**Proceedings of 9th IOE Graduate Conference**
***Peer Reviewed***
**ISSN: 2350-8914 (Online), 2350-8906 (Print)**
**Year: 2021 Month: March Volume: 9**

# The Opportunity of Greenhouse Gases Emission Reduction - A case study of Selected Hotel in Bhairahawa, Nepal

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**Abstract**
The tourism sector is most developed economic sector in Nepal. Hotels are large consumers of energy and fossil fuels to provide high-quality services to the guests. The aim of this study is to develop energy mix concept in a hotel to reduced greenhouse gas emission and waste production. In order to do this, the energy uses, carbon dioxide emission and waste materials generated have been estimated, assuming a life cycle of 20 years, with a sample of hotel from the Bhairahawa. Primary data was used for base year analysis and low emission analysis plateform (LEAP) model was used to analyze energy demand and greenhouse gas emission under different scenario. The base year for the study was 2019 and the end year to 2040. Result show that 25.3 tera joule energy was consumed in 2019. Energy consumption is expected to be increased from 25.3 tera joule to 65.9 tera joule in 2040 under business as usual scenario. In combined policy scenario, energy consumption is expected to increase from 25.3 tera joule to 37.76 tera joule in 2040. Per capita greenhouse gas emissions was 9.7 kg of carbon dioxide in base year 2019 and which will be gradually increased and reach to 17.6 Kg of carbon dioxide in 2040. In the base year it was found 327.4 metric tons of carbon dioxide produce in hotel under business as usual scenario. Emissions will increased and reach to 1100 metric tons of carbon dioxide produced in 2040. After the implementation of the system, greenhouse gas emissions will gradually reduce and reach 158.5 metric tons of carbon dioxide equivalent in 2030 later on gradually reduce. Similarly, per capita greenhouse gases emissions will gradually reduce and reach 3 kg of carbon dioxide in 2030 later on gradually reduce. Thus large amount of energy can be saved and large quantity of greenhouse gas emission can be stopped by applying the Combined policy scenario.

**Keywords**
Energy Consumption, greenhouse gas emissions, carbon dioxide

## 1. Introduction

The hospitality industry is one of the most important sectors for economic development in Nepal [1]. The tourism sector is an important sector for Nepal to generate revenue and foreign exchange and Nepal with rich ancient cultures set against the most dramatic scenery in the world is a land of discovery and unique experience. The diversity in nature and culture increase potentiality in the tourism sector. The overall economics of Nepal is very backward and the tourism industry is one of the most vital sectors for economic development[2].So country policies need to be changed to enhance the tourism sector and economic development.Nepal is a country where fossil fuels are imported from other nation and the dependence on fossil fuels has been a matter of international concern from energy security perspective, especially for the low net energy importing developing countries. The variation on the price of fossil fuels and LPG gas has increased the economic vulnerability for country like Nepal. Ongoing international concerns for climate change due to the greenhouse gas emissions are attracting an increasing attention on rapidly growing cities. The dependence on fossil fuels and greenhouse effects can be reducing when utilizing wood biomass [3]. In the hotel, biogas can generated from kitchen solid waste which has capacity to reduce dependence on fossil fuels and reducing GHG emissions. Tourism sector is receiving increased attention from governments and the public due to its effect on the climate change, which will grow up in near future unless the mitigating action are taken.There is a great concern to

the reduction of $CO_2$ emissions in the tourism sector will come only through shared and consistent leadership across the stakeholder [4]. The governmental body and public are becoming concerned with the tourism industry's contribution to the climate change, so hotels can limit and manage their greenhouse gas emissions. Carbon taxes or energy taxes, emissions reducing programs and benchmarking for regulation and standards on energy efficiency can support for the greenhouse gas emissions [5].The reduction of greenhouse gas emission has become challenging issue so tourism industry can support to reducing the impact on greenhouse gas emissions. Tourism sector can minimize the carbon emissions using standards methods and take necessary steps to minimize the GHG emissions. In order to reduce carbon emissions strategies, it is necessary to quantify them properly. Several guidelines are available for quantifying the carbon emission but it is lack of practice on hotel sector so it is necessary to develop simple guidelines for the hotel sector [6].

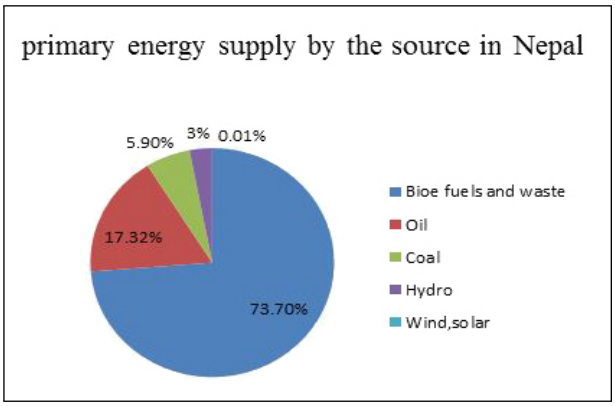


**Figure 1:** Primary energy supply by the source in Nepal

The figure 1 illustrates how much the total primary energy supply in Nepal by source in the year 2017[7] . It is clear that biofuel and oil were the two most popular types of energy supply by source in that year. Looking at the information in more details, we can see that, 73.7% of the primary energy supply by biofuels and waste and 17.32% of primary is supply by oil, which is second highest energy supply by source. Wind and solar provide only .007% energy which is least among others. Recent trends in energy consumption and energy-related carbon emissions for the global buildings and construction sector are varied, with increasing energy use but limited growth in buildings-related emissions. Buildings construction and operations accounted for 36% of global final energy use and 39% of energy-related carbon dioxide$CO_2$ emissions in 2017 which has shown in Figure 2. The buildings and construction sector therefore have the largest shares of energy and emissions, even when excluding construction-related energy use for transport associated with moving building materials to construction sites. The buildings and construction sector is a key factor in the fight against climate change.It accounted for 36% of final energy use and 39% of energy-and process-related emissions in 2017 [8].

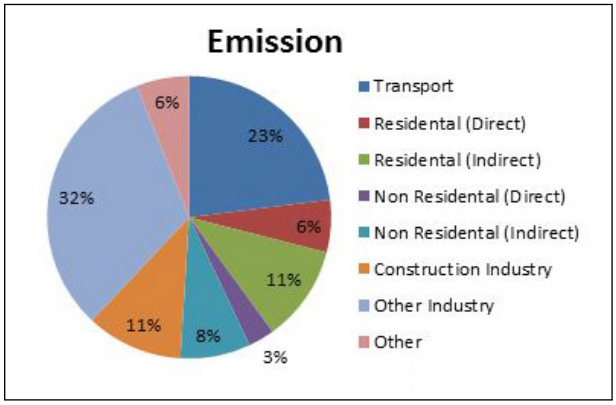


**Figure 2:** Carbon emissions for the global buildings and construction sector

Energy and environment have related to each other in our time. Bulk amount of fossil fuels was used in hotel sector which has to lead us on the era of global warming and ozone layer depletion. Fossil fuels such as diesel, gasoline, natural gas etc emit the harmful greenhouse gas emission when used by someone else. The greenhouse gas emit the dangerous health impact of human life so researchers around the universe have started the alternate researching on alternative energy source like use of solar, wind and biogas etc [9]. Nowadays, worldwide researchers focus on the analysis of reducing fossil fuels that have great impact on the surrounding environment was extremely important. Hotel sector are large consumer of fossil fuels so they must be focus on reducing negative impact from fossil fuels. Hotels sector must be create energy policy to reduce dependence on fossil fuels in electricity generation and other uses in hotel [10].

Direct use of fossil fuels and indirect use of electricity can be produced $CO_2$ gas in the hotels sector. In hotel, steam generation system and cooking steam means direct or indirect energy consumption: thus, carbon dioxide emission can be calculated from this end use

sector.

Energy consumption in hotel building is high compared with other building categories. Hotels consume bulk amount of energy for daily operational work and to satisfy the guest demand. In hotel, bulk amount of energy has been losses from the system due to lack of energy managing practice in a hotel sectors. Even the experienced people in the hotel sector have poorly realized on the identification of problem related to emission issue and the benefit's of adopting renewable technology both on the basis of economy as well as greenhouse gas reduction be . Electricity and fossil fuels was used for covering their energy demand but the use of renewable energy is still limited. Renewable energy technologies have capacity to reduce their operational cost. Nepal is a country where fossil fuels are import from foreign country and pay high cost for fuels. Renewable energy resources can be used in hotels to reduced greenhouse gas emission and minimizing economic crisis. Investigate of using renewable energy technologies in hotels for covering their energy demand could be support for the reducing their carbon footprint and improving sustainability [11].

The greenhouse gas emission analysis is based on types of fuels used in hotel and energy share of different purpose. The aim of this study is to reduce the dependence on fossil fuels, reduction of $CO_2$ emission from fossil fuels and development of greener energy with the use of renewable energy technology [12]. This study helps to find out the selection of the efficient technology and strategies for the sustainable development of the hotel sectors.

## 2. Methodology

### 2.1 Research Methodology

The study is carried out according to the research framework as shown in figure: 3. The study framework consists of issue identification and research question related to star hotel energy performance, impact of fuels type, analytical model development, Scenario development and analysis, and analysis of environmental effects as well. The principle methodology for the study is primary data collection and a set of questionnaires was developed and survey was carried out on sample hotel. The survey data was used in the computer by using LEAP software.

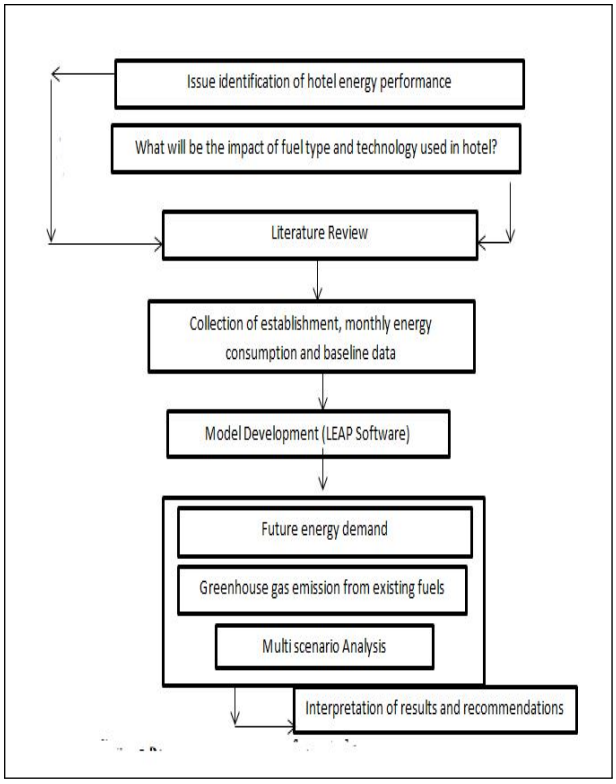


**Figure 3:** Research Framework of the study

#### 2.1.1 LEAP software

LEAP model is a static energy-economy-environmental model which has been used software for energy policy analysis in the future. This four are key assumptions, demand, transformation and resources [13]. LEAP is forecasting software which helps to analysis the current energy scenario and forecast for future under certain condition.

#### 2.1.2 LEAP Model Scenario Description

Study Parameters and Assumptions/ Constraints This study was based on the number of parameter and assumptions. These mainly covered the technical and economic aspects descried in details and were used as input to LEAP.

**Key Parameters** For completion of this study: - the base year was 2019, demand, historical data for analysis, technologies for electricity generation and other trend were taken as the key parameters. Different variable are consider while doing the research i.e GDP, GDP growth, occupancy, occupancy growth and system loses etc.

**Study Period** Twenty year plan for this study in the year 2021 to 2040 meet the target. The prediction of the results reference year was 2019

**Field Survey**

The field visit was done on sample hotel which is out of Kathmandu valley and located at Bhairahawa, Lumbini.

**Modeling**

LEAP software was used for modeling purpose. Collected data from field visit were used for analysis. The base year for the study was 2019 and the tree structure of the LEAP model are given as figure 4

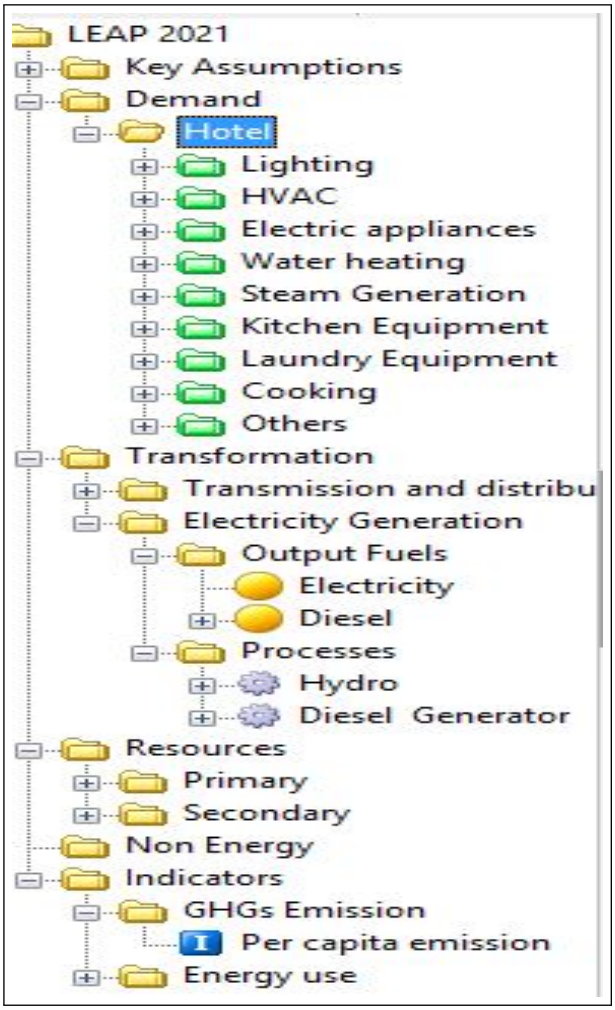


**Figure 4:** LEAP Tree

Low emission analysis platform (LEAP) model was used for this study. Integrated energy system model consider the sample selected hotel in Bhairahawa. LEAP model consists of mainly: Key parameter, end use service demand, energy resource, transformation process. The primary energy supply module represents extraction of primary energy from indigenous energy resources and import of fossil fuel. Conversion and process technology module consists of secondary energy generation, transmission and distribution to the end use sectors. End use service demand module contain different sector like lighting, HVAC system, steam generation system, electrical appliance, laundry equipment, kitchen equipment, cooking system and others system and environmental emissions consists of major GHG emissions ($CO_2$, $CH_4$ and $N_2O$) [14]. This model is used to estimate the per capita greenhouse gas emissions under different scenario.

#### 2.1.3 Energy Demand Projections

For the energy demand analysis, 2019 was the base year, tourist arrival and GDP per capita is taken as the variable for the energy demand projection. The regression analysis was used for the relationship between tourist arrival in selected area, GDP per capita and energy service demand per capita for different sub sector is achieved using the following equation 1 [15]

$$\frac{ESD_{(i,t)}}{ESD_0} = (\frac{NOT_t}{NOT_0})^{\alpha i} x (\frac{GDP_i}{GDP_0})^{\beta i} \quad (1)$$

Where,
ESD0 and ESDt = Energy Service Demand per capita for sub sector 'i' in year t and base year,
GDP0 = GDP per capita for base year,
GDPt= GDP per capita for sub sector 'i' in year t,
NOT0 = Number of tourist arrival in the base year,
NOTt = Number of tourist arrival for sub sector 'i' in year t,
$\alpha$ i,$\beta$ i = Occupancy elasticity and GDP elasticity

### 2.2 Scenario Analysis

#### 2.2.1 Business as Usual Scenario

It is the base case scenario which helps to find base year energy demand according to reference data and demand trend will continue for the future with no intervention. For this scenario analysis, the value of tourist arrival growth and GDP growth is taken as the average growth in the past ten years. End-use technologies are not changed in this scenario. In this scenario GDP growth are taken 2% as per the past average tourism growth rate on national GDP [16]. Tourist arrival growth consider the 3% as per the average tourist forecasted on future [17].

**Table 1:** Monthly life cycle cost of different fuels [21]

| Year | Kerosene Price | LPG Price | Electricity tariff |
|---|---|---|---|
| 2000 | 289 | 550 | 630 |
| 2003 | 476 | 700 | 730 |
| 2006 | 816 | 900 | 730 |
| 2011 | 1249.5 | 1325 | 730 |
| 2012 | 1581 | 1415 | 875 |
| 2018 | 1411 | 1375 | 1050 |

### 2.2.2 Combined policy Scenario

In this scenario, the entire mentioned efficient scenarios were added. efficient cooking scenario and efficient steam generation scenario GHG emission were analyze and added on this best case scenario and compare the value of business as usual (BAU) scenario with this combined policy scenario on this report.In this scenario, replacement of all the traditional fuels like LPG, coal and diesel by clean energy like electricity, promotion of electricity in all the subsector to eliminate emissions and intervention through more efficient system [18]

**Efficient Cooking Scenario**

The device is generally the most efficient device which heat up fast and cook food fast. The efficiency of LPG stove is 68% while using brass burner for cooking purpose and efficiency of LPG cooking stove is 64% while using cast iron burner for cooking purpose [19]. Recently, induction base cooking stove is introduced in market but lack of practice for cooking system. The efficiency of induction cooking stove is 90% [20]. From above analysis, the efficiency of induction base cooking stove is more than LPG base cooking stove. In Nepal, recently NEA promote use of electricity for cooking purpose and NEA focus on subsidy while use more electricity. Many hydro-powers are being introduced in Nepal so near in future the availability of electricity is high. But the government needs to be change policy to promote use of electricity in Nepal because most of houses energy meter in Nepal is low ampere rating like 5A/6A rating so the government and NEA body has to promote minimum16A rating energy meter with induction cooking system from subsidy. On the other hand, LPG is not self-produced by the government it is imported source of fuel for Nepal and which does not have its reserve so near in future used of LPG for cooking is expensive and market may be shortage so use of LPG for cooking is more expensive than induction base cooking system. The government body has to remove subsidy for LPG and promote electricity.

The cost of kerosene, LPG and electricity from the year 2000 to 2018 has shown in above table. In the hotel, only 1% of cooking system was used from electricity in the year 2019 but in future, policy need to be change by management team and it is better efficient system when cooking system from electricity rather than cooking by LPG so it was assumed that for efficient cooking system, 40% of the LPG consumption will be replaced by electricity by the year 2030 and Cooking from LPG by electricity will totally replace by 2035. Coal base cooking system will replace by electric cooking system by 2025

**Steam Generation scenario**

The operating principle of efficient boiler is that which can exploiting heat from flue gases to pre heat the feed water or reuse of losses steam to increase the temperature of boiler [22]. The efficiency of boiler in the sample hotel was 76.98% while feed water temperature is $20^{0C}$ and lots of steam was losses from the system i.e no provision for return use of steam in the hotel. When proper reuse of steam, the boiler efficiency reaches to 86.89% while the feed water temperature is $85^{0}C$. According to study, boiler efficiency can be reach up to 89.66% [23]. In this efficient scenario, boiler efficiency will improve to 85% by 2023 and 89.66% by 2030. This improved on boiler efficiency can reduce consumption of diesel in the hotel. Similarly, steam generation from diesel fuel will replace by electric boiler according organizational energy policy i.e it was assumed that, 30% steam will generate from boiler in 2030 and 100% steam will generate from electric boiler by 2035

**Generator Replacement Scenario**

This is a supply side management scenario. In the sample hotel, 23.08% of the total kwhr was generated by DG in the year 2018 and which was down and reach to only 8.81% of the total Kwhr was generated by the DG in the year 2019. In the context of Nepal, most of the electricity came from hydropower where 1029.58MW electricity produced by hydropower and only 53.4 MW electricity generated by thermal system which per-unit cost is higher than hydropower. Many hydro powers are under construction, planned and proposed in Nepal so it is possible to replace DG by grid electricity. According to NEA data, 957.1 MW capacity hydropower are under construction, planned and proposed hydropower capacity are 2285.2 MW and there is also 25622 MW hydropower are also planned and proposed of the government of

Nepal so no power deficiency in near future. NEA started the high voltage transmission lines and many of them are under construction i.e total 805 KM length circuit of 132 kV transmission line will be completed on 2021/2022, 630 KM length circuit of 220kV transmission line will be completed on 2021/2022 and 576 KM length circuit of 400kV Transmission line will be completed on 2020/2021 [24] so near in future voltage stability and transmission line losses will be less than now.

## 3. Result and discussion

### 3.1 Base year Energy Consumption

The total energy consumption in the hotel is calculated according to fuels used and end use sector. Figure 5 show the energy share of different end use sector in the base year 2019. From the figure, end use sector share of HVAC system was the highest share among the other enduse sector i.e 39.1% share. The second highest share was cooking sector whose was 19.9% which is then followed by electric appliance and steam generation i.e 11.1% and 10.9% respectively and laundry equipment consumed the lowest energy than other remaining system i.e 1.2%.

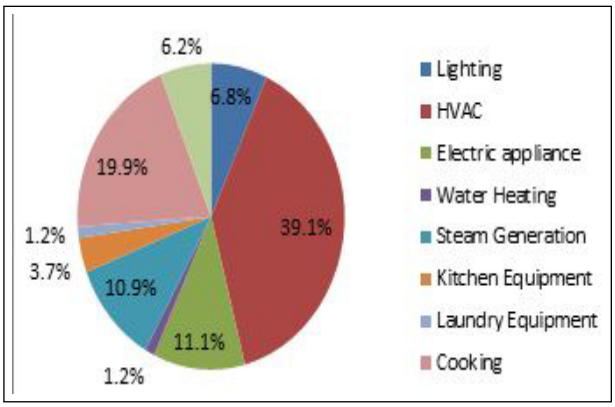


**Figure 5:** Energy share of different end use sector in the base year 2019

The figure 6 show the share of different fuels in hotel where grid electricity share was highest among other i.e 64.49% energy was generated from electricity which is then followed by the diesel whose share was 16.59% which was the second highest among the other. The share of LPG and coal was 13.97% and 4.95% respectively. The figure clearly show that the total energy share of electricity was 64.49% and remaining 35.51% share was from fossil fuels which emit environmental pollution.

**Table 2:** GDP Elasticity and Occupancy Elasticity for different subsectors

| Subsector | GDP Elasticity | Occupancy Elasticity |
|---|---|---|
| Lighting | -0.07 | 0.378 |
| HVAC | -0.07 | 0.378 |
| Electrical Appliances | -0.07 | 0.378 |
| Water heating | -0.07 | 0.378 |
| Steam Generation | -0.65195 | 1.3867 |
| Laundry | -0.07 | 0.378 |
| Kitchen equipment | -0.07 | 0.378 |
| Cooking | -0.38079 | 1.123235 |
| Others | -0.07 | 0.378 |

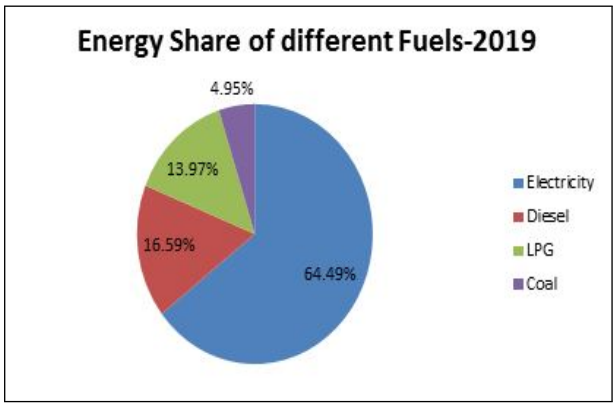


**Figure 6:** Energy share of different fuels in the base year 2019

**Energy Technologies** The technology for energy usage in hotel sector is shifting to electricity from traditional ones. According to base year data, 16.59% of total energy was consumed from diesel, 13.97% of total energy was consumed from LPG and 4.95% of total energy was consumed from coal. Coal and LPG was used for cooking purpose and diesel was used for electrical power generation and steam generation. After the regression analysis, the elasticity's of occupancy and GDP for the final energy intensity for the different sub sector are calculated.

### 3.2 GHG emission under Business as usual Scenario

The figure 7 show the per capita greenhouse gas emissions under business as usual scenario. In this scenario, per capita GHG emissions was 9.7 kg of $CO_2$ in base year 2019 and which will be gradually increased and reach to 17.6 Kg of $CO_2$ in 2040. According to study, per capita GHG emissions on similar type of hotel are in between 6.3 kg $CO_2$ per person to 28.9 kg $CO_2$ per person as per facility

provided by the company [25]. As per the above discussion, the GHG per capita value of calculated hotel is normal range so it is validated by this report.

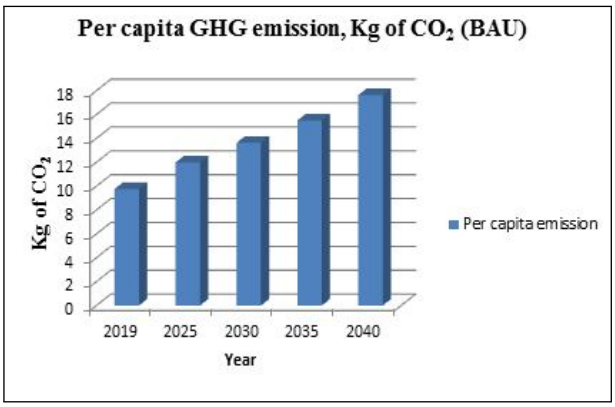


**Figure 7:** Per capita GHG emission,

Figure 8 the GHG emissions metric tons of $CO_2$ equivalent under BAU scenario. In the base year it was found 327.4 metric tons of $CO_2$ produce in hotel under BAU scenario. Emissions will increased and reach to 1100 metric tons of $CO_2$ produced in hotel by 2040. GHG emission can be calculated on the basis of per meter square as well. It was found that 0.076 metric tons of $CO_2$ per meter square produced in 2019 under BAU scenario. According to study, per meter square GHG emissions on similar type of hotel has 0.4 076 metric tons of $CO_2$ in India [26].Per capita GHG emission was .4 ton of CO2 in Nepal which is lowest among South Asian [7] As per the above discussion, per meter square GHG emissions value of calculated hotel is normal range so it is validated by this report.

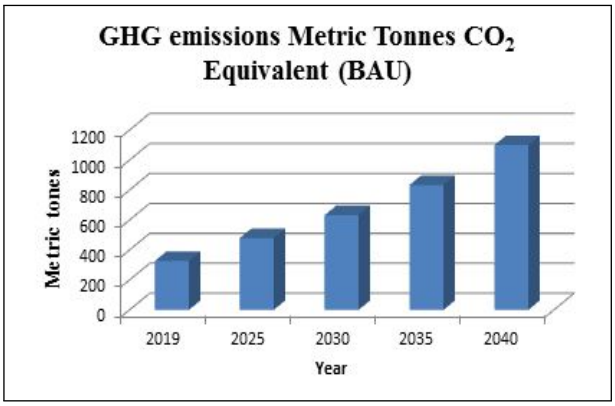


**Figure 8:** GHG emissions metric tons of $CO_2$ equivalent under BAU scenario

### 3.3 GHG emission under Combined policy Scenario

The figure 9 the GHG emission under combined efficient scenario up to 2040. In base year, 327 metric tons of $CO_2$ equivalent produced and after the implementation of the system greenhouse gas emissions will gradually reduce and reach 158.5 metric tons of $CO_2$ equivalent in 2030 later on gradually reduce.

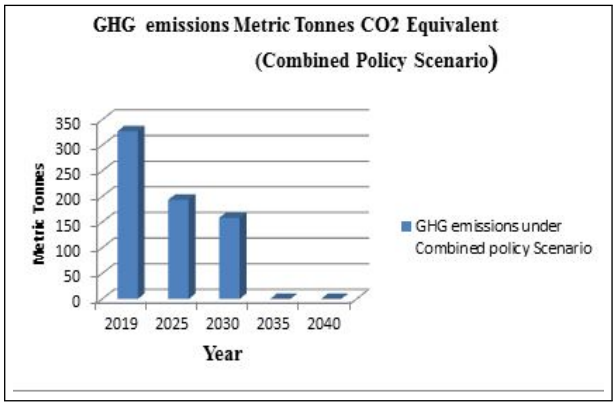


**Figure 9:** GHG emissions metric tons of $CO_2$ equivalent under combined efficient scenario

The figure 10 the GHG emission per capita under combined efficient scenario up to 2040. In base year, 9.7 kg of $CO_2$ equivalent produced and after the implementation of the system greenhouse gas emissions will gradually reduce and reach 3 kg of $CO_2$ 2030 later on gradually reduce and reach zero.In this calculation, CO2 emissions produced from fuel only and emissions calculation is based on IEA energy balance system [7] After the implementation of the electric system in the hotel it was assumed that no emissions produced from fuels when all the fuels are replaced by electricity system and LEAP also calculated emissions from only fuels and LEAP emissions calculation is also based on IEA energy system that why emissions produced in hotel is zero. Emissions can be calculated from electricity, when fuels are used for electricity generation. Total CO2 emission can be calculated from mathematical expression. In this method, first calculate the total emission produced from end use fuels types then divided by total number of tourist stay inside the hotel[25]. This study is based on LEAP model so here also emissions is zero.

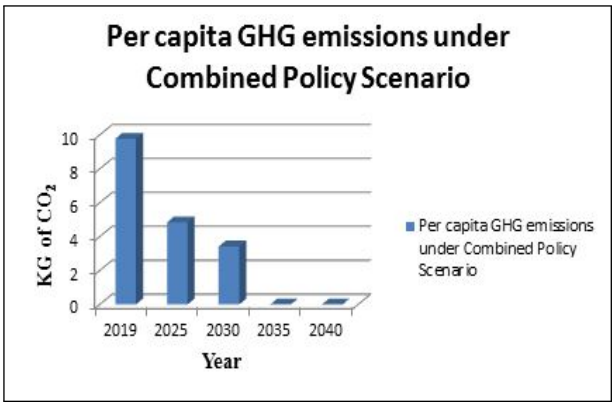


**Figure 10:** GHG emission per capita under combined policy scenario

## 4. Conclusion and Recommendation

### 4.1 Conclusion

The necessary calculations were made by using the measurement and existing meter values and all the necessary value are fed into LEAP software for energy measurement. Calculated data show that, 25.3 tera joule energy was consumed in 2019 where as 9 tera joule energy was produced from diesel, LPG and coal and remaining 16.3 tera joule energy was produced from grid electricity. Energy consumption is expected to be increased from 25.3 tera joule to 65.9 tera joule in 2040 under business as usual scenario. In combined efficient scenario, energy consumption is expected to increase from 25.3 tera joule to 37.76 tera joule in 2040 under combined efficient scenario. In the base year, 91.19% of total electricity was supplied through national NEA grid and remaining 8.8% of total electricity was supplied through diesel generator which had low efficiency so more fuel cost pay by organization to meet the energy demand in the hotel. per capita GHG emissions was 9.7 kg of $CO_2$ in base year 2019 and which will be gradually increased and reach to 17.6 Kg of $CO_2$ in 2040. In the base year it was found 327.4 metric tons of $CO_2$ produce in hotel under BAU scenario. Emissions will increased and reach to 1100 metric tons of $CO_2$ produced in hotel by 2040. After the implementation of the system greenhouse gas emissions will gradually reduce and reach 158.5 metric tons of $CO_2$ equivalent in 2030 later on gradually reduce similarly, after the implementation of the system greenhouse gas emissions will gradually reduce and reach 3 kg of $CO_2$ in 2030 later on gradually reduce. Thus large amount of energy can be saved and large quantity of greenhouse gas emission can be stopped by applying the Combined policy scenario.

### 4.2 Recommendations

Diesel generator produced more emissions while producing power so use of hydroelectric system for power generation is suitable for hotel. Cost and energy needed for electricity generation from diesel generator system is high as compared to the hydroelectric, thus use of hydroelectric should be promoted in hotel. LPG, coal and diesel leads to increase greenhouse gas emission so replacement of fuel base appliance by electric appliance should be promoted in hotel. Biogas can be produced from kitchen waste so installation of biogas plant leads to make hotel less dependent on fossil fuels. Boiler feed water temperature was low and lots of steam losses while steam was used in laundry purpose so feed water temperature can be increased by utilizing of losses steam and fuel required for steam generation can be reduce so greenhouse gas emission also reduced but it is more efficient when steam will generate from electricity. Details energy audit should be carried out to identify the potential energy saving area in hotel.

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