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Energy consumption pattern in Residential Sector: Policy Review of Kathmandu Metropolitan City

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Abstract

In a double sense, the home energy sector has become a crucial to achieving rapid emission reductions globally. In recent years, more people in Nepal have moved into cities as a result of increasing urbanization. Current urban expansion, as well as the residential way of life, has been proved to have a negative impact on world ecology, environment, and climate. The report examines the residential sector's energy consumption in Kathmandu Metropolitan City, as well as its projections until 2030, as well as policy evaluation. The base year data was derived from census 2011 secondary data. Energy Data Sheet and Energy Synopsis Report were used to collect the energy intensity and other characteristics needed for the Long-Range Energy Alternatives Planning System (LEAP). The demographic factors were computed using information from the report and other sources. According to the evaluation findings, the effective policy, i.e., switching LPG to electricity by the end of 2030, is not practicable based on the current scenario analysis because no such arrangements or developments have been witnessed to date. New policies introducing various energy-saving technologies should be suggested, and policymakers should be more cautious about the policies' legitimacy, involving energy professionals, designers, and urban planners in the policy-making process to make it more effective and efficient. A correctly planned strategy would result in a reduction in energy consumption as well as emissions, as well as the ability to maximize the use of energy resource potential.

Keywords

Energy Consumption, Policy, Scenario, Residential Sector, LEAP, Simulation

1. Introduction

Global energy use is increasing, putting more pressure on pollution and global warming. In a dual sense, the home energy sector has become a crucial to achieving significant emission reductions globally. Residential energy usage accounts for roughly 25 percent of worldwide energy consumption and 17 percent of global CO2 emissions [1].

More individuals have been relocating into cities in Nepal in recent years as the country's urbanization has increased [2]. This has resulted in increasing demand on public service infrastructures as well as increased energy usage, posing major environmental concerns. Current urban development and residential lifestyles have been proved to have a negative impact on world ecology, environment, and climate [3]. Nearly 87 percent of the country's overall final energy consumption is consumed by households [4]. In the Kathmandu Metropolitan City, for example, LPG provided around 94 percent of cooking energy while electricity provided about 98 percent of lighting energy in 2010. Nepal is one of the few poor countries that has pledged to support the UN's Sustainable Energy for All initiative [4]. However, formulating national energy action plans and policies to support this endeavour will necessitate a thorough understanding of home energy use trends in various parts of the country. Several research studies and reports on the energy consumption patterns in the transportation and residential sectors are available [5, 6]. For example, from 2015 to 2035, research by [7] demonstrates and evaluates anticipated domestic cooking energy demand as well as its environmental and economic implications. In addition, a report by [8] examines the current energy consumption trend of the Kathmandu valley's residential sector. It demonstrates that "given the current situation, an effective policy is an absolute necessity." Water and Energy Commission Secretariat [4] and other organizations have recommended policies, but no research has been done to see if these are valid in Kathmandu Metropolitan City. Since [9] has demonstrated that human settlements, particularly cities, are hotspots of human activity and major sources of greenhouse gas (GHG) emissions, a study of the residential sector is required. The major goal of this article is to examine residential energy usage in 2011 and forecast it through 2030, using a critical examination of policies created by the Water and Energy Commission Secretariat (National Energy Strategy of Nepal) and the United Nations Development Programme (sustainable energy for all initiative).

2. Methodology

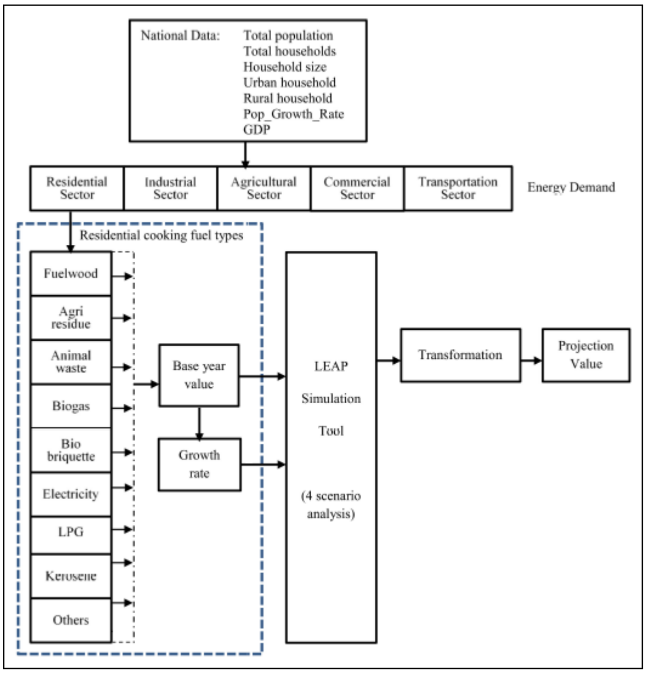

Figure 1: Methodological Framework

The study will examine the residential sector's energy use using a pragmatic approach. This is a research paper. The topic's major method is to calculate the energy consumption of Kathmandu metropolitan city's residential sector through data collecting; analysis is done in LEAP using policy scenarios to assess the policy's effectiveness. The next step is to determine the main categories of possible energy source measurements that are crucial for the energy transition. The policies and activities that can be done to have an impact on energy production and consumption, and consequently affect energy consumption patterns, are referred to as measures. After then, a critical study of the policies is carried out, with the results of 2011, 2021, and 2030 being compared. Because the conclusions are based on modeling, calculations, as well as a literature review and secondary sources of data, this study will employ a mixed paradigm of both positivism and post positivism.

The study's methodological approach is depicted in Figure 1. The framework shown here is used to examine energy possibilities from 2011 to the next 20 years. The secondary data was used to create the base year data. [4] gathered the energy intensity and other parameters needed for LEAP from the Energy Data Sheet and Energy Synopsis Report. The demographic factors were determined using information from the report and literature [10].

3. Case Study and Research Context

According to the 2011 census, Kathmandu Metropolitan City (KMC) has a population of 975, 453 people and 254,292 homes. The metropolitan area is 50.67 square kilometers in size, with a population density of 19,250 people per square kilometer. The city is virtually in the center of Nepal's Kathmandu Valley, at a height of around 1,400 meters (4,600 feet) [11]. KMC is currently undergoing fast population increase, which has resulted in the conversion of significant open spaces, agricultural land, forest land, and vegetation to built-up areas (Figure 2). Simultaneously, the city lacks effective city planning regulations, resulting in unplanned growth [12].

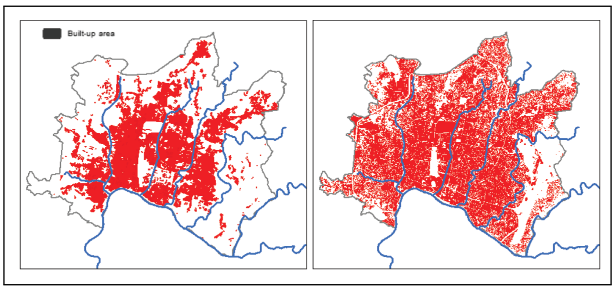

Figure 2: Built-up area of KMC: (A) Year - 1996; (B) Year– 2008

3.1 Energy Consumption by Fuel Type in Residential Sector

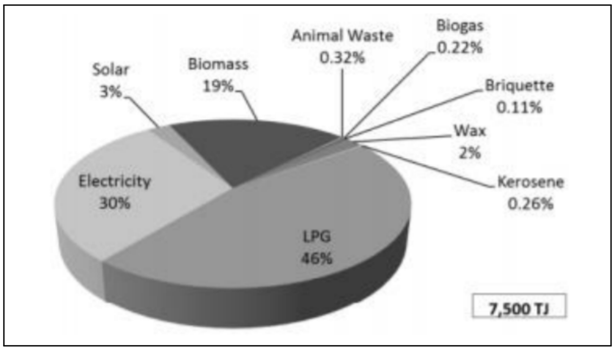

Figure 3: Final energy demand share by fuel type

94 percent of all homes use LPG as their primary source of cooking fuel, whereas biogas is utilized by the smallest number of households, as seen in the pie chart below (Figure 4) [10]

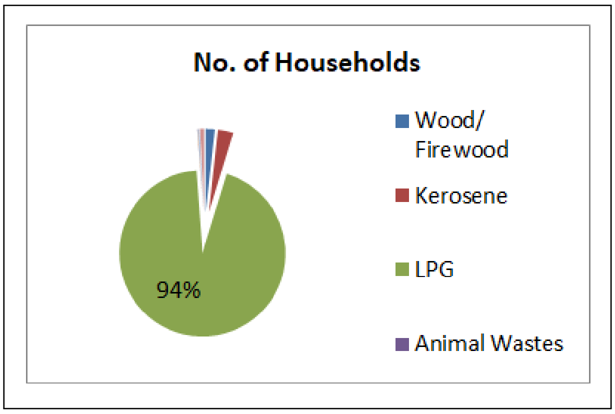

Figure 4: Fuel used for cooking

Electricity is utilized by 98 percent of total households for illumination, whereas solar is used by the smallest percentage of houses, as seen in the pie chart below (Figure 5).[10]

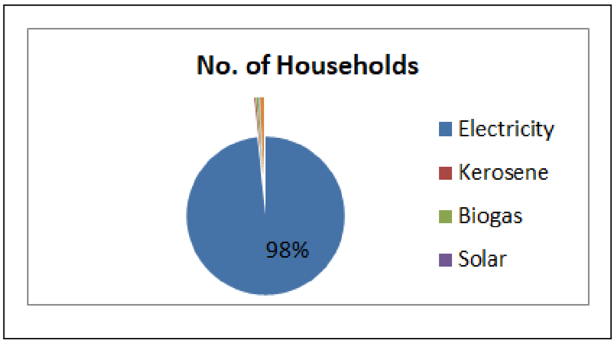

Figure 5: Fuel used for lighting

Television is used by a greater number of houses, whereas refrigerator is used by a smaller number of households, as shown in the bar graph below (Figure 6). [10]

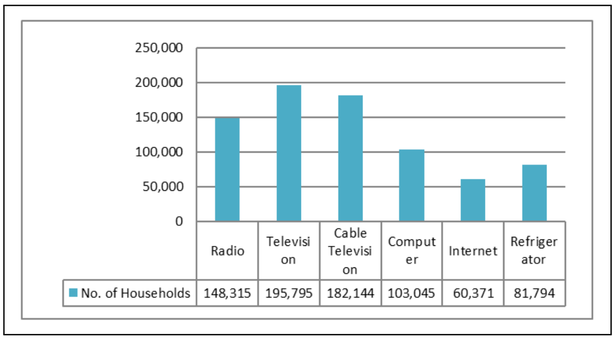

Figure 6: Electrical Appliances used by Households

4. Simulation and Analysis

The study's basic parameters have been established. GJ and NPR are the standard energy and money units, respectively. With other basic monetary parameters, the base year, scenario year, and end year are set to be 2011, 2012, and 2030, respectively. As previously noted, the preliminary demand study includes the energy consumption in Kathmandu's residential sector. Then, for the most recent year for which statistics are available, 2011, a set of "Current Accounts" was created to show energy usage.Then, in the absence of any new policy measures, they created a "Reference Scenario: Business As Usual" to look at how energy consumption patterns are likely to alter in the following years. Finally, four policy scenarios were designed to analyze how energy consumption patterns change in the future as a result of policies: "Energy Efficient Lighting Scenario," "Clean Energy Technology Scenario," "SE4ALL Scenario," and "Combined Scenario."

The following are the policy scenarios that were developed:

4.1 Business-as-usual Scenario (BAU)

It's business as usual here. The baseline scenario, also known as the reference scenario, is the starting point. In the absence of intervention, the historical trend of exogenous variables is assumed to continue in the future. As a result, the share of each demand technology in energy supply in future years will be the same as in the base year, implying that identical consumption patterns will persist.

4.2 Energy Efficient Lighting Scenario (EEL)

GDP growth rate according to BAU, i.e. 3.9 percent average GDP growth rate. Energy efficient lighting will replace incandescent bulbs at a pace of 50 percent in 2020 and then linearly to 75 percent in 2030. Electricity grid transmission and distribution losses decreased from 25 percent in the base year to 20 percent in 2015, then linearly to 10 percent in 2030.

4.3 Clean Energy Technology Scenario (CET)

The following assumptions are used to generate the CET scenario in conjunction with the low carbon scenario, as specified in the National Energy Strategy Report, WECS. The rate of GDP growth is set in accordance with the reference case (BAU). Fuel wood's proportion in the Residential Urban sector fell by 50 percent in 2020 and by 75 percent in 2030, compared to the base year. Electricity, kerosene, and LPG are used to replace it. Improved cook stoves (ICS) will replace traditional fuel wood stoves in the household and commercial sectors at a pace of 25 percent in 2020 and then linearly to 50 percent in 2030 [4].

4.4 Sustainable Energy for All Scenario (SE4ALL)

The fundamental goal of the SE4ALL action agenda is to catalyze action around the three goals listed below. Despite the fact that the number of homes expected to have access to the minimum modern energy is growing, alternative energy sources are nevertheless employed in households for cooking. For cooking, rural households will continue to rely on solid biomass and renewable energy technologies like biogas plants, whereas urban households are predicted to migrate to electricity by 2030. In the beginning, commercial energy in houses meant electricity, LPG, Kerosene, and coal, but by the end of the year, it was mostly electricity and LPG [13].

4.5 Combined Scenario

This scenario combines all of the assumptions from the "Energy Efficient Lighting Scenario" and the "Sustainable Energy for All (SE4ALL) Scenario."

4.6 Output Analysis

After then, a comparison of all scenario development is carried out. In terms of fuel consumption, a base year consumption pattern is contrasted to an end year consumption pattern.

5. Results and Discussion

The ultimate total energy demand estimate varies depending on which of the five scenarios used to project energy demand to 2030. The LEAP results, as well as expected data, are displayed here. LEAP provided the following result without any error messages based on the data availability and data structure model presented in the methodological approach.

5.1 Scenario 1: Business as Usual (BAU)

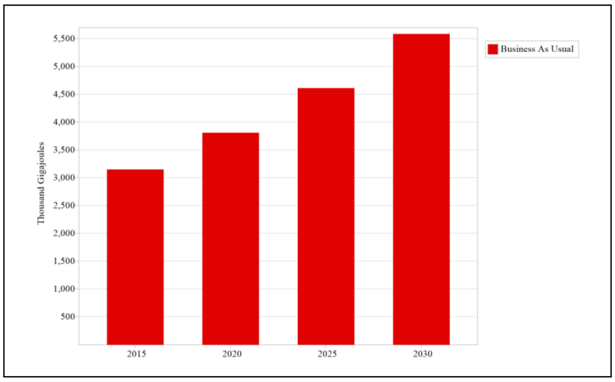

Figure 7: Total Energy Demand (BAU)

With the Business As Usual Scenario, the entire energy demand is anticipated up to 2030. Without any policy interventions, energy demand is anticipated to grow at a rate of 3.9 percent through 2030, as shown in Figure 7. In the year 2030, total energy demand is expected to be 5.58 million GJ.

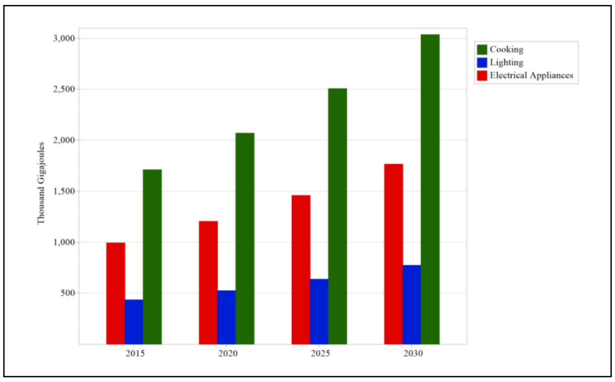

Figure 8: Energy Demand According to the Activities (BAU)

Figure 8 shows that cooking is the activity that uses the most energy, while lighting uses the least.

5.2 Scenario 2: Energy Efficient Lighting (EEL)

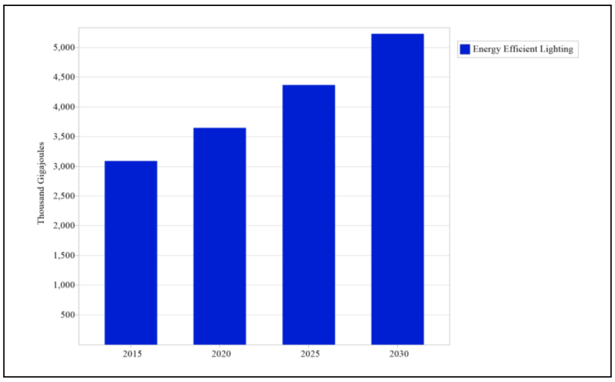

Figure 9: Total Energy Demand (EEL)

When comparing Figure 9 to the BAU Scenario, total energy demand in 2030 has only fallen by 6.3 percent.

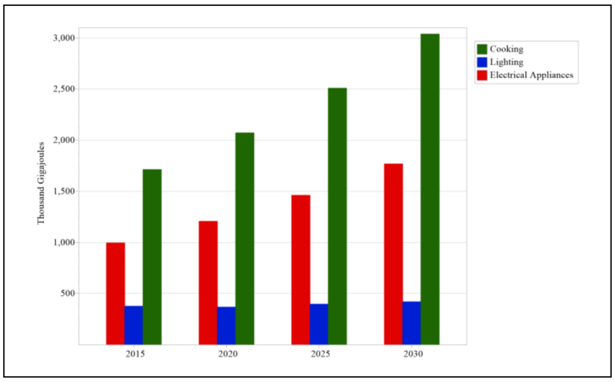

Figure 10: Energy Demand According to the Activities (EEL)

Figure 10 shows that as a result of the policy action, lighting energy demand has fallen to 419,300 GJ. When compared to the BAU Scenario, lighting energy demand has fallen by 45.85 percent in 2030.

5.3 Scenario 3: Clean Energy Technology (CET)

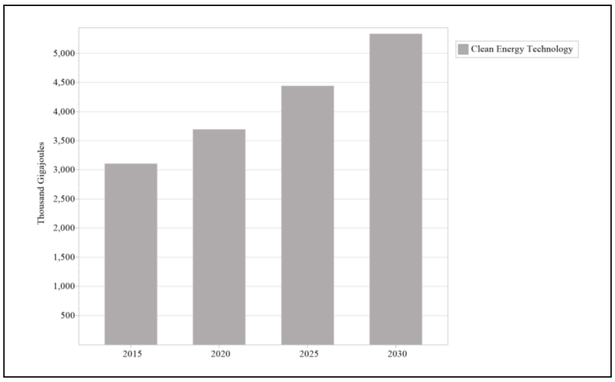

Figure 11: Total Energy Demand (CET)

When comparing Figure 11 to the BAU Scenario, total energy demand in 2030 has only fallen by 4.48 percent.

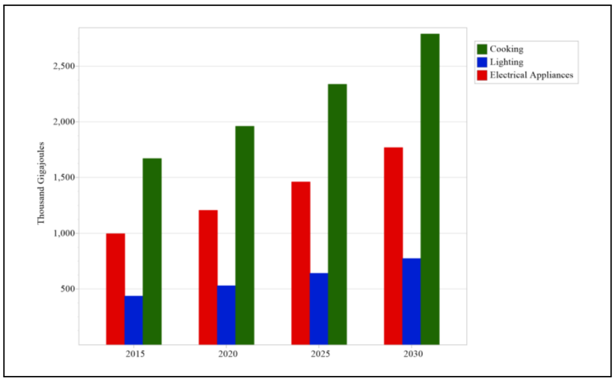

Figure 12: Energy Demand According to the Activities (CET)

Cooking energy demand has fallen to 2.78 million GJ as a result of the policy action, as shown in Figure 12. In 2030, compared to the BAU Scenario, the energy consumption for cooking has dropped by 8.22 percent.

5.4 Scenario 4: Sustainable Energy for All (SE4ALL)

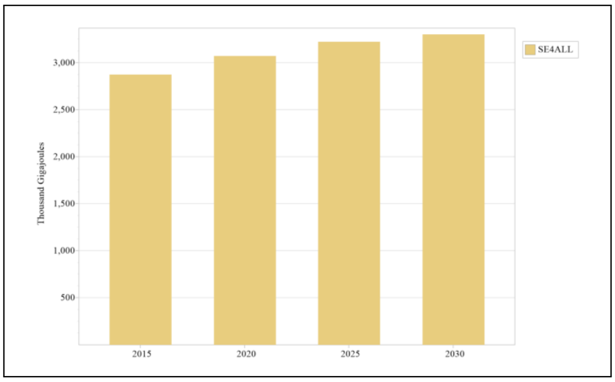

Figure 13: Total Energy Demand (SE4ALL)

In 2030, overall energy demand has fallen by 40.87 percent when compared to the BAU Scenario (Figure 13).

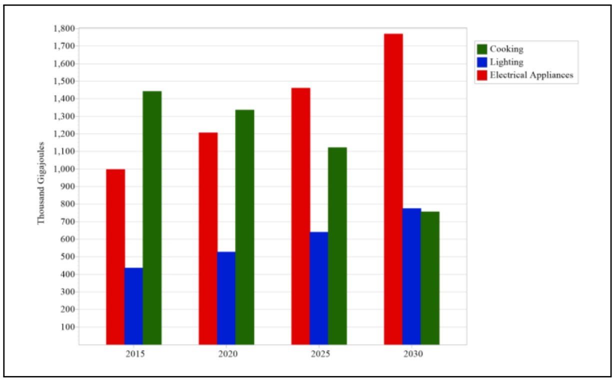

Figure 14: Energy Demand According to the Activities (SE4ALL)

Cooking energy demand has lowered to 757,500 GJ as a result of the policy action, as shown in Figure 14. In 2030, compared to the BAU Scenario, the energy consumption for cooking has fallen by 75.08 percent.

5.5 6.5 Scenario 5: Combined

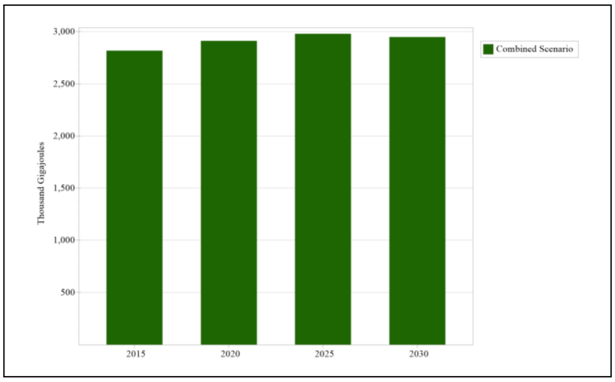

Figure 15: Total Energy Demand (COM)

In 2030, overall energy demand has dropped by 47.23 percent when compared to the BAU Scenario (Figure 15).

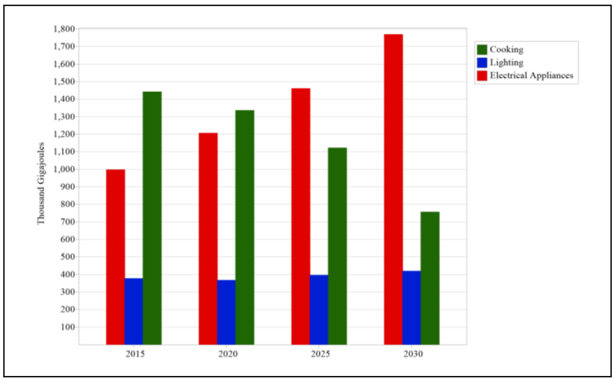

Figure 16: Energy Demand According to the Activities (COM)

Figure 16 shows that as a result of the policy intervention, cooking energy consumption has fallen to 757,500 GJ and lighting energy demand has decreased to 419,300 GJ. In 2030, compared to the BAU Scenario, cooking energy demand has fallen by 75.08 percent, and lighting energy demand has decreased by 45.85 percent.

5.6 Comparative Analysis

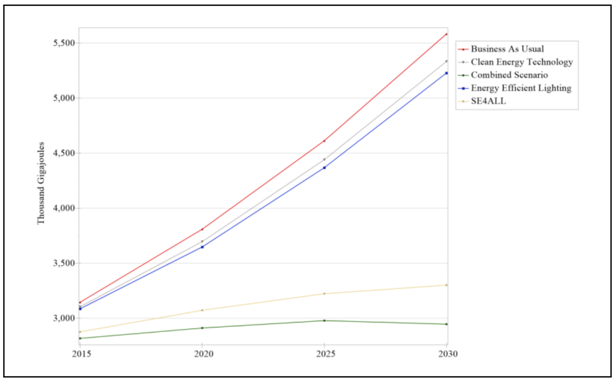

Figure 17: Comparative graph between all 5 scenarios

The “Sustainable Energy for All Scenarios” and “Combined Scenario” curves show the most significant departure, with a significant reduction in overall energy consumption.

6. Conclusion

The energy consumption of the Kathmandu Metropolitan City is found to be 5.58 Million GigaJoule (GJ) in BAU Scenario, 5.33 Million GJ in CET Scenario, 5.23 Million GJ in EEL Scenario, 3.3 Million GJ in SE4ALL Scenario and 2.95 Million GJ in COmbined Scenario. From all the data calculated and analysed from simulation SE4ALL scenario which specifies that rural households will continue to cook with solid biomass and renewable energy technology such as biogas plants, while urban households will migrate to electricity by 2030 is found to be the least energy consumption scenario among the policy scenarios whereas combined scenario with two policies combined (i.e, EEL and SE4ALL), has the lowest energy usage pattern in 2030. The policies are examined, and it is discovered that certain policies, such as SE4ALL, have been proposed to dramatically reduce the Kathmandu Metropolitan City’s energy usage.

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