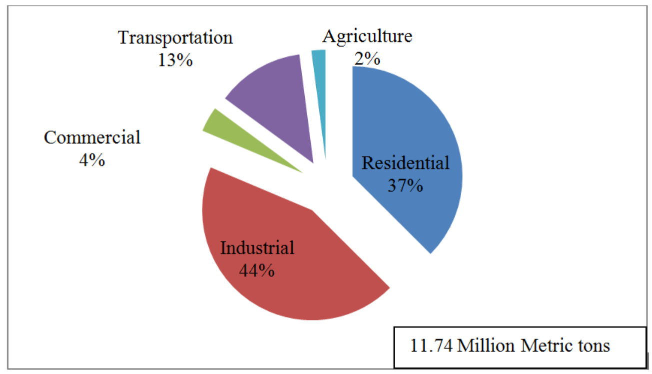


**Figure 9:** Emission from different economic sectors in base year 2013

## 4.3 Scenario Comparisons

**REF vs. VIS Scenario**

If Nepal moves through the VIS scenario, 5,069 PJ of energy needs to consume from 2013 to 2022 which is 209 PJ of more energy than through REF scenario.

In VIS scenario 176 million metric tons of $CO_2$ equivalents of carbon emission will be obtained which is 23 million metric tons of $CO_2$ equivalents more than in REF scenario. This shows, if Nepal wants to go throw VIS scenario there is a huge scope in LCD strategy implementation.

**Table 7:** Energy Demand projection in REF and VIS scenario (in PJ)

| Scenarios | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| REF | 420 | 432 | 445 | 459 | 474 | 489 | 506 | 524 | 544 | 566 |
| VIS | 420 | 432 | 445 | 464 | 484 | 507 | 532 | 561 | 593 | 630 |

In the base year out of 420 PJ of energy consumption 18% is commercial energy. But the portion of commer-

**Table 8:** Fuel wise energy consumption in base year and end year (in 000 GJ)

| Fuels | Base Year 2013 | REF 2022 | VIS 2022 |
|---|---|---|---|
| All Others | 1,506 | 2,236 | 2,886 |
| Electricity | 11,202 | 18,635 | 24,829 |
| Gasoline | 7,407 | 11,644 | 14,705 |
| Jet Kerosene | 3,648 | 5,416 | 6,614 |
| Diesel | 25,212 | 63,703 | 82,045 |
| LPG | 9,447 | 12,884 | 14,909 |
| Coal Bituminous | 17,375 | 32,905 | 52,139 |
| **Total Commercial Energy** | **75,798** | **147,423** | **198,129** |
| Wood | 298,915 | 364,252 | 377,706 |
| Biogas | 9,301 | 11,039 | 11,039 |
| Animal Wastes | 21,395 | 25,395 | 25,395 |
| Biomass | 14,779 | 17,542 | 17,542 |
| **Total** | **420,188** | **565,651** | **629,811** |

cial energy in total energy portfolio increases to 26% in reference scenario and to 31% in vision scenario for year 2022. This means to get the higher economic growth we need to increase the portion of commercial energy consumption in total energy portfolio. This is due to the higher contribution of commercial energy in GDP production.

The electricity demand is 11 PJ in base year 2013. In REF scenario the electricity consumption is projected to about 19 PJ and in the VIS scenario the value increases to 25 PJ in 2022. Total electricity demand in the VIS scenario is 165 PJ in total period of ten year which is 20 PJ more than in REF scenario.

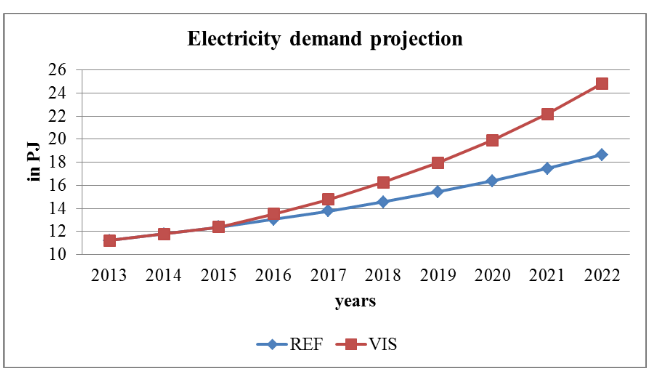


**Figure 10:** Electricity demand projection in REF and VIS scenario

The per capita electricity demand is 114 kWh in base year 2013. In REF scenario the per capita electricity consumption is projected to 169 kWh and in the VIS scenario the value increases to 225 kWh in 2022.

The diesel consumption is 25 PJ in base year 2013. In REF scenario the diesel consumption is projected to about 64 PJ and in the VIS scenario the value increases to 82 PJ in 2022. Total diesel demand in the VIS scenario is 57 PJ more than in REF scenario over the ten year period. That means, diesel play the vital role in economic activities of the country.

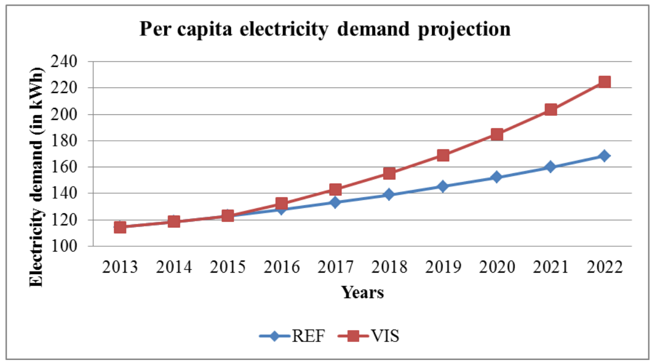


**Figure 11:** Per capita electricity demand projection in REF and VIS scenario

The diesel consumption is 25 PJ in base year 2013. In REF scenario the diesel consumption is projected to about 64 PJ and in the VIS scenario the value increases to 82 PJ in 2022. Total diesel demand in the VIS scenario is 57 PJ more than in REF scenario over the ten year period. That means, diesel play the vital role in economic activities of the country.

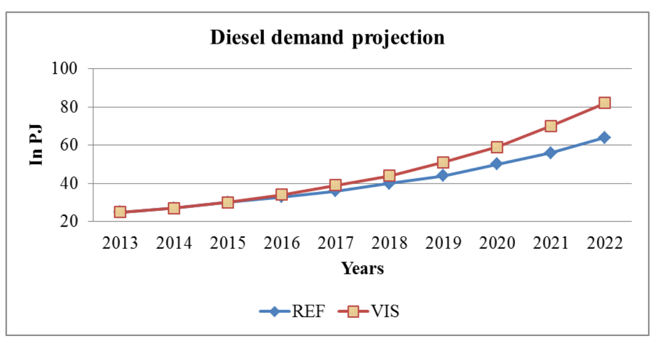


**Figure 12:** Diesel Consumption projection in REF and VIS scenario (in PJ)

The wood consumption in the base year is 299 PJ. The value is increase to 364 PJ for REF scenario and to 382 PJ for VIS scenario in 2022. The graph shows the wood consumption in both the scenarios is very close. That means the wood consumption do not play vital role in the economic development. The gradual increase in wood consumption in small amount is due to the population growth.

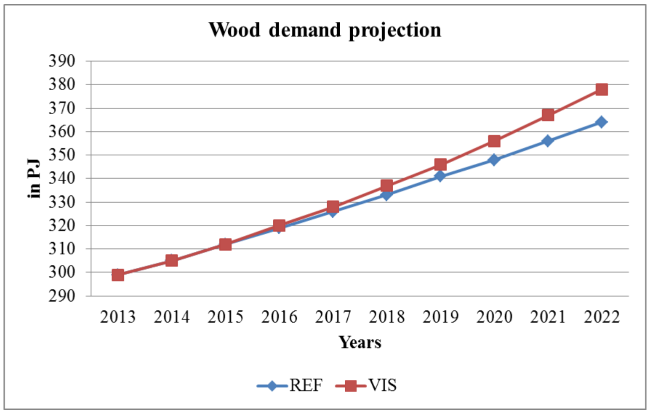


**Figure 13:** Wood Consumption projection in REF and VIS scenario (in PJ)

### VIS vs. REF, MEG and LEG scenario

The comparison of different scenario with the Vision scenario shows that none of the scenarios can meet the demand of the vision scenario. That means the REF, MEG and LEG scenario are not able to make Nepal graduate from LDC category by 2022.

By keeping the per capita energy consumption and the per capita commercial energy consumption obtained in the vision scenario for the year 2022 as a threshold for graduation, the year of graduation could be estimated for the other economic scenario. For that the energy demand for REF, MEG and LEG scenario were further forecasted up to the year 2030.And then the per capita energy consumption and per capita commercial energy consumption is estimated and are depicted in the figure.

The threshold per capita commercial energy consumption is 6.5 GJ which is obtained from the vision scenario in the year 2022. The threshold per capita commercial energy for different scenario is obtained at different year beyond the year 2022. For MEG, REF and LEG scenario the threshold per capita commercial energy consumption for graduation is obtained in the year 2023, 2026 and after 2030 respectively.

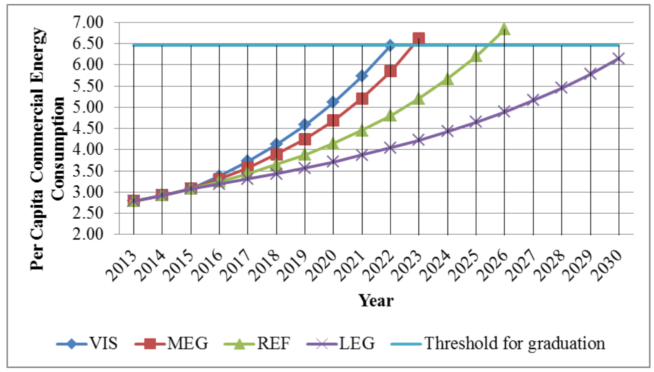


**Figure 14:** Threshold per capita commercial energy consumption and its position in different VIS, MEG, REF and LEG scenario

The threshold per capita total energy consumption is 20.5 GJ which is obtained from the vision scenario in the year 2022. The threshold per capita total energy consumption for different scenario was obtained at different year beyond the year 2022. For MEG, REF and LEG scenario the threshold per capita commercial energy consumption for graduation is obtained in the year 2023, 2026 and 2030 respectively.

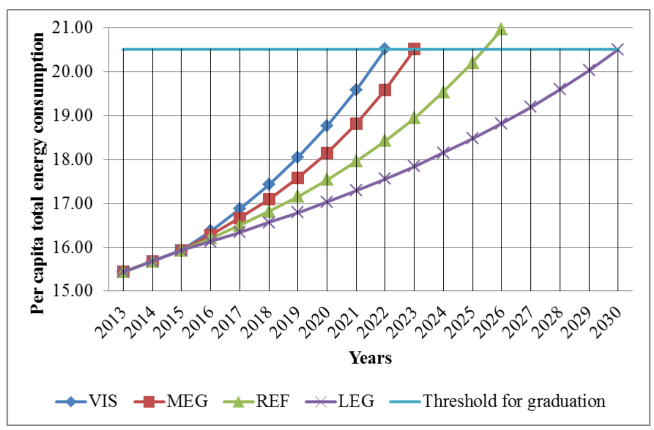


**Figure 15:** Threshold per capita energy consumption and its position in different VIS, MEG, REF and LEG scenario

## 5. Conclusion

In reference scenario (REF) the future energy consumption of Nepal is expected to increase from 420 PJ in base year 2013 to 566 PJ in 2022 and is expected to increase to 630 PJ in vision scenario. Similarly in the base year 2013 GHG emission is 12 million metric tons of $CO_2$

equivalents. In the reference scenario the value is increases to 20 million metric tons of $CO_2$ equivalents and in vision scenario the value is increases to 27 million metric tons of $CO_2$ equivalents in 2022.

In the base year per capita total energy consumption and per capita commercial energy consumption are 15.4 GJ and 2.8 GJ respectively. Per capita total energy consumption and per capita commercial energy consumption is estimated to be 18.4 GJ and 4.8 GJ under the reference scenario whereas the values are projected to be 20.5 GJ and 6.5 GJ under the vision scenario for the year 2022. In 2013 the per capita GHG emission is 0.43 metric tons. The base year per capita electricity consumption is 114 kWh, to graduate from least developed country category the demand will have to be increased to 225 kWh. The per capita GHG emission is projected to 0.73 metric tons and 0.99 metric tons for 2022 in reference and vision scenario respectively.

The estimated per capita total energy consumption and per capita commercial energy consumption for graduating Nepal from least developed country category under the vision scenario are found to be 20.5 and 6.5 GJ respectively. Going through the different economic scenario viz. Medium economic growth at 7% (MED), REF and lower economic growth at 4% (LEG), Nepal will graduate from LDC category by the year 2023, 2026 and after 2030 respectively.

## Recommendations

Based on the findings of the research, the recommendations for the energy planner and policy makers are depicted as follows.

1. The proper energy planning is necessary for achieving the sustainable economic growth of the country.
2. There is need for developing the effective implementing mechanisms (institutional, legal and regulatory) for the sustainable supply of energy resources required for economic growth of the country.
3. The portion of the commercial energy in the energy portfolio needs to be increased for the economic growth of the country.
4. There is a need of establishing integrated energy planning unit for continuous monitoring and review of energy planning of the country.

The present study can be further extended in the following areas.

1. The cost data can be incorporate in the model to get the information related to investment required, total fuel cost, total operation and maintenance costs etc. for different scenarios.
2. The different strategic scenarios can be made for the sustainable economic growth in the direction of low carbon development path.

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