Energy Consumption and Demand Projection of Manufacturing Industries in Kathmandu Valley

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Abstract

This paper analyzes present energy consumption by industrial sector within Kathmandu Valley. Initially, author has gone through intensive literature review and prepare questionnaire. Kathmandu Valley is considered as hub of economic sectors. There are large numbers of industries therefore Sample Distribution method is applied to select location. Out of 1,372 industries, 239 industries have been visited to collect data regarding various energy sources available, technologies used, manufactured final products etc. Collected data is compiled using MS-Excel. It was found that total energy consumption by manufacturing industries in Kathmandu Valley is 16.4 PJ. Diesel is the main energy sources which contribute about 37.21% of total energy consumption. The energy demand is projected from base year 2019 to 2050 using MAED energy model tool. The energy demand for manufacturing industries in Kathmandu Valley is estimated to grow from 16.4 PJ in 2021 to 50 PJ at low growth rate (3.95%), 116 PJ at medium growth rate (7%) and 524 PJ at high growth rate (12.7%). However, the demand of diesel and electricity will increase from 38% and 6% in base year to 60% and 14% respectively by 2050.GHG emission in 2021 was 1,249.6 thousand metric tons and it is expected to increase by 2050 at low growth, medium growth, and high growth is 3842.8 thousand metric tons, 8890 thousand metric tons, and 40,043 thousand metric tons respectively.

Keywords

Energy Consumption, Industrial sector, Energy Scenario Development, GHG Emission

1. INTRODUCTION

Energy is vital for the development of the country economics useful in formulating plan and policies. In Nepal, the use of traditional fuel dominates the energy consumption at 67% followed by imported fuels (petrol, diesel, LPG, kerosene, coal and furnace oil) 27% [1]. The high use of traditional fuels not only creates the unnecessary burden on the forests in Nepal, but also releases several greenhouse gases in the atmosphere. Similarly, the use of imported fuel is increasing at an alarming rate, which creates burden in the country's economy.

While looking at the energy consumption in different economic sectors, the residential sector consumes 80% of the overall energy consumption while the industrial sector consumes around 8% of the energy [1]. When compared to the global scenario of energy consumption by sector, the industrial sector consumes 23% while the residential sector consumes 20% of the total energy consumption respectively [2]. The gross value added by the industrial sector to the country's economy at basic price is at 51% [3]. The lower share of energy consumption in industrial sector while contributing more than 50% of the country's economy suggests that with

increase in energy consumption in industry, the country's economy can also be improved. Coal is major source of energy consumption in industrial sector in Nepal which produces enormous quantity of hazardous GHGs gases [4]. However, electricity source of energy in industrial sector is in increasing trends [1].

Kathmandu Valley is one of the industrial hubs in Nepal with 1,372 manufacturing industries registered according to the Department of Industry, Nepal. This study aims to determine the energy consumption in various sub-sectors of the manufacturing industry by end use and fuel type.

2. STATEMENT OF THE PROBLEM

Sustainable Development Goal (SDG) 9 targeted that industrial sector has to increase the share of energy consumption up to 25% and shift the nation from least developing country to middle by 2030 [5]. It requires tremendous consumption of energy resources and more energy efficient technology to achieve the targeted goal. However, there are not enough study that analyzes long term plan for energy consumption and GHG emissions at local city level. The economic activities are increasing in Kathmandu Valley with increasing population and the numbers of operational industries. Therefore, it is essential to carry out long term analysis regarding energy consumption and demand projection for industrial sector in Kathmandu Valley.

3. OBJECTIVE OF STUDY

- To determine the present status of energy consumption in industrial sector of Kathmandu valley
- To estimate the energy demand of all type of energy up to 2050 AD at 5 years interval in industrial sectors
- To access the emissions due to the consumption of various fuels in industrial sector

4. METHODOLOGY

Research methodology is a way to solve research problem systematically and appropriately [6]. Figure 1 indicates the methodology adopted to carry out this research.

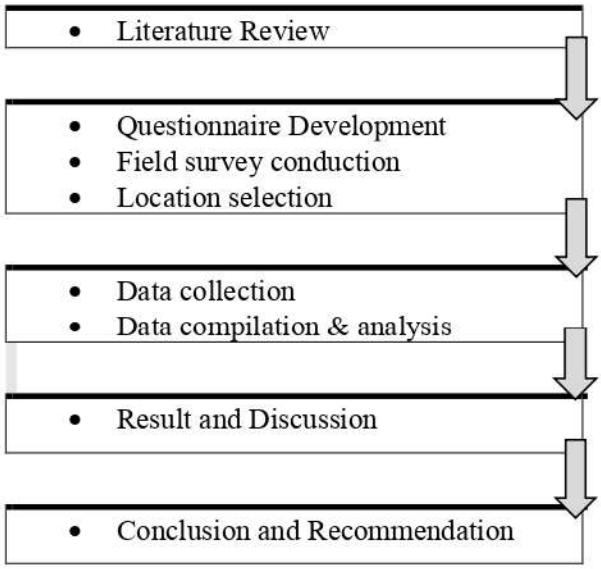

Figure 1: Methodological chart

4.1 Literature Review

Extensive literature review was conducted to calculate energy consumption by industrial sector. Relevant documents, plan, policies and guidelines regarding energy resource, potential, supply, demand and consumption from various secondary sources and institution has been collected and reviewed.

4.2 Questionnaire Development

The information acquired from literature review reports has been used to design questionnaires. The questionnaire has included various parameters such as annul energy consumption by sources, technologies used, fuel cost, efficiency of equipment, and emissions.

4.3 Sample Size Determination

According to Department of Industry, there are 1,021 numbers of manufacturing industries in Kathmandu Valley. Therefore, it was impossible to collect energy data from all the industries therefore; sampling method was applied to determine appropriate sample size. For sample size proportionally determination, it was designed with 95% level of confidence, 5% margin error and 5% non-response rate for the manufacturing industries. The sample size will be calculated using Krejci and Morgan formula [7],

$$n = \frac{\chi^2 \, x \, p \, x \, qxN}{e^2 \, (N-1) + \chi^2 x \, px \, q}$$

where,

χ^2 = chi-square for specific confidence level (95%)

p = probability of success

e = margin of error

N = Population size

n = required sample size

Non-response rate: Total non-response rate is assumed as 5%, which considers non-respondent and unavailable unit.

Hence, total sample size = $n + 5\% \; of \; n$

4.4 Location Selection and Field Survey

After questionnaire development, and sample size proportionally determination, location has been selected to conduct field survey. Locations to collect data are different classification of industries categorized by Nepal Standard Industrial Classification (NSIC) within Kathmandu Valley. Then, the survey has been conducted in 239 various manufacturing industries as shown in Table 1. During field survey phase, primary data regarding energy consumption has been collected by interview and observation. And, the secondary data such as electricity bill, machine log book, generator log book etc. has also been collected from the record.

Table 1: Number of samples collected in different industries

NSIC	Collected Sample Number
Cement, Bricks, Concrete and Clay products	15
Chemical Products, Rubber, Glass and Plastics/ Lubricants	35
Electrical and Electronic products	5
Food, Beverage and Tobacco	29
Mechanical Engineering, machineries, Iron and steel and other metals	28
Miscellaneous (Jewelry, musical instrument, sporting goods, toys etc.)	38

Paper, Publication & Printing, Furniture & Fixtures	48
Textiles, Readymade Garment & Leather Products	41
Grand Total	**239**

4.5 Data Collection, Compilation and Analysis

The energy consumption data collected from manufacturing industries by field survey was further compiled using MS Excel. During this phase, the error and invalid data were eliminated. Then, the compiled data has been analyzed which proceed for result and conclusion.

5. RESULTS AND CONCLUSION

5.1 Total Energy Mix

Final energy consumption by manufacturing industries in Kathmandu Valley is 16.4 PJ. Figure 2 shows the share of various fuels consumption in manufacturing industries in Kathmandu Valley. It was found that industrial sectors are highly dependent on fossil fuel. It accounts for about 67% of total energy consumption while biomass and electricity contribute 27% and 6% respectively. Diesel is the main source of energy consumption in industrial sector. It accounts about 37.21% share of total energy consumption. After diesel, coal is most consumed energy source which contributes 21.5% share of total energy consumption. Furthermore, fuelwood, agriculture residue, furnace oil and others occupied shares of 14.5%, 12.5%, 5.4% and 2.6% respectively.

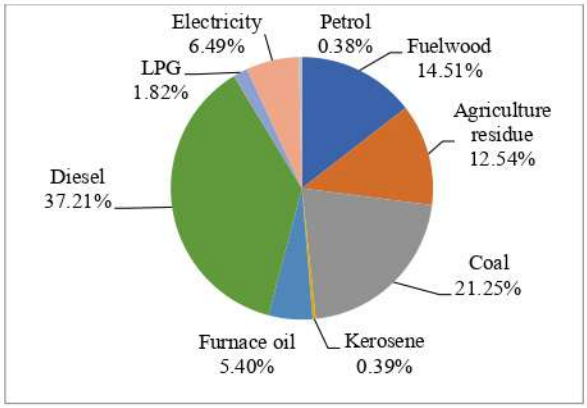

Figure 2: Share of energy consumption by fuel types

5.2 Energy Consumption by End-use

In industrial sector, boiler, process heat and motive power are major process under which final products are manufactured. It was found that 36.86% of total energy is consumed for process heat which is followed by boiler (34.84%), motive power (25.84%) and others (2.5%). Mostly, coal and fuelwood are used for process heat in cement, brick, food and beverage industries. Meanwhile, diesel and electricity is also used for process heat and motive power in chemical and plastic industries. It seems uses of biomass (fuelwood and agricultural residue) are still higher for boiler but consumption of coal is being replaced by electricity and diesel.

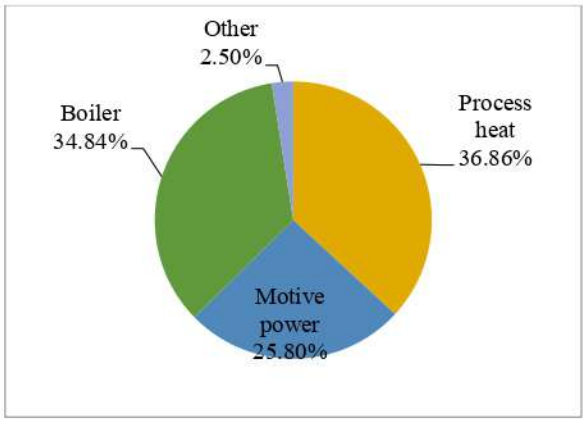

Figure 3: Share of energy consumption by end use

5.3 Energy Consumption by Category-wise

According to NSIC, manufacturing industries are classified in several categories among which food, beverage and tobacco (39%) consumes highest energy as shown in Figure 4.

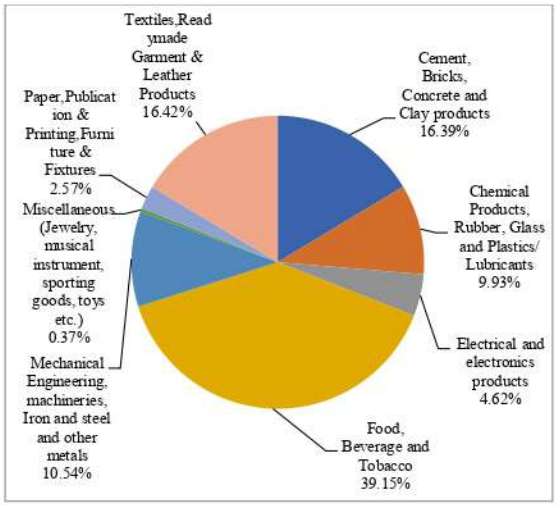

Figure 4: Share of energy consumption by industries wise

Then, cement, brick, concrete and clay product and textile, readymade garment and leather product both accounts about 16% of total energy consumption which is followed by mechanical engineering, iron and steel and other metal (10.5%), chemical products, rubber, glass and plastic (10%) and remaining others.

5.4 Energy Scenario Development

In order for scenario development, different sets of possible future energy demand have been considered are Low Growth Scenario, Medium Growth Scenario and High Growth Scenario.

Low Growth Scenario

Low growth was considered as the average growth rate of GDP for manufacturing industries of Nepal within a decade. The assumptions for this scenario are:

- Average growth of 3.95%
- The share of each demand technology in the supply energy for future year will be same as base year

Medium Growth Scenario

For medium growth scenario, the growth rate has been considered as the targeted growth rate of GDP by SDG. The assumptions for this scenario are:

- Average growth of 7% [5]
- The share of each demand technology in the supply energy for future year will be same as base year.

High Growth Scenario

For high growth scenario, the growth rate is considered as the targeted growth of GDP for manufacturing by the 15th plan. The assumptions of this scenario are:

- Average growth of 12.7% [8]
- The share of each demand technology in the supply energy for future year will be same as base year.

Policy Scenario

Major assumptions for policy scenario are:

- Average growth of 7%
- For boiler,
  - ❖ Penetration of 100% share of electric boiler in food beverage and tobacco by 2050
  - ❖ Penetration of 100% share of electric boiler in textile and leather by 2050

- ❖ Penetration of 100% share of electric boiler in chemical rubber and plastic share by 2050
- ❖ Penetration of 100% share of electric boiler in wood products and paper by 2050

5.5 Energy Demand Projection

The total energy demand for industrial sector from base year 2021 to 2050 is expected to grow at average annual growth rate of 3.95% from 16 PJ in 2021, 23 PJ in 2030 and 50 PJ in 2050 which has increased in more than three folds. Similarly, at medium growth rate, the total energy demand for industrial sector is expected to grow from 16 PJ in 2021 to 30 PJ in 2030 and 116 PJ in 2050. Meanwhile, the total energy demand for industrial sector from base year 2021 is expected to grow from 16 PJ in 2021 to 30 PJ in 2030 and 116 PJ in 2050. Then, the total energy demand is expected to grow from 16 PJ in 2021 to 29 PJ in 2030 and 106 PJ in 2050.

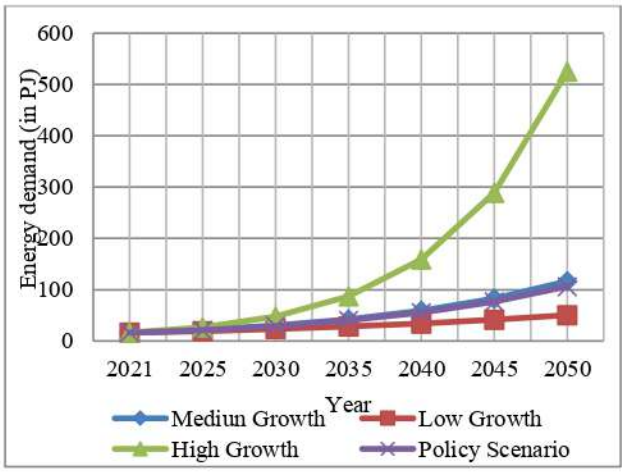

Figure 5: Comparison of energy demand projection at low, medium, high and policy scenario

5.6 GHG Emissions

GHG emission was 1,249.6 thousand metric tons and would increase to 1770.8 thousand metric tons, 2297 thousand metric tons and 3665 thousand metric tons in 2030 while, this would increase to 3842.8 thousand metric tons, 8890 thousand metric tons and 40,043 thousand metric tons in 2050. However, at policy scenario GHG would increase from base year to 2163 thousand metric tons in 2030 and further it would increase to 6,964 thousand metric tons in 2050. In comparison with reference and policy scenario, it seems the growth rate of emission would decrease by 2050 where GHG would be controlled significantly.

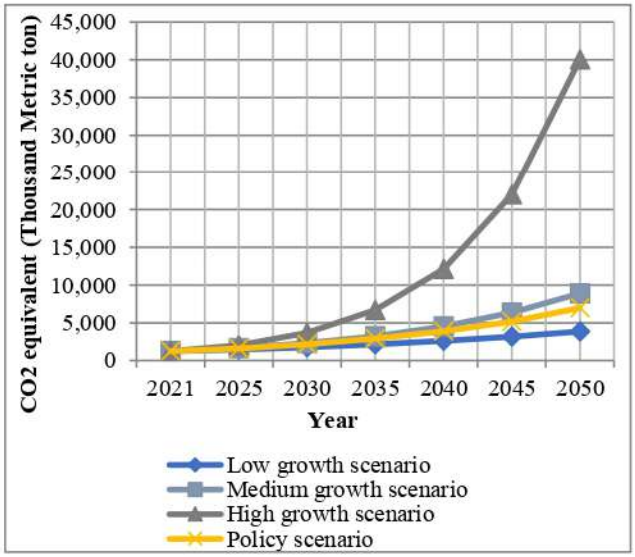

Figure 6: Comparison of GHG emissions projection at low, medium, high and policy scenario

6. CONCLUSION

- Total energy consumption of manufacturing industrial sector in Kathmandu Valley is 16.4 PJ. Industrial sector accounts 67%, 27% and 6% share of total energy consumption fossil fuel, biomass and electricity respectively.
- 36.86% of total energy is consumed for process heat which is followed by boiler

(34.84%), motive power (25.8%) and others (2%)

- Among several categories of industries, food, beverage and tobacco has major energy consumption types which accounts 39% of total energy consumption.
- The energy demand for manufacturing industries in Kathmandu Valley is estimated to grow from 16.4 PJ in 2021 to 50 PJ at low growth rate (3.95%), 116 PJ at medium growth rate (7%) and 524 PJ at high growth rate (12.7%).
- In policy scenario, penetration of 100% electric boiler by 2050 results as the share of biomass (28%) and coal (21%) in 2021 will decrease to 4% and 15% respectively by 2050. However, the demand of diesel and electricity will increase from 38% and 6% in base year to 60% and 14% respectively by 2050.
- GHG emission in 2021 was 1,249.6 thousand metric tons and it is expected to increase by 2050 at low growth, medium growth, high growth and policy scenario is 3842.8 thousand metric tons, 8890 thousand metric tons, 40,043 thousand metric tons and increase to 6,964 thousand metric tons respectively

7. FURTHER RESEARCH AREA

This paper represents total energy consumption in industrial sector in Kathmandu Valley. Further research can be conducted to find energy consumption in other economic sector such as residential sector, transport sector, commercial sector, agriculture sector and construction and mining sector.

REFERENCES

[1] M. o. Finance, "Economic Survey 2020/21," Ministry of Finance, Kathmandu, Nepal, 2021.

[2] IEA, "Largest end uses of energy by sector, selected IEA countries," International Energy Agency, Paris, 2021.

[3] CBS, "National Economic Census 2019," Central Buerue of Statistic, Kathmandu, Nepal, 2021.

[4] T. R. B. Khem Gyanwali, "Demand Side Management in Industrial Sector of Nepal," in *Proceedings of IOE Graduate Conference*, Kathmandu, 2013.

[5] NPC, "Nepal's Sustainable Development Goals - Status and Roadmap: 2016-2030," Government of Nepal, National Planning Commission, Kathmandu, 2017.

[6] C. Kothari, Research methodology: method and techniques, 2004.

[7] K. &. Morgan, "Determining Sample Size for Research Activities," 1970.

[8] National Planning Commission, "The Fifteenth Plan," Government of Nepal, National Planning Commission, Kathmandu, 2020.