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Electricity Demand Creation in Industrial Sector of Nepal

by

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A THESIS

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The undersigned certify that they have read, and recommended to the institute of engineering for the acceptance, a thesis entitled "**Electricity Demand Creation in Industrial Sector of Nepal"** submitted by Santosh Thapa (072/MSREE/517) in partial fulfillment of the requirements for the degree of master of science in Renewable Energy Engineering.

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ABSTRACT

Nepal is also transforming into renewable form of energy in form of electricity as source of energy consumption. Nepal accounts only 8.87% of electricity consumption in of energy sector which is very less in comparison to developed nations. Sustainable Development Goal (SDG) targeted that the industrial sector has to increase the share of energy consumption up to 25% and uplift the nation from least developed country to middle by 2030. The electricity demand is projected from base year 2021 to 2050 using the LEAP energy model tool. Here, Business-as-usual and Policy scenarios with low growth rate, medium growth rate, and high growth rate are taken into account to electricity demand projection with 2021 as base year.

For industrial sector overall electricity demand increase from 2,800.70 GWh in the base year to 57,172.17 GWh, 43,047.05 GWh and 32,408.31 GWh for high (6.52 %), medium (5.46%) and low (4.41%) growth rate respectively at Business-as-Usual Scenario by 2050. For policy scenario, overall demand increases from 2,800.70 GWh in the base year to 1,01,080.91 GWh, 76,107.57 GWh and 57,298.19 GWh for high, medium and low growth rate by 2050. Overall, in industrial sector is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth are 43,908.74 GWh, 33,060.52 GWh and 24,889.88 GWh in 2050 respectively. In Food, beverage & tobacco manufacturing it is observed that there is more electricity demand and less demand in electrical & electronic products manufacturing industry.

In policy scenario with high growth, medium growth, and low growth the electricity consumption values in 2022 are 3,722.72 GWh, 3,685.49 GWh, and 3,648.61 GWh respectively. In Business-as-usual scenario, with high growth, medium growth, and low growth rates, the electricity consumption values in 2022 are 3,231.57 GWh, 3,199.26 GWh, and 3,167.24 GWh respectively. The actual electricity consumption for the industrial sector in 2022, as reported by the Nepal Electricity Authority (NEA), is 3,448.00 GWh. It is noted that the Business-as-Usual scenario with a high growth rate and the Policy Scenario with a low growth rate are quite close to the actual electricity consumption by the industrial sector in 2022. This suggests that these particular scenarios are more accurate or representative of the real-world consumption patterns in the industrial sector of Nepal.

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ABBREVIATIONS

OECD	Organization for Economic Co-operation and Development
TWh	Terawatt - hour
MoF	Ministry of Finance
NEA	Nepal Electricity Authority
PJ	Petajoule
WECS	Water and Energy Commission Secretariat
O&M	Operating and Management
SDG	Sustainable Development Goals
GJ	Gigajoule
IFC	International Finance Corporation
kWh	Kilowatt – hour
GWh	Gigawatt-hour
GDP	Gross Domestic Product
GVA	Gross Value Added
IPP	Independent Power Producers
BAU	Business-as-Usual
LEAP	Low - Emission Analysis Platform
GHG	Green - House Gases
CAGR	Compound Annual Growth Rate
IVA	Industrial Value Added
NSIC	National Standard Industrial Classification
MG	Medium Growth
LG	Low Growth
HG	High Growth

CHAPTER ONE: INTRODUCTION

1.1. Background

Industrial development is very essential backbone for the economic development of a nation. The major economic development in the country is largely dependent on the industries operating within the country. With the active number of various industries running in the country, helps the country to achieve independence in economic status, decreasing imports and increasing exports. Not only does it create economic independence but also job opportunities within the country. So, with the development of industries, there is huge energy consumption needed to run them. In terms of energy consumption, fossil fuel is used as primary energy since most of the industrial technology is fossil fuel powered. With the growing concern about the effects caused by use of fuel, many countries are trying to shift their fuel power to electricity. As electricity can be generated using hydropower, which is considered green energy i.e., environment - friendly energy. In Nepal, hydropower facilities account for more than 95% of total power generating capacity. However, there are also solar photovoltaic (PV) and wind power stations operating on both on-grid and off-grid systems. These installations are predominantly located in sparsely populated regions.

So, most developed countries use electricity as a major source of energy for the operation of industry. According to OECD, industrial sectors in developed nations consume about 42.2% of the electricity. Despite periods of decreased economic activity, the total energy demand continued to steadily increase over time. Therefore, a developed and reliable electric power system is an essential component of the long-term foundation to improve the nation's economic position through efficient manufacturing processes and a cost-effective structure. Based on the BAU, LG, MG, and HG scenarios, it has been ascertained that the nation's overall total energy usage will experience growth from 2005 to 2030 at rates of 2.4, 2.7, 2.8, and 3 times the demand of the base year. This will result in respective consumption figures of 30.5 PJ, 34.3 PJ, 35.7 PJ, and 37.8 PJ within the industrial sector. By 2030, the sector's distribution of end-use energy consumption for various purposes will be approximately 35.8% for motive power, 35.2% for boilers, 24.6% for process heat, 2.1% for lighting, and 2.3% for other uses (Bhattarai & Bajracharya, 2016). Remarkably, the demand for electricity has exhibited a considerably swifter growth rate compared to the final energy

demand. The industrial sector's yearly electricity demand in 2021 was 2,823 GWh, up from about 2,550 GWh in 2020. Nepal is indeed considered a developing country, and its industrialization level has been relatively low compared to more developed nations. By 2021, there are a total of 8764 industries registered in Nepal – large industries 1305; medium industries 2017 and small industries 5442, (DOI, 2021/22). So, there is potential demand and creation of electricity in industry.

1.2 Problem statement

In Nepal, the industrial sector stands out as a notably energy-intensive segment of the economy. This sector's collective energy consumption reaches 114.5 PJ, signifying a substantial 16% portion of the overall energy usage. Within the industrial domain, the primary energy utilization centers around thermal applications. Nevertheless, a noteworthy observation is that coal takes the lead as the primary energy source in this sector, constituting a significant 48% of the energy composition. Despite the growing integration of novel technologies, the adoption of electricity for heating needs is on the rise. However, the rate of phasing out older technologies in favor of these modern alternatives is currently inadequate. As per the Nepal Energy Vision 2050, there is a projected implementation of novel electric boilers within industries, aiming for them to constitute 50% of the total by 2030. By the same year, complete electrification is targeted for motive power and other sectors. Further advancements are expected, with a full 100% share projected by 2050, facilitated by the introduction of new electric boilers. So, there is room for creating demand of electricity in industry with efficient and cost-effective methods. In recent years, Nepal has achieved significant progress in expanding its electricity generation capacity, showing a commendable upward trend. The average annual growth rate for electricity generation over the past five years is an impressive 16.29%, while the ten-year growth rate remains strong at 10.63%. Notably, electricity generation saw a remarkable growth of 57.50% in the last year alone. This positive development reflects Nepal's dedicated efforts to utilize its abundant water and energy resources to meet the increasing energy demands of the country. Simultaneously, electricity consumption in Nepal has also been increasing significantly, with an average annual growth rate of 27.39%. The growth rates for the last five and ten years are 10.87% and 11.43%, respectively, indicating the rising energy needs in various economic sectors, showcasing the nation's overall progress. Although both electricity generation and consumption are experiencing substantial growth, the

rate of electricity generation surpasses that of consumption. This suggests that in the future, there may be a surplus in electricity supply compared to existing demand. To address this scenario, it becomes crucial to focus on creating electricity demand, optimizing the increased generation capacity, and ensuring the long-term sustainability of Nepal's energy sector. The need for electricity demand creation goes beyond managing the growing surplus in electricity. The Government of Nepal recognizes the potential benefits of increasing domestic electricity consumption. To align with this vision, various energy policies have been outlined, including the Nationally Determined Contributions (NDCs) and a commitment to achieve net-zero emissions by 2030. Promoting and incentivizing electrification in different sectors is seen as a critical strategy. These initiatives underscore the importance of enhancing electricity demand across diverse economic sectors, achieving energy security, sustainability, and fostering overall economic growth.

Given these significant developments and the projected trajectory of electricity generation and consumption, the urgency for electricity demand creation is evident. The "Electricity Demand Creation in Industrial Sector" research aims to identify and implement strategic interventions that align with national objectives. Through this comprehensive effort, Nepal aims to optimize its energy resources, reduce reliance on imported fossil fuels, and pave the way for a more resilient and electrified future. The thesis emphasizes the significance of well-informed policy decisions and outlines pathways to achieve the nation's energy aspirations sustainably and efficiently. According to Nepal Energy Sector Synopsis Report 2022, industry accounts only 8.87% of electricity which is very less in comparison to developed nations. Industry is in demand of more electricity for a clean and green manufacturing process which is part of the Sustainable Development Goal. There is less research in the creation of electricity demand in industries of Nepal by academicians, researchers, organizations, governmental bodies. As outlined in the 2013 WECS report, the long-term vision for 2050 involves expediting the transition towards viable, innovative, and alternative energy sources across urban residential, commercial (encompassing institutions, food, and lodging establishments), and industrial sectors nationwide. Key energy initiatives essential for fulfilling the Sustainable Development Goals (SDGs) encompass a range of strategies. These involve the establishment of expansive hydroelectric ventures, smaller off-grid micro hydro projects, integration of solar systems into the grid,

enhancement of transmission and distribution networks, heightened focus on energy efficiency, and allocation of resources for effective operation and maintenance to uphold a reliable power supply quality. So, switching towards electrical appliances in industry has become a topic of research. This hasn't been addressed by much literature. They are focused on overall electricity and energy consumption. Research related to creation of electrical demand in industry is limited.

1.3 Scope

This study will be advantageous for industry for switching from traditional mode of operation to electrical mode of operation. It is done to assist industry for switching in electrical mode with optimal cost and method.

1.4 Research objective

The main objective of this study is to analyze electrical demand creation in industrial sector of Nepal. In order to achieve the aim, a number of Specific objectives have been defined, which is listed below:

- To determine components in industry to switch in electric mode of operation.
- To analyze and predict the future electricity demand creation in industrial sub-sectors.
- To analyze and make a comparative assessment of electricity demand creation across different scenarios in industrial sector.

CHAPTER TWO: LITERATURE REVIEW

Industrial sector's importance in advancing the economy makes electricity demand a key factor in global energy networks. As global energy demand rises, understanding power demand creation within industries becomes increasingly important. Increasing industrial electricity consumption can significantly impact sustainability and energy efficiency. Integrating renewable power sources into industrial operations is now crucial, aligning with the global push for cleaner energy. Creating electricity demand within a nation's industry is economically advantageous compared to exporting to neighboring countries like India and Bangladesh. This approach fosters energy independence, supports local industries, and promotes sustainability while combating climate change.

2.1 Energy Consumption Pattern

In Nepal, the main energy source is biomass, while coal, petroleum, and electricity serve as the primary commercial energy sources. According to a 2015/16 economic survey, the overall energy consumption has risen to 11.8 million tons of oil equivalent, with an annual growth rate of 3%, as reported by the Ministry of Finance (MOF, 2016). The distribution of energy usage is as follows: approximately 80% of the total energy is utilized in residential sectors, followed by 8% in industrial sectors, 7% in transportation, 3% in commercial activities, and 1% in agriculture, according to the WECS 2013 report. In 2014/15, in commercial sources, approximately 63% of fuel came from petroleum products, 17% by electricity and remaining from coal (Clean Energy Nepal, 2019). According to International Energy Outlook (2013), global energy demand will increase by 56% between 2010 and 2040 (Azad et al., 2014). Electric energy from that source can be helpful to meet demand in the industrial sector. From 2005 onwards, there has been an approximately 50% growth in gross final energy consumption, reaching a yearly total of about 600 petajoules (PJ/a). The primary bulk of energy consumption occurs within the residential sector, while a mere 8% is allocated to industrial use and 11% for transportation purposes. Hence, there exists a potential for growth in the industrial sector that is timely and relevant. It is very essential to know the energy demand scenario in period of time. For that certain trend past data is also

important. So, prediction of future is done on basis of past scenario. The energy demand between 2005 to 2019 shows less energy demand in industrial sector. But there is possibility to create demand in this sector through use of renewable energy supply in this sector. In rural areas, households rely on a variety of resources for energy, including fuelwood, agricultural residues, animal waste, biogas, and other forms of biomass. Conversely, urban regions utilize solar and hydro energy predominantly for cooking and lighting purposes. Within the industrial sector, the primary energy sources consist of coal, fuelwood, diesel, and electricity. These non-renewable sources collectively make up 63% of the energy mix in the industrial sector.

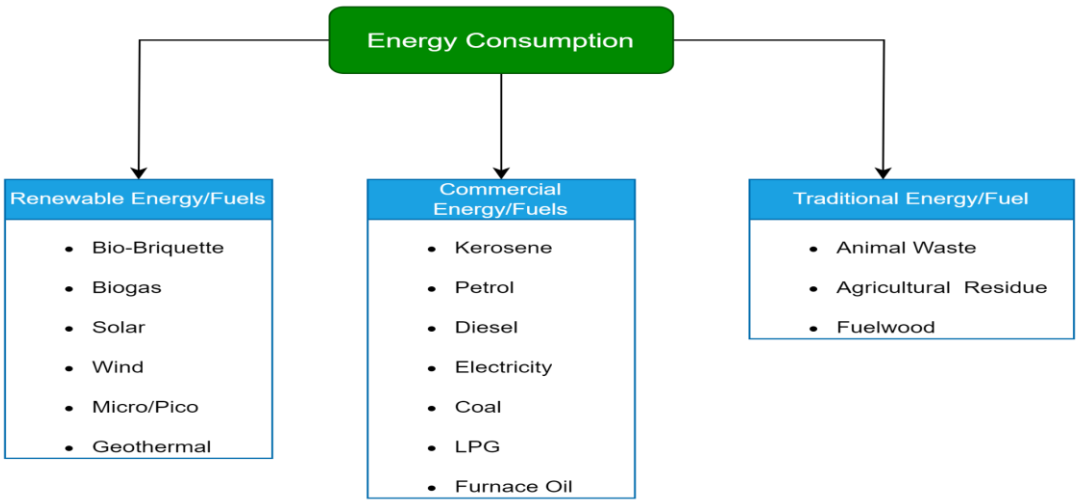

Figure 2.1 Category of energy resource

There are several factors that contribute to the level of energy consumption which are the size of the population, economic activity, technological progress, climate conditions, energy prices etc. The primary objective of energy management is to implementing energy-efficient technologies, promoting behavioral changes, and embracing renewable energy sources. This approach aims to minimize the environmental impact and cut down on costs. The figure 2.2 shows the category of energy demand. It is mainly categorized into traditional, commercial and renewable. Here electricity is categorized into commercial commodity/fuel. Its demand in industrial sector, agricultural and other sector helps to generate income.

According to table 2.1, the energy consumption in the industrial sector from 2019 to 2021 with more consumption of fuelwood. The table below shows the energy consumption in the industrial sector from 2019 to 2021 with more consumption of fuelwood which is about 19,273.78 GJ in 2021 compared to other. The energy

consumption in form of electricity is also about 10162.52 GJ in 2021 compared to 9755.77 GJ in 2019.

Table 2.1: Energy consumption in industrial sector in Nepal

Fuel type	2019	2020	2021
Fuelwood	19,906.9	18,262.8	19,273.8
Agricultural Residue	10,836.8	10,975.5	11,432.1
Kerosene	303.2	218.5	278.1
Petrol	240.7	223.2	231.3
Diesel	14,448.8	9,453.9	14,597.1
LPG	1.7	1.8	2.0
Furnace Oil	1,221.9	373.9	3,399.1
Coal	37,514.2	40,049.6	55,150.2
Electricity	9,755.7	9,193.7	10,163.5
Total	94,229.9	88,752.9	114,527.2

Nepal energy synopsis report, 2022, WECS

According to Sustainable Energy Finance Market Study for Financial Sector in Nepal, IFC the consumption of energy in industrial sub-sector found that Food Beverage and Tobacco consume 28.4% energy which is very high compared to another sector. Electricity consumption in Food Beverage and Tobacco is 1.64% which is large compared to other. Industrial Electrical Engineering Products uses low energy of 0.48%.

2.2 Energy Demand and Consumption in Industry

A significant guide for decision-making, managing, and controlling the demand for the consumption of electricity in the industrial sector could be the price mechanism from the supply side and the productivity of the industries from the demand side (Yevdokimov et al., 2019). In 2009, the industrial sector accounted for roughly 3.5% of the entire national energy consumption. Many manufacturers claimed to be operating at only 30–40% of production capacity during the worst parts of the electricity crisis. These supply issues severely hampered the nation's economic growth (World Bank, 2015). As a result, commerce and industry suffered significant losses. So, it is essential to meet the demand and create the opportunities in industries with optimal solutions.

The consumption of energy in the industrial sector is determined by factors such as the count of industries, the gross value added by manufacturing, and the level of energy intensity. Forecasts of industrial demand are based on the principles of industrial value added and energy intensity. The energy intensity for the industrial sector is determined by calculating the ratio of energy consumption in a specific year to the corresponding value added for that sector in the same year (Bhattarai & Bajracharya, 2016).

Table 2.2: Forecast of energy demand for industrial different sub-sectors

Demand (PJ)	Year /AAGR							Ratio
Sub-sector	2005	2010	2015	2020	2025	2030	2005-2030	2030-2005
Other manufacturing	4.13	4.89	5.87	7.03	8.44	10.13	3.70%	2.5
Food beverage and tobacco	3.59	4.29	5.25	6.53	8.21	10.44	4.40%	2.9
Mechanical engineering	2.05	2.16	2.37	2.66	3.06	3.6	2.30%	1.8
Textile & leather	1.29	1.51	1.8	2.16	2.62	3.21	3.70%	2.5
Chemical, rubber and plastics	0.89	0.9	1.02	1.2	1.45	1.78	2.80%	2
Wood & papers	0.57	0.65	0.75	0.9	1.08	1.32	3.40%	2.3
Electrical engineering products	0.08	0.04	0.03	0.03	0.05	0.06	-1.10%	0.8
Total	12.6	14.4	17.1	20.5	24.9	30.5	3.60%	2.4

Table 2.2 presents the energy demand projections for various industrial sub-sectors under the Business-as-Usual (BAU) scenario. According to research, the growth rate of the food, beverage, and tobacco subsectors will be higher than that of the other subsectors (Bhattarai & Bajracharya, 2016). There is 4.4% increment for 2005-30 demand projection in this sub-field of industrial sector. There is decrement prediction of 1.1% in electrical engineering products sub-sector. In general, energy finds its application in various forms such as lighting, boilers, process heat, motive power, and other uses which are shown in table 2.3.

Table 2.3: Energy consumption in industrial sector (technology wise)

Industry	Lighting	Boiler	Process heat	Motive power	Other	Total
Food Beverage and Tobacco	0.03	12.35	9.51	2.78	4.18	28.85
Textile and Leather Goods	0.05	3.50	0.95	1.48	0.24	6.22
Chemical Rubber and Plastic	0.02	1.24	3.59	2.65	0.24	7.74
Mechanical Engineering and Manufacturing	0.01	0.00	4.44	2.56	3.99	11.00
Electrical Engineering Products	0.01	0.06	0.04	0.29	0.04	0.43
Wood Products and Paper	0.09	4.08	0.07	1.04	0.43	5.70
Bricks & Structural Clay Products	0.01	1.58	15.24	3.57	2.00	22.40
Cement and Non-metallic Products	0.02	0.02	12.75	2.31	0.63	15.73
Other Manufacturing	0.01	0.84	0.39	0.31	0.38	1.93
Total	0.24	23.67	46.98	16.99	12.13	100.00

2.3 Electricity generation

The current status of electricity generation of Nepal which includes IPPs, NEA and its subsidiaries is about 2130 MW and there are hydropower plants under construction which have a total generation capacity of 3260 MW. In 2022, Nepal's total electricity generation is 11064 GWh where 3259 GWh is generated by NEA, 1976 GWh purchased from subsidiaries, 4286 GWh purchased from IPPs (Independent Power Producers), and 1543 GWh imported from India.

In Nepal, the total sales of electricity were 9,316 GWh in 2022. In 2022, total installed capacity in Nepal is adequate to provide electricity at peak load. There is significant growth in consumers over years. It also includes the industrial sector. So, there is demand of electricity in industrial sector.

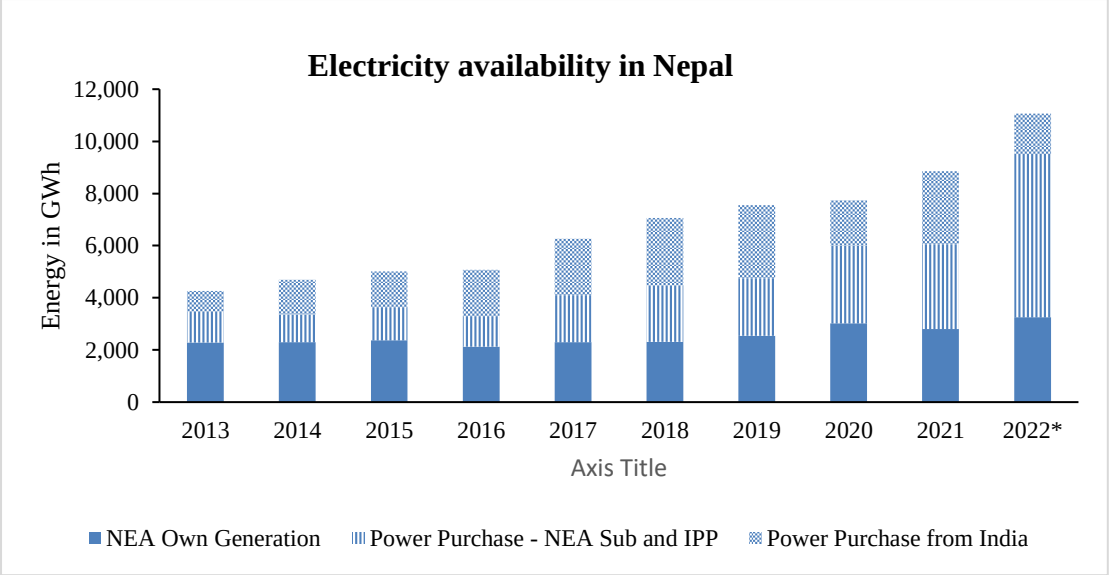

Figure 2. 2 Energy Availability Status

2.4 Electricity consumption scenario

According to a NEA report, electricity consumption in Nepal is 9.3 TWh in 2022. In the past 30 Years from 1990 to 2022 total electricity consumption has increased from 0.7 TWh to 9.3 TWh which is in large proportion.

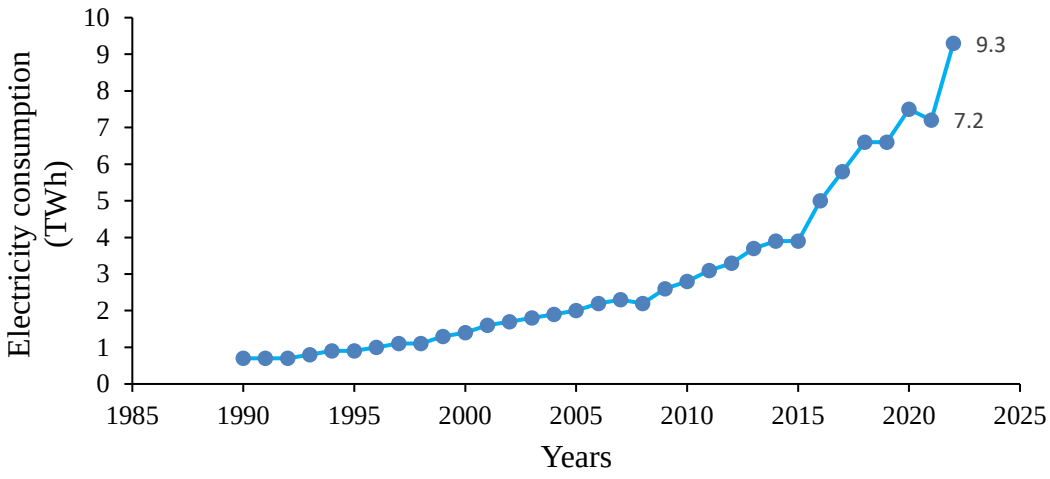

Figure 2. 3 Electricity consumption status in past years

It is also found that electricity consumption per capita is 304 kWh in 2022. According the report of energy synopsis 2022, the residential sector accounted for the highest consumption at 44.24% of electricity consumption, followed by the industrial sector at 38.54%, and the commercial sector at 14.41%.

Electricity consumption has expanded far faster than total energy demand. Annual energy demand was close to 6.5 billion kilowatt-hours (6.5 TWh/a) in 2019, up from 2 TWh/a in 2005 a factor of almost three. The residential sector increased the fastest once again, followed by the industrial sector. So, this shows electricity demand creation in industrial sector. Some of countries with use of electricity with respect to total energy consumption of the world is given below (World Energy & Climate Statistic Yearbook, 2022):

Table 2.4: Electricity consumption in world

S.N.	Country	Consumption (%)
1.	USA	21.7
2.	India	18.2
3.	China	27
4.	Japan	26.6
5.	Russia	12.4

It is found that there is increasing trend of electricity demand. This is from 2014 to 2030 where energy demand is increased in form of electricity.

The demand has risen from 2000MW to 10000 MW in 2030 during its peak hour. So, this demand also includes industrial sector where it is high demand for operation of machineries component which run through electricity. According to the study entitled "Energy Demand Projection 2030", it is found that an increase in GDP has a direct impact on electricity demand. This study also projected the share of electricity consumption in different economic sector is shown in Annex. The projection is done at 5%, 7% and 10% of low, medium and high growth rate for year 2025 and 2030. It is seen that construction mining and manufacturing will have 30%, 34% and 40% in low, medium and high growth at 2025 which will increase to 32%, 37% and 46% in low, medium and high growth at 2030.

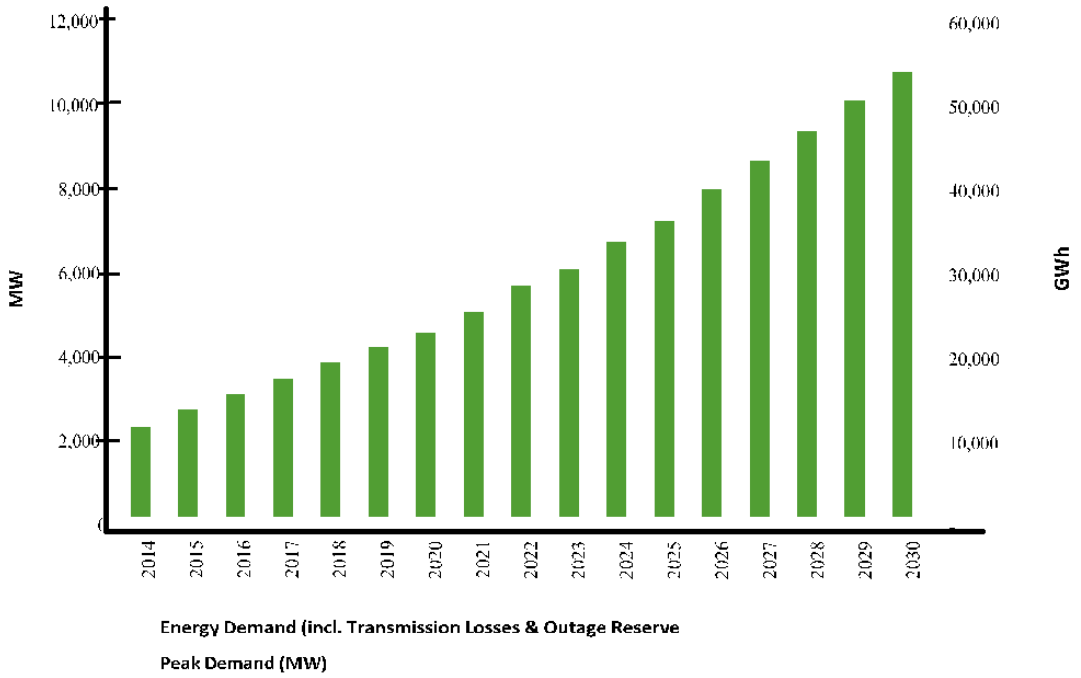

Figure 2. 4 Electricity demand of Nepal till 2030 (IBN,2011)

2.5 Electricity consumption with different consumer's category in Nepal.

Table 2.5 shows the electricity consumption in Nepal with different categories. In industrial consumer's category, there is an increasing trend in electricity consumption.

Table 2.5 Electricity consumption with different consumer's category in Nepal.

Consumer's category with electricity consumption (GWh)/years	2019	2020	2021	2022
Domestic	2,666	2,852	3,138	3,730
Non commercial	186	190	204	260
Commercial	466	487	511	656
Industrial	2,422	2,301	2,816	3,448
Water supply & irrigation	176	182	211	242
Street light	79	84	88	98
Temporary supply	3	3	4	4
Transport	5	3	2	4
Temple	8	8	8	11
Non domestic	148	151	116	187
Entertainment	6	5	4	8

2.6 Electricity tariff

The electricity infrastructure has considerable development in the recent years in context of our country. With high generation, there arises the challenge for effective demand creation within the country. So, Government of Nepal has directed the Nepal Electricity to come up with the affordable tariff rates so there is increase in the demand from the areas like residential, industrial and commercial sectors. To meet the optimum electricity demand, Electricity Regulatory Commission has been running many strategies in Nepal. In case of residential, charges are reduced to encourage the use of electric appliances for purposes like cooking, heating, etc. It started to incentivize the farmer by decreasing the tariff rate for the irrigation purposes. There is a program for encouraging the industrial sector to be flourished by stopping the increase of demand charges for electricity. The electricity consumer status in Nepal over a period of time is given in the following table;

Table 2.6: Consumer over years

Years	2017	2018	2019	2020	2021	2022*
Consumers (million)	3.25	3.57	3.91	4.21	4.52	4.76
Growth	10%	10%	9%	8%	7%	5%

According to the Electricity Tariff Collection Regulation, 2078, following are the tariffs rate prevailing in Nepal as: In consumer level,

- Single phase low voltage (230V)

Table 2.7: Tariff rate of different current

kWh (Monthly)	5 Ampere		15 Ampere		30 Ampere		60 Ampere	
	Monthly Min. Charge (NRs.)	Energy Charge Per unit (NRs.)	Monthly Min. Charge (NRs.)	Energy Charge Per unit (NRs.)	Monthly Min. Charge (NRs.)	Energy Charge Per unit (NRs.)	Monthly Min. Charge (NRs.)	Energy Charge Per unit (NRs.)
0 – 20	30	0	50	4|00	75	5|00	125	6|50
21 – 30	50	6|50	75	6|50	100	6|50	125	6|50

31 – 50	50	8|00	75	8|00	100	8|00	125	8|50
51 – 100	75	9|50	100	9|50	125	9|50	150	9|50
101 – 250	100	9|50	125	9|50	150	9|50	200	9|50
More than 250	150	11|00	175	11|00	200	11|00	250	11|00

- Three phase low voltage (400V)

Table 2.8: Tariff rate of three phase (400 V)

kWh (Monthly)	Up to 10 kV			Above 10 kV		
	Monthly Min. rate (NRs.)	Energy rate per Unit (kWh)		Monthly Min. rate (NRs.)	Energy rate per Unit (kWh)	
		Asadh-Kartik	Mangsir-Jestha		Asadh-Kartik	Mangsir-Jestha
For any consumption	1,100|00	10|50	11|50	1,800|00	10|50	11|50

- Three phase mid voltage (33/11 kV)

Table 2.9: Tariff rate of three phase (33/11 kV)

kWh (Monthly)	Monthly Min. rate (NRs.)	Energy rate per Unit	
		Asadh - Kartik	Mangsir-Jestha
For any consumption	10,000|00	10|50	11|00

For industrial consumer,

Table 2.10: Tariff Rate for various industry

S.N.	Voltage level	Demand rate (NRs. per kVA per month)	Energy rate (NRs. per Unit)
	Low voltage (230/400 V)		

1.	a. Rural and domestic industry	60|00	7|80
	b. Small industry	110|00	9|60
2.	Mid voltage		
	a. 11 kV	255|00	8|60
	b. 33 kV	255|00	8|40
3.	High Voltage		
	a. 66 kV	240|00	8|30
	b. 132 kV	230|00	8|20

2.7 Categories of industries, technology use and electricity consumption

The industrial sector of Nepal has been categorized into the subsequent seven sub-sectors, (NSIC).

- Cement, bricks, concrete & clay products
- Chemical products, rubber, glass & plastics Products
- Electrical & electronic products
- Food, beverage & tobacco Products
- Mechanical engineering, iron, steel, machineries, & other metal Products
- Paper, publication & printing, furniture & fixtures Products
- Textiles, readymade garment & leather products
- Miscellaneous Products

Each of the industrial sub-sectors comprises five distinct end uses which

- Process heat
- Motive power
- Boiler
- Lighting and
- Others

Boiler is in demand for most of the energy. Therefore, coal and wood are heavily consumed in the sector (Bhattarai et.al, 2014). To obtain a sustainable goal and mitigate climate change, it is necessary to switch to an electrical medium. Some of industries with their electrical equipment is given below:

Table 2.11: Industries with Electrical Equipment

Industries Type	Electrical Equipment
Clinker Based Cement Industry	Conveyor, Material Handling Equipment, Crusher Mill, Air Compressors, Dust Collector, Ball Mill, Cement Mill, Waste Heat Recovery System, Packing Machine
Non-Clinker Based Cement Industry	Air Compressor, Dust Collector, Material Handling Equipment, Ball Mill, Packing Machine
Brewery	Mash Converter, Lauter Tun, Pre-run Vessel, Wort Kettle, Whirl Pool, Wet Mill, Plate Cooler, Washer, Filler, Crowner, Pasteurizer, Labeler, Air Compressor, Boiler, CO2 Recovery Plant, Refrigerators, Wastewater Treatment Plant
Rolling Mills	Rolling Mill (Multi Phase), Thermo-Mechanically Treated Iron Bar Producing Machine, Cutting Machine, Furnace
Tea	Dryer, Sorting Machine, Conveyor, Boiler/Furnace, Weathering Fan, Rollers/CTC Machine
Steel structure	Furnace, Galvanized Iron Plant, Compressor, Slitting, Tube Mills, Blowers, Welding Mill
Paper & Pulp	Digester, Evaporator, Washing & Screening, Bleaching, Soda Recovery, Stock Preparation, Paper Machine, De-aerator, Chipper
Plastic	Injector, Molder, Compressor, Cooling Tower, Water Pump, Extruder
Cold Storage	Cooling Tower, Receiver, Water Pump, Kiln, Excavators, Molder, Generator, Pug Mill, Compressor

So, there is opportunity for switching the traditional equipment into electrical ones. This is average electricity consumption to meet demand in various industries in 2021.

Table 2.12: Electric Consumption by Industries

Types of industry	Electricity Consumption
Electric arc furnaces	up to 100 MW
Cement Kilns	up to 55 MW
Paper mills	up to 30 MW
Urea plants	up to 350 MW
Metal working shops	up to 10 MW

2.7 Policy review

2.7.1 Sustainable development goal

According to the Sustainable Development Goals (SDGs), Status and Roadmap: 2016-2030 report, Nepal has the opportunity to meet its energy needs through clean hydroelectricity which will help to provide consumer goods at affordable prices, improve the competitiveness of Nepali enterprises, and allow the country to switch to clean energy. During this period, Nepal has established the objective of moving up from the least developed countries to the medium developed countries, aiming for rapid economic growth of over seven percent over a period of a decade. Sustainable Development Goal (SGD) 9*:* Build resilient, infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Target: By 2030,

- To promote inclusive and sustainable industrialization
- To increase the share of industry to 25%

The following electricity generation plan were suggested by Energy Sector Vision 2050 AD:

- 11500 MW in 2030
- 31000 MW in 2050

2.7.2 Industrial policy (2011)

- Provisions for industries to use environment-friendly and energy-efficient technologies and providing technical, and financial support also provide incentives.

- Provision for No or lower tax for Industry using completely electricity as fuel.
- Procedure for auditing and documenting the energy intensity of industries.

2.7.3 The fifteenth plan (Fiscal year 2019/20-2023/24)

- Provide support and assistance towards the development of infrastructure and promotion of industries based on domestic raw materials including cement, sugar, footwear, medicine, juice, dairy, tea, cashmere, handicrafts
- Connection of industry with agriculture, tourism, education, health, and other sectors
- Establishment of industrial estates in all provinces in line with the policy of establishing at least one modern industrial estate in every province
- The establishment of environment-friendly and agriculture-based industries will be emphasized.

By 2050, electric boilers in food beverage and tobacco, textile and leather and chemical rubber and plastic will share 100%. Similarly motive power electrification in industry is also targeted to 100% electrification.

2.8 Scenario classification

Here various scenario analysis like baseline, medium growth, high growth and policy (electrification) scenario are studied and they are explained below

2.8.1 Baseline scenario

In this context, there exist two distinct categories of factors: independent variables, often referred to as exogenous variables, and dependent variables, also known as endogenous variables. Within the group of independent variables are policy-related factors and other external variables. In constructing this model, a significant portion of policy variables are estimated through trend analysis, while the remaining policy variables are established based on logically sound assumptions that hold economic validity. Additionally, certain external factors like EXGRATE1, POP1, ATCA1, and INDCP11 are presumed to follow their existing trajectory, thus they are projected utilizing the same trend analysis approach. The annual growth rate of FXGS is forecasted through a combination of informed judgment, incorporating economic rationale and historical patterns.

2.8.2 Medium growth rate scenario

It is postulated that the nation's economic situation will gradually ameliorate in the forthcoming period. Following a prolonged period of Maoist conflict and political turmoil, the country has managed to establish stability and initiate developmental endeavors with the overarching vision of "Prosperous Nepal and Happy Nepali." The government has taken steps to boost the industrial and agricultural sectors by motivating and engaging both domestic citizens and overseas returnees through economic incentives and skill enhancement programs. The significant achievement of the National Electricity Authority (NEA) in achieving a zero-load shedding program, coupled with the rapid expansion of the transmission grid, has opened avenues for the establishment of new industries and foreign investments. Consequently, there is an anticipation of growth in both the agricultural and industrial domains. In an effort to alleviate the foreign trade deficit, the government is actively pursuing policies that promote exports and encourage the substitution of imports, aiming to increase the export of goods and gradually curtail imports. As a result, investments in these broad sectors are predicted to be externally determined. Variables such as ATCA1 and ACMFERT1 are projected to experience growth, along with an anticipated rise in FXGS.

2.8.3 High growth rate scenario

In this context, it is postulated that all policy-associated external variables, namely CDIAG1, CDIIND1, and CDISERV1, are externally estimated to experience a notable increase. This strategic elevation is aimed at attaining more substantial growth rates for both individual sectors as well as the overall GDP growth. After undergoing nearly two decades of political upheavals and transformations, the country has eventually achieved political stability following an extended phase of economic decline. Looking forward, the nation is confronted with the necessity of achieving heightened economic growth to counterbalance the economic setbacks incurred during this extended period and to regain its normal growth trajectory.

2.8.4 Policy scenario

In this scenario, the analysis takes into account a range of policies and set objectives. Industrial sector comprises boilers, motive power and process heat for electrification. y the year 2050, electric boilers are expected to account for 100% of the energy usage

in sectors such as food and beverage, textile and leather, and chemical rubber and plastic. Similarly motive power electrification in industry is also targeted to 100% electrification. The premises align with a range of officially published reports and materials from Nepalese government bodies, as well as international entities such as the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the Paris Agreement, and the United Nations' Sustainable Development Goals (SDGs) initiatives.

CHAPTER THREE: METHODOLOGY

3.1 General methodology

The flowchart given below shows the general methodology of this research.

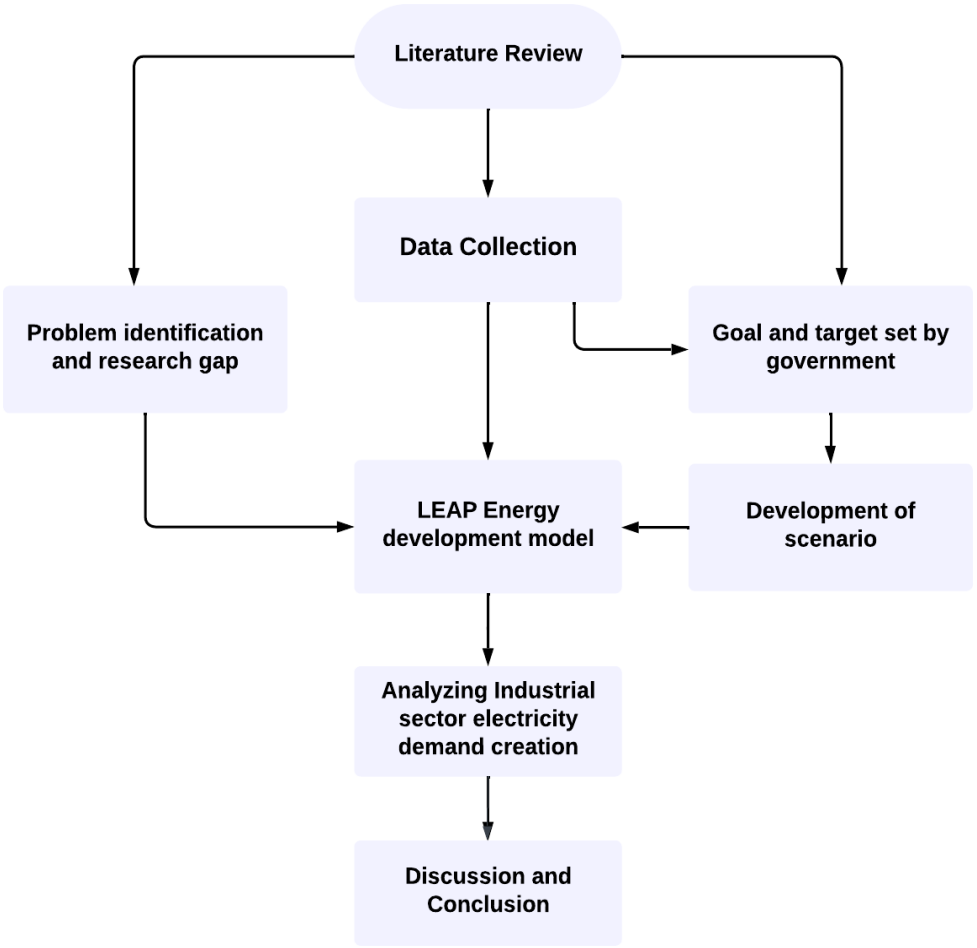

Figure 3. 1 Flowchart of the research

3.2 Data collection

Since the electricity consumption pattern of all provinces of Nepal are to be found out, the report from different governmental organizations were used as reference. Due to governmental policies, the data from the actual office is difficult to procure. So, the published report in their organization's official website is taken as the source of the data. Mainly reports like fiscal report, yearbook, etc., from the government organization like NEA, WECS, other NGOs and INGOs.

The gathered data and information are outlined as follows

- Information on all province's industrial status.
- Industrial sector electricity consumption status of all province individually.
- Industrial sector electricity consumption status of Nepal.
- National and provincial GVA value, IVA Value, and GDP growth rate.
- Future vision or plan regarding the electricity demand and supply in the industry sector.

3.3 Modelling

The model used for the analysis of industrial electrical status is Low - Emission Analysis Platform (LEAP) System. This method adopts an approach driven by both end use and demand, commencing the analysis from the perspective of energy consumption. The demand aspect is subdivided into various hierarchical levels, encompassing sectors, sub-sectors, end uses, and specific devices. This model serves as a simulation tool that portrays the current energy landscape within a selected region and predicts forthcoming energy demand based on specific assumptions such as population growth and GDP trends.

Initially, the model constructs the current energy system's status by utilizing data from a base year, and a fundamental scenario is formulated under the presumption of the perpetuation of existing trends. Widely employed as a versatile integrated modeling tool, it spans across diverse economic sectors, delineating energy production, consumption, and resource extraction. This tool also extends its application beyond energy, branching into areas such as non-energy sectors, greenhouse gas emissions, and the sources and sinks of such emissions. Its extensive use encompasses the analysis of air pollutants' effects on local and regional environments, contributing to climate research.

As a result of its straightforward and uncomplicated application for handling intricate energy analysis principles, this model has gained increasing popularity and has become more accessible to users over time. It caters to a diverse range of expertise levels, from global specialists to decision-makers, all of whom seek to present their findings in a more comprehensible and user-friendly manner.

3.4 Scenario assumption

In scenario development, different scenario with Low Growth Rate, Medium Growth Rate, and High Growth Rate for the possible future energy demand with different types of fuel have been considered. These growth rates are taken with the reference of relevant documents, past growth rate in industrial sector and report of Nepal governmental organs. Present energy consumption scenario, end use technology efficiency, technology and economic growth are major parameters. These parameters are provided as input to LEAP which results as the projection of demand in different sub-sector of industry.

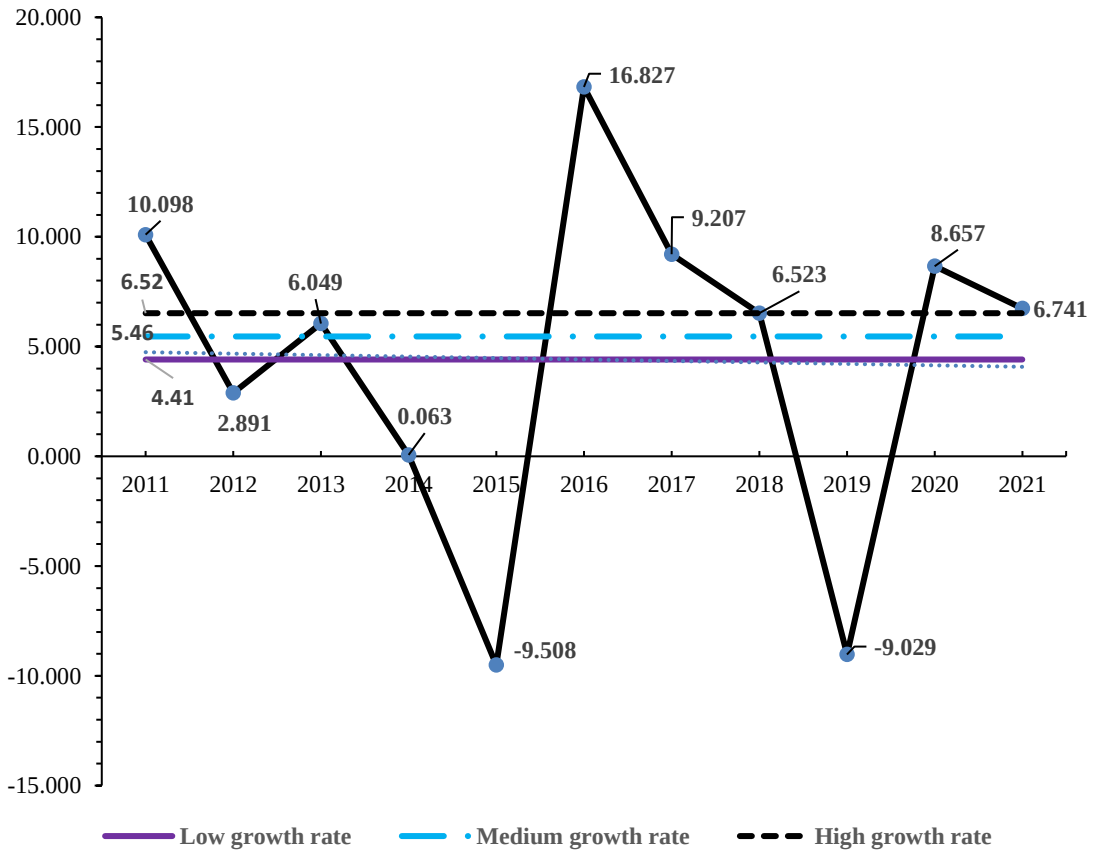

Figure 3. 2 LG, MG and HG assumption from past year growth rate (manufacturing)

3.4.1 High growth rate

For High growth rate, 6.52 % has been considered. The 6.52 % growth rate taken by observing growth rate in (manufacturing value) 2013, 2017 and 2021 respectively.

3.4.2 Low growth rate

For Low growth rate, 4.41% has been considered. The 4.41 % growth rate taken by averaging growth rate (Manufacturing) within last decade i.e., 2011 to 2021.

3.4.3 Medium growth rate

For Medium growth rate, 5.46 % has been considered. The 5.46 % growth rate taken by averaging low growth rate and high growth rate.

Table 3.1: IVA Growth Consideration

Growth rate/ Year	2022	2025	2030	2035	2040	2045	2050
Low growth	4.46%	4.53%	4.64%	4.76%	4.29%	3.82%	3.36%
Medium growth	5.52%	5.61%	5.75%	5.90%	5.31%	4.73%	4.15%
High growth	6.59%	6.69%	6.87%	7.04%	6.35%	5.65%	4.96%

In the table 3.1, it is seen decreasing trend of GPD after 2035 which is on increasing trend before. The main sector that is going to be focused is industrial sector with GDP as driving factor in various industrial subsector.

3.4.4 Driving Factor

Table 3.2: Driving Factors

Type of Industries *(As per NSIC)*	Driving Factor
Cement, bricks, concrete & clay products	GDP
Chemical products, rubber, glass & plastics Products	
Electrical & electronic products	
Mechanical engineering, iron, steel, machineries, & other metal Products	
Food, beverage & tobacco Products	
Paper, publication & printing, furniture & fixtures Products	
Textiles, readymade garment & leather products	
Miscellaneous Products	

Here eight industrial sub-sectors are taken in account with GDP as main driving factor in all sub-sector.

3.4.5 Business as Usual scenario

This scenario is based without technological intervention, policy change. In this case normal circumstance is assumed to be unchanged over a period of time with no significant change in people's attitude. Due to the fluctuating nature of GDP, various growth rate is taken in account to meet electricity demand and supply.

3.4.6 Policy scenario

This scenario is based on technological intervention, policy change. In this case normal circumstance is changed over a period of time with significant change in people's attitude. The industrial electrification scenario considers a range of information sources: 15th plan, Sustainable Development Goal (SDG) and Nationally Determined Contribution (NDC) all developed by the government. These provides essential insights and directives for predicting electricity needs, shaping the assumptions made about electricity adoption in the industrial electrification scenario. Based on Combined Policy Scenario for Technology Intervention there are certain possible cases which could be obtained after given below.

Table 3.3: Policy Scenario Intervention

Subsector	End Use	Consideration	Target Year
Food Beverage and Tobacco	Boiler	100% Electric	2050
	Motive power		2030
	Other		2030
Textile and Leather	Boiler	100% Electric	2050
	Motive power		2030
	Other		2030
Chemical Rubber and Plastic	Boiler	100% Electric	2050
	Motive power		2030
	Other		2030
Wood Products and Paper	Boiler	100% Electric	2050
	Motive power		2030
	Other		2030
Mechanical Engineering and Manufacturing	Boiler	100% Electric	2050
	Motive power		2050
	Other		2050

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Cement, bricks, concrete & clay products manufacturing

4.1.1 Business as usual scenario

The figure 4.1 and table in annex I (3) presents the projected electricity demand for the Cement, Bricks, Concrete, and Clay Products manufacturing industries under different growth rate for Business-as-Usual scenario from the base year up to 2050.

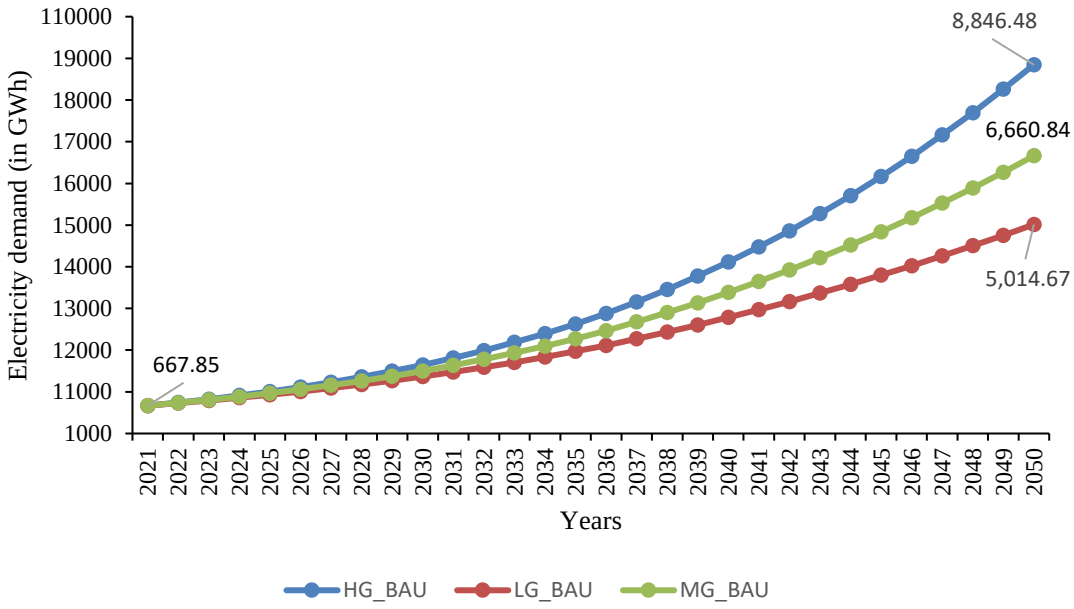

Figure 4. 1 BAU Scenario of cement, bricks, concrete & clay products manufacturing

For the High growth rate scenario, the total electricity demand in this category is expected to increase from 667.85 GWh to 8,846.48 GWh by 2050. Under the Medium Growth ate scenario, the total electricity demand in this sector is predicted to rise from 667.85 GWh to 6,660.84 GWh by 2050. Finally, the Low growth rate scenario anticipates the total electricity demand in this category to grow from 667.85 GWh to 5,014.67 GWh by 2050.

4.1.2 Policy Scenario

The figure 4.2 and table in annex I (4) illustrates the projected electricity requirements for the cement, bricks, concrete, and clay products manufacturing sectors across various growth rate for policy scenario until 2050.

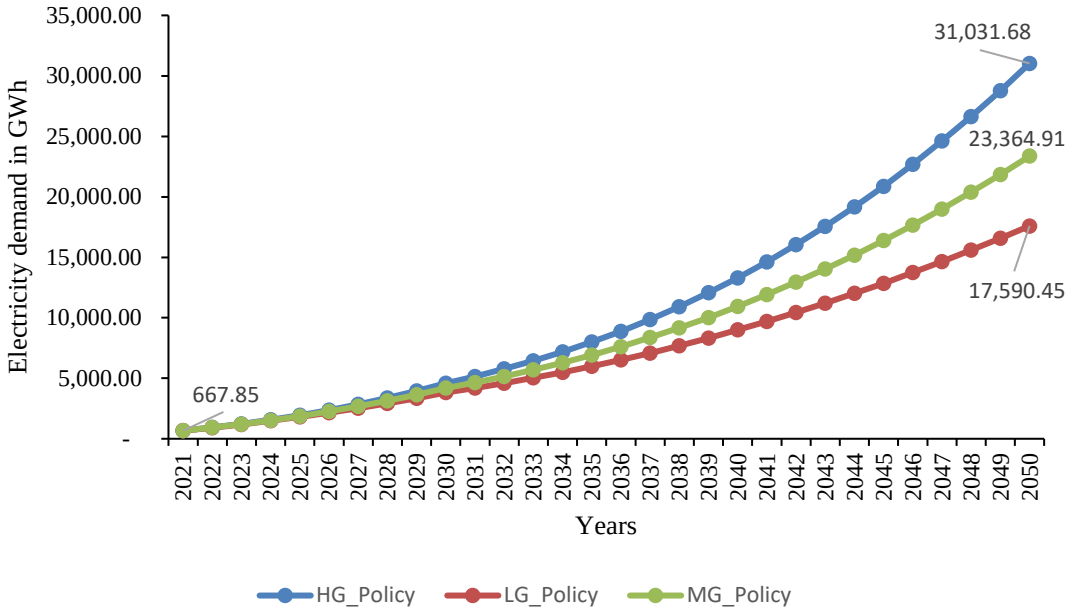

Figure 4. 2 Policy scenario of cement, bricks, concrete & clay products manufacturing

In the High Growth Rate scenario, the total electricity demand for this category is expected to experience substantial growth, starting at 666.85 GWh in the base year and reaching 31,031.68 GWh by 2050. The Medium Growth Rate scenario predicts a gradual increase in electricity demand, with levels rising from 666.85 GWh to 23,364.91 GWh by 2050. Lastly, the Low Growth Rate scenario foresees a more conservative growth in electricity demand, starting at 666.85 GWh and reaching 17,590.45 GWh by 2050.

4.1.3 Comparison between BAU and policy scenario

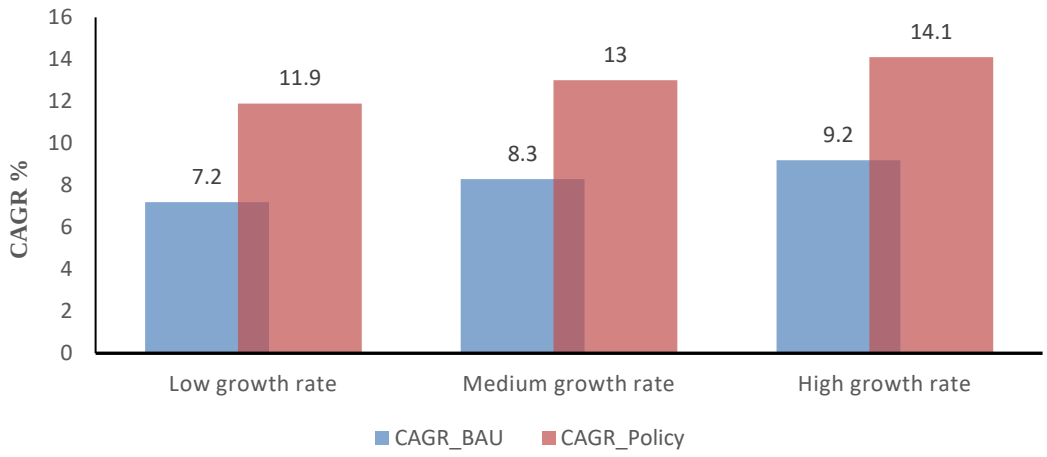

Figure 4. 3 CAGR of BAU and policy scenario of cement, concrete, and clay products

The figure 4.3 provides the comparison of CAGR between BAU and policy scenario for the cement, bricks, concrete, and clay products manufacturing industries under different growth rate until 2050. In cement, bricks, concrete, and clay products manufacturing sectors it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth are 22,185.2 GWh, 16,704.07 GWh and 12,575.78 GWh in 2050 respectively.

This is due to increment of about 5% CAGR in policy scenario compared to BAU scenario where fuel trend is only considered in BAU scenario where in policy scenario, there is need of technological intervention possible through electrification where is demand more.

4.2 Chemical products, rubber, glass & plastics manufacturing

4.2.1 Business as usual scenario

The figure 4.4 and table in Annex I (5) provides an overview of the projected electricity demands for the chemical products, rubber, glass & plastics manufacturing industries under different growth rate for BAU scenario until 2050.

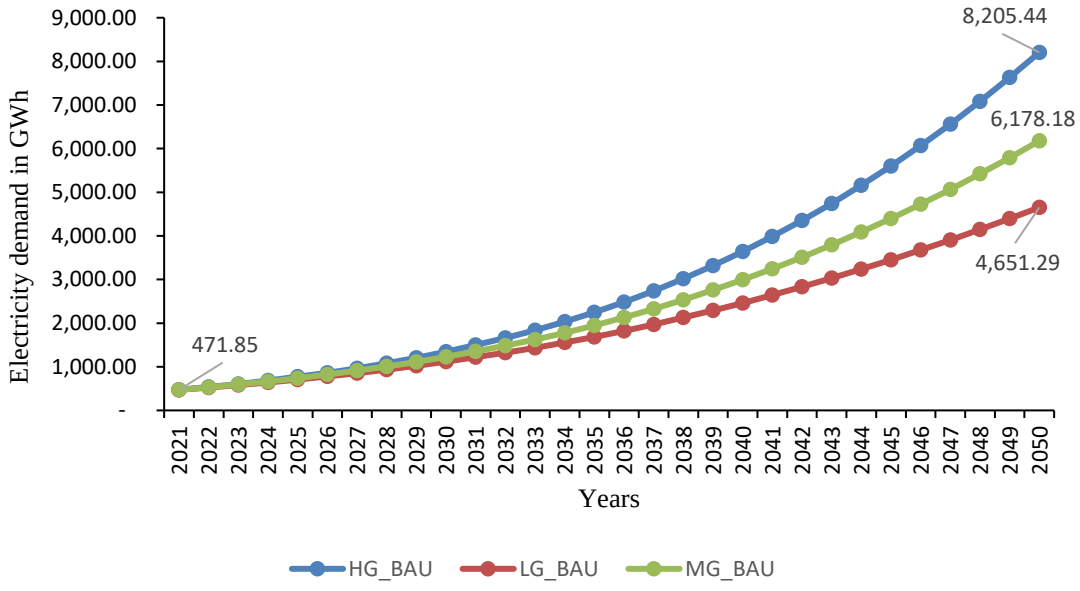

Figure 4. 4 BAU scenario for chemical products, rubber and plastics manufacturing

In the High growth rate scenario, this category is expected to undergo significant expansion, starting at 471.85 GWh in the base year and rising to 8,205.44 GWh by

2050. The medium growth rate scenario forecasts a more gradual increase in electricity demand, beginning at 471.85 GWh and reaching 6,178.18 GWh by 2050. Conversely, the low growth rate scenario predicts a conservative growth in electricity demand, starting at 471.85 GWh and reaching 4,651.29 GWh by 2050.

4.2.2 Policy scenario

The figure 4.5 and table included in the Annex I (6) present a comprehensive overview of the projected electricity requirements across various growth rates in the policy scenario until 2050.

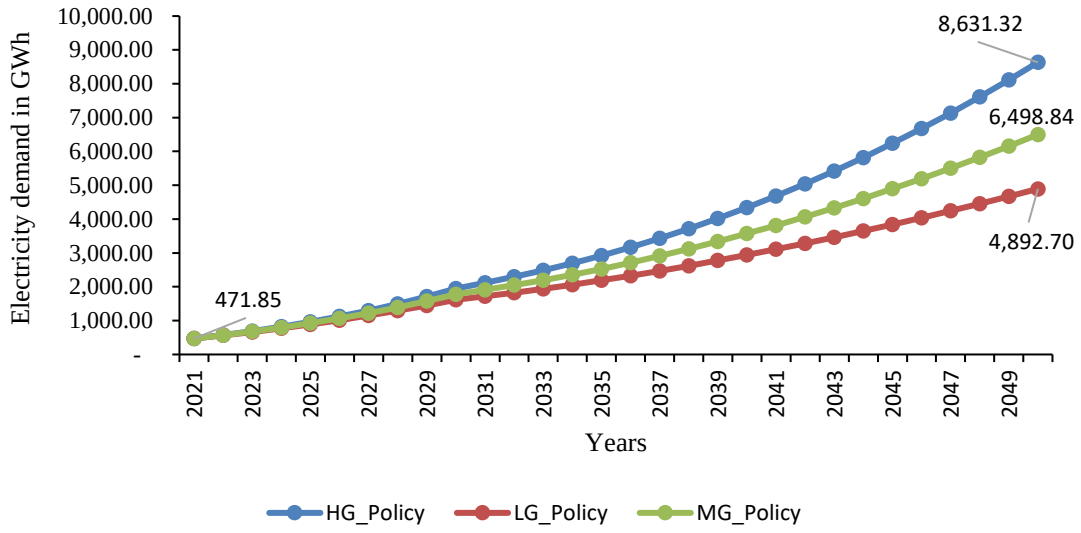

Figure 4. 5 Policy scenario for chemical products, rubber and plastics manufacturing

In the high growth rate, policy scenario of chemical products, rubber, glass and plastics manufacturing category of industries is expected to experience substantial expansion, commencing at 471.85 GWh in the base year and progressively increasing to 8,631.32 GWh by 2050. The medium growth rate scenario foresees a gradual rise in electricity demand, starting at 471.85 GWh and reaching to 6,498.84 GWh by 2050. Conversely, the low growth rate scenario anticipates a conservative growth in electricity demand, initiating at 471.85 GWh and reaching to 4,892.70 GWh by 2050.

4.2.3 Comparison between BAU and policy scenario

The figure 4.6 provides the CAGR comparison between BAU and policy scenario for the chemical products, rubber, glass & plastics manufacturing industries under different growth rate until 2050.

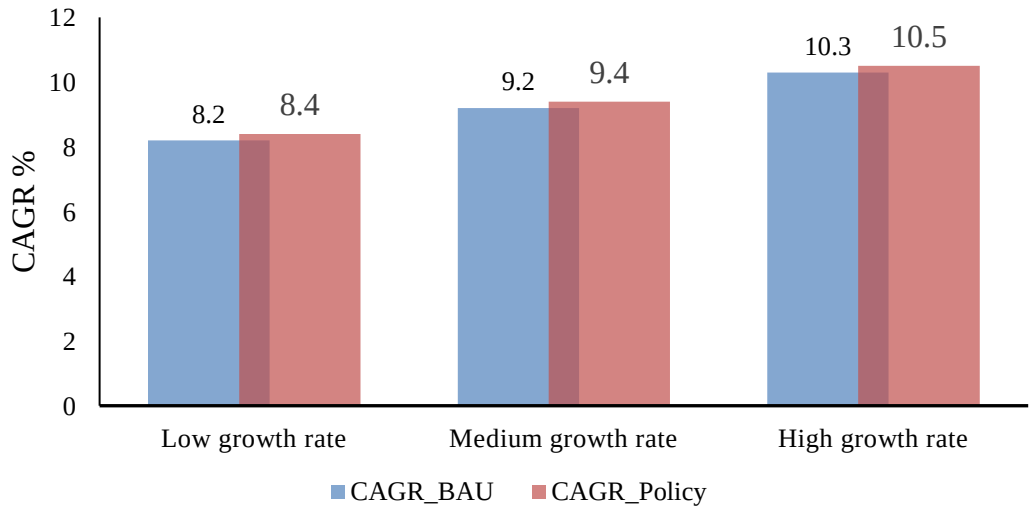

Figure 4. 6 BAU and Policy comparison of chemical and plastics manufacturing

In chemical products, rubber, glass & plastics manufacturing it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth in 2050 are 425.88 GWh, 320.66 GWh and 241.41 GWh respectively. This is due to increment of about 0.2% CAGR in Policy compared to BAU where fuel trend is only considered in BAU scenario where in policy scenario there is need of technological intervention possible through electrification where is demand more.

4.3 Electrical & electronic products manufacturing

4.3.1 Business as usual scenario

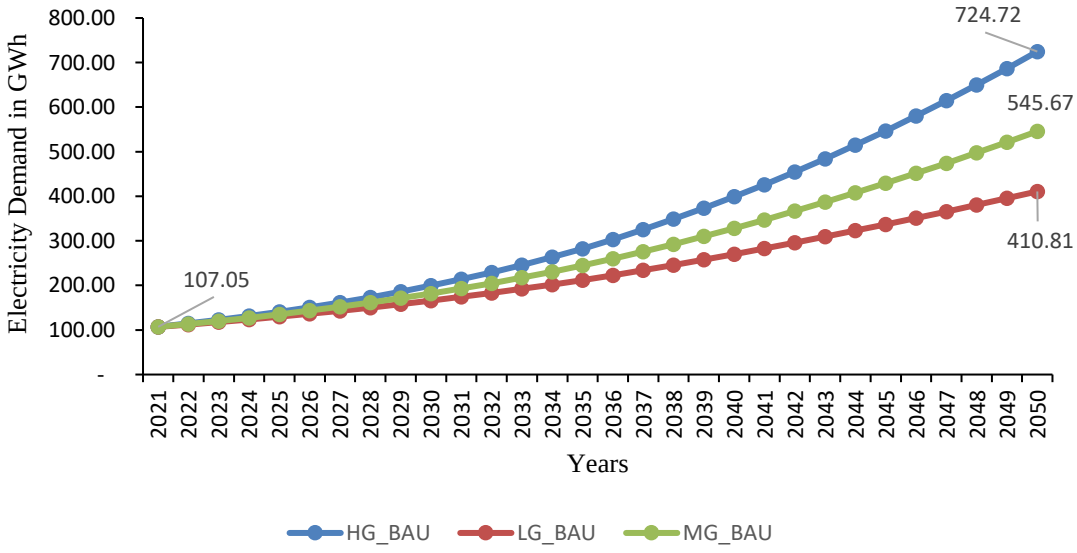

Figure 4. 7 BAU scenario of electrical & electronic products manufacturing

4.3.2 Policy scenario

The figure 4.8 and table in the Annex I (8) provide a comprehensive summary of the projected electricity requirements for the electrical and electronic products manufacturing sectors under different growth rates in the Policy scenario until 2050.

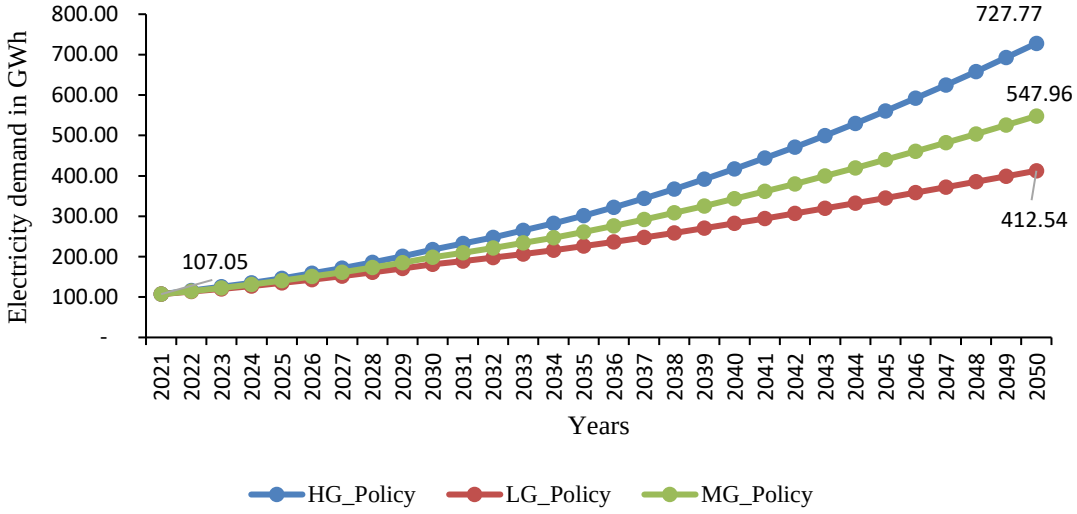

Figure 4. 8 Policy scenario of electrical & electronic products manufacturing

In the high growth rate scenario, this industry segment is expected to experience significant expansion, beginning at 107.05 GWh in the base year and gradually increasing to 727.77 GWh by 2050. The medium growth rate scenario foresees a more gradual rise in electricity demand, starting at 107.05 GWh and reaching 547.96 GWh by 2050. Conversely, the low growth rate scenario envisions a conservative growth in electricity demand, starting at 107.05 GWh and reaching 412.54 GWh by 2050.

4.3.3 Comparison between BAU and policy scenario

The figure 4.9 provides the comparison of CAGR between BAU and policy scenario for the scenario of electrical & electronic products manufacturing industries under different growth rate until 2050. In electrical & electronic products manufacturing industry it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, low and medium growth are 3.05 GWh, 2.3 GWh and 1.73 GWh in 2050 respectively.

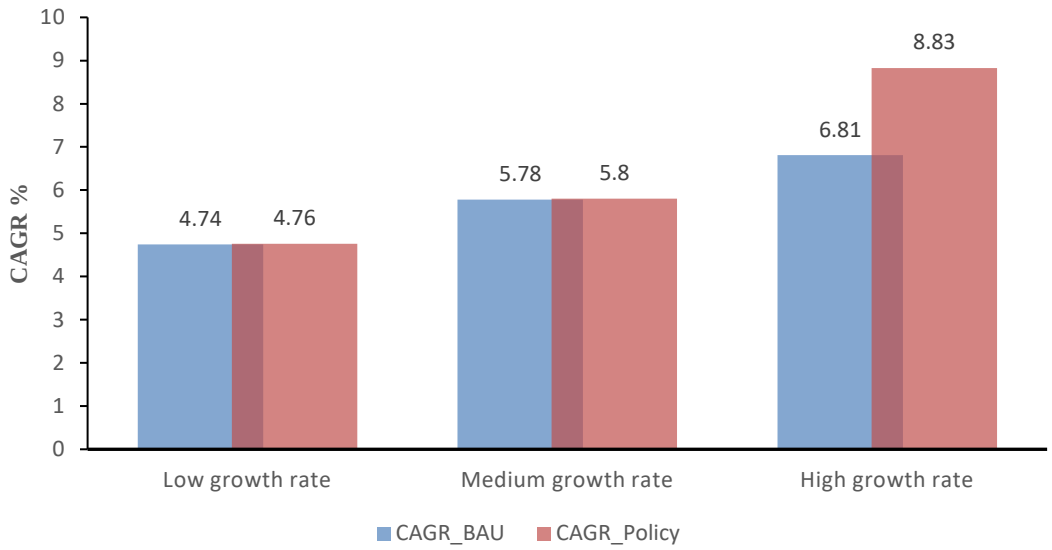

Figure 4. 9 CAGR comparison between BAU and policy scenario

This is due to increment of about 0.02% CAGR in Policy compared to BAU where fuel trend is only considered in BAU where in policy there is need of technological intervention possible through electrification where is demand more.

4.4 Food, beverage & tobacco Manufacturing:

4.4.1 Business as usual scenario

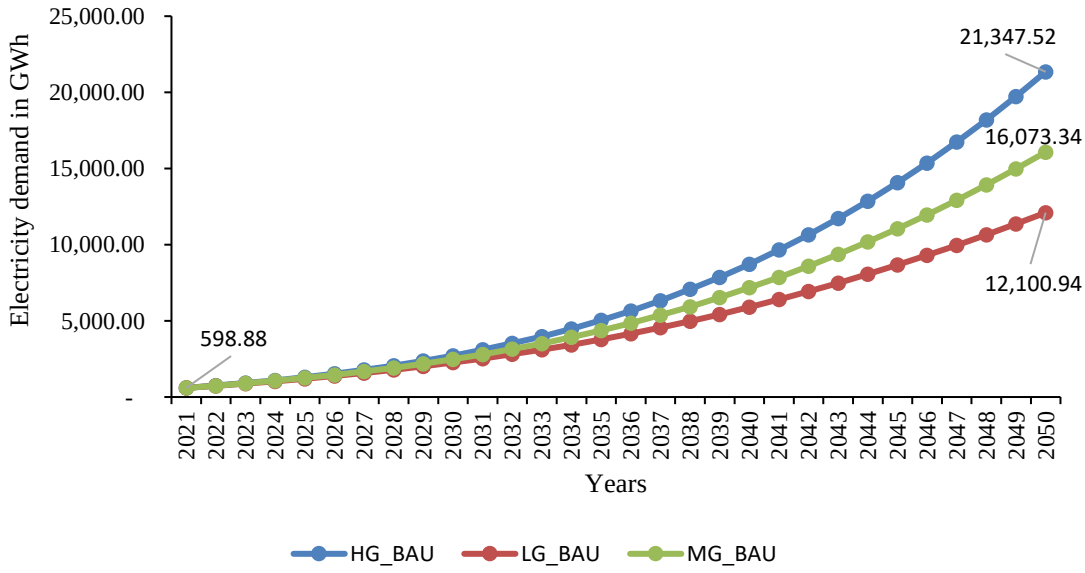

Figure 4. 10 BAU scenario of food, beverage and tobacco manufacturing

The figure 4.10 and table in the Annex I (9) provides a summary of the projected electricity requirements for the food, beverage and tobacco manufacturing industry sectors under different growth rates in the BAU scenario until 2050.

In the high growth rate scenario, this industry segment is expected to experience significant expansion, beginning at 598.88 GWh in the base year and gradually increasing to 21,347.52 GWh by 2050. The medium growth rate scenario foresees a more gradual rise in electricity demand, starting at 598.88 GWh and reaching 16,073.34 GWh by 2050. Conversely, the low growth rate scenario envisions a conservative growth in electricity demand, starting at 598.88 GWh and reaching 12,100.94 GWh by 2050.

4.4.2 Policy Scenario

The figure 4.11 and table in the Annex I (10) provide a comprehensive summary of the projected electricity requirements for the food, beverage & tobacco manufacturing industry under different growth rates in the policy scenario until 2050.

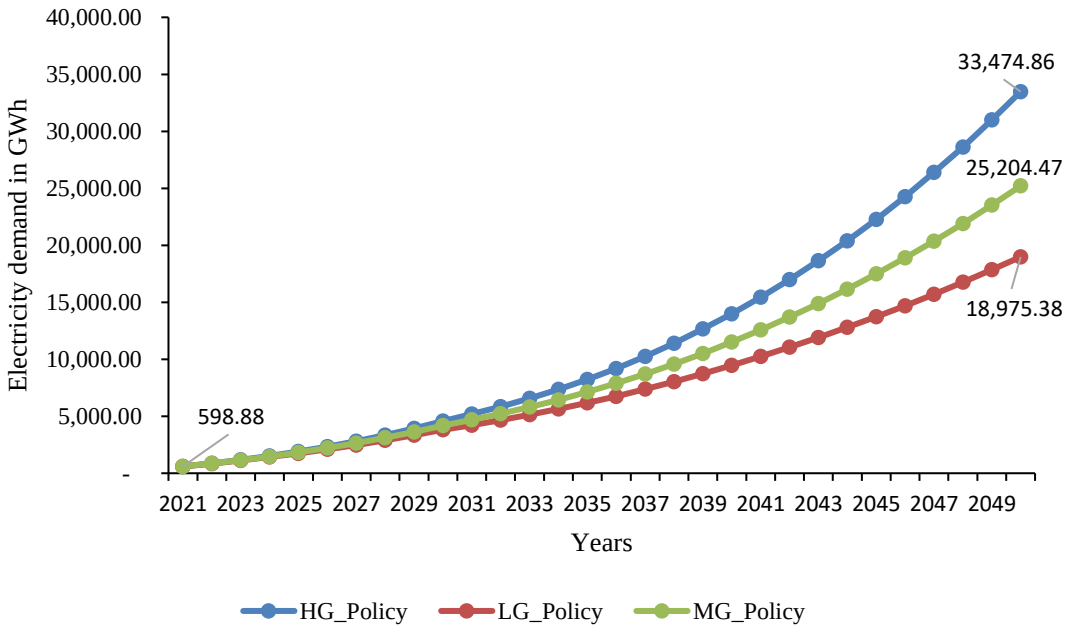

Figure 4. 11 Policy scenario of food, beverage and tobacco manufacturing

In the high growth rate scenario, this industry segment is expected to experience significant expansion, beginning at 598.88 GWh in the base year and gradually increasing to 33,474.86 GWh in 2035. The medium growth rate scenario foresees a more gradual rise in electricity demand, starting at 598.88 GWh and reaching 25,204.47

GWh in 2050. Conversely, the low growth rate scenario envisions a conservative growth in electricity demand, starting at 598.88 GWh and reaching 18,975.38 GWh by 2050.

4.4.3 Comparison between BAU and policy scenario

The figure 4.12 provides the comparison of CAGR between BAU and policy scenario for food, beverage & tobacco manufacturing industries under different growth rate until 2050. In food, beverage & tobacco manufacturing it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth in 2050 are 12,127.34 GWh, 9,131.13 GWh and 6,874.44 GWh respectively. This is due to increment of about 2% CAGR in policy compared to BAU where fuel trend is only considered in BAU where in policy there is need of technological intervention possible through electrification where is demand more.

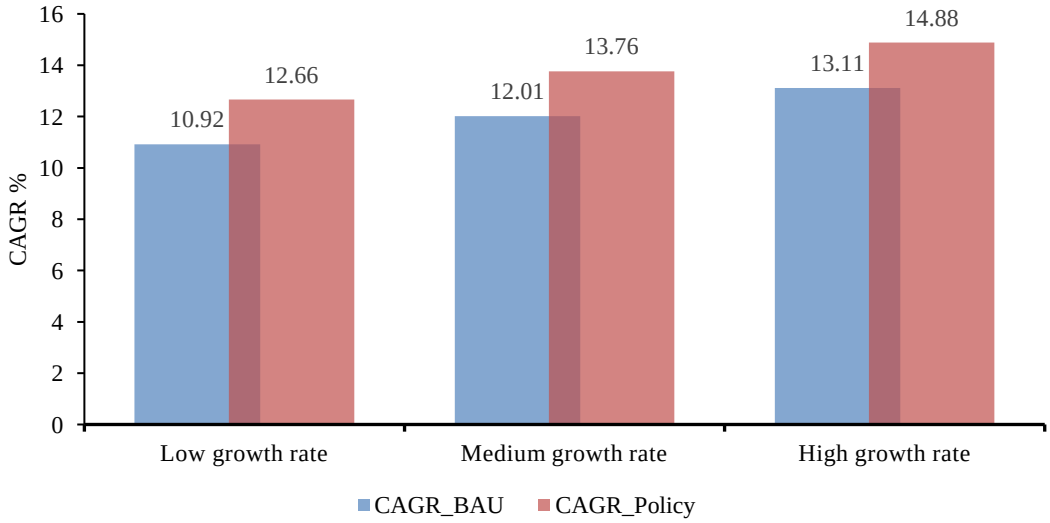

Figure 4. 12 BAU and Policy comparison of food, beverage & tobacco manufacturing

4.5 Mechanical engineering product manufacturing:

4.5.1 Business as usual scenario

The figure 4.13 and table in annex I (11) present the expected electricity demand for Mechanical engineering product manufacturing across three different growth scenarios which are low growth rate, medium growth rate, and high growth rate from the base year to 2050.

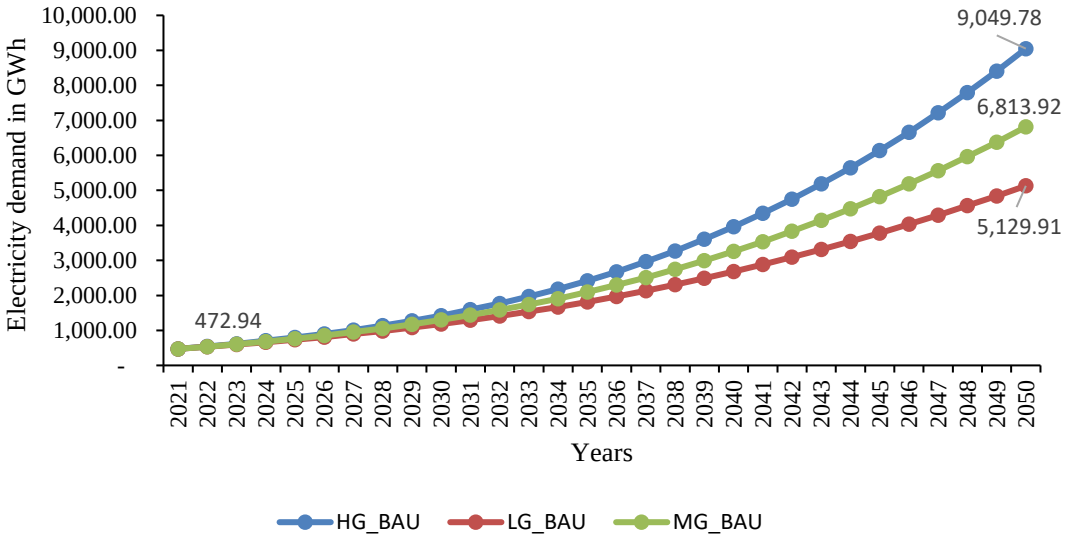

Figure 4. 13 BAU scenario of mechanical engineering product manufacturing

Under the high growth rate, there will be a substantial increase in total electricity demand in this sector, starting at 472.95 GWh in the base year and reaching 9,049.78 GWh by 2035. The medium growth rate scenario predicts a rise in total electricity demand from 472.95 GWh to 6,813.92 GWh by 2050. The low growth rate scenario, in contrast, envisions more modest growth, with total electricity demand increasing from 472.95 GWh in 2021 to 5,129.91 GWh by 2050.

4.5.2 Policy scenario

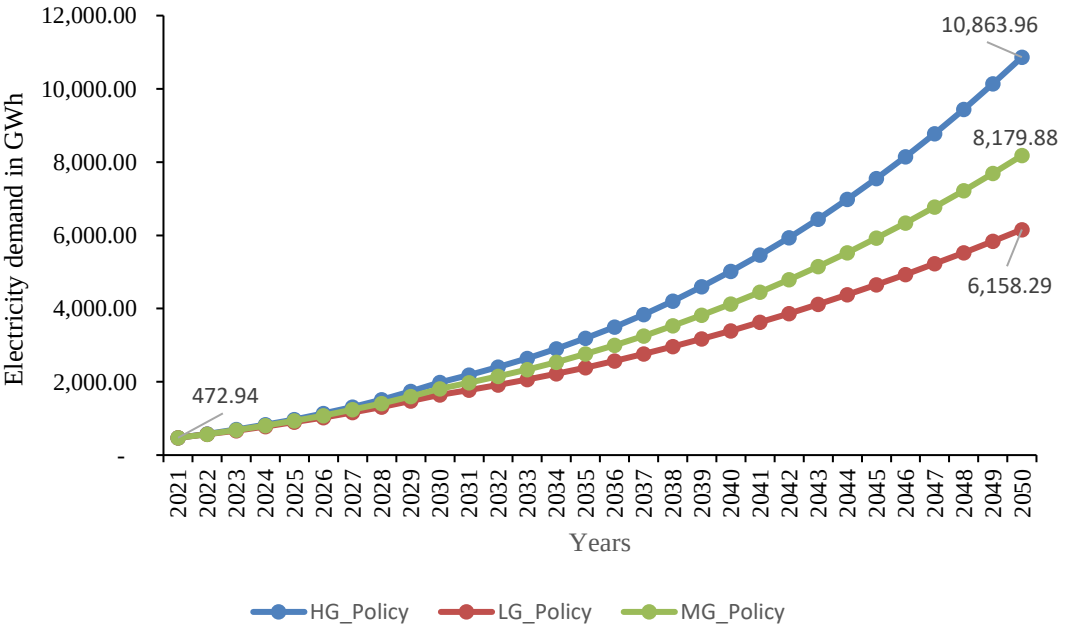

Figure 4. 14 Policy Scenario of Mechanical Engineering Product Manufacturing

In the high growth rate scenario, there will be a significant increase in total electricity demand in this sector, starting at 472.94 GWh in the base year and reaching 10,863.96 GWh by 2050. The medium growth rate scenario predicts a rise in total electricity demand from 472.94 GWh to 8,179.88 GWh by 2050. On the other hand, the low growth rate scenario envisions more modest growth, with total electricity demand increasing from 472.94 GWh to 6,158.29 GWh by 2050.

4.5.3 Comparison between BAU and policy scenario

The figure 4.15 provides the comparison between BAU and policy scenario for mechanical engineering manufacturing industries under different growth rate until 2050.

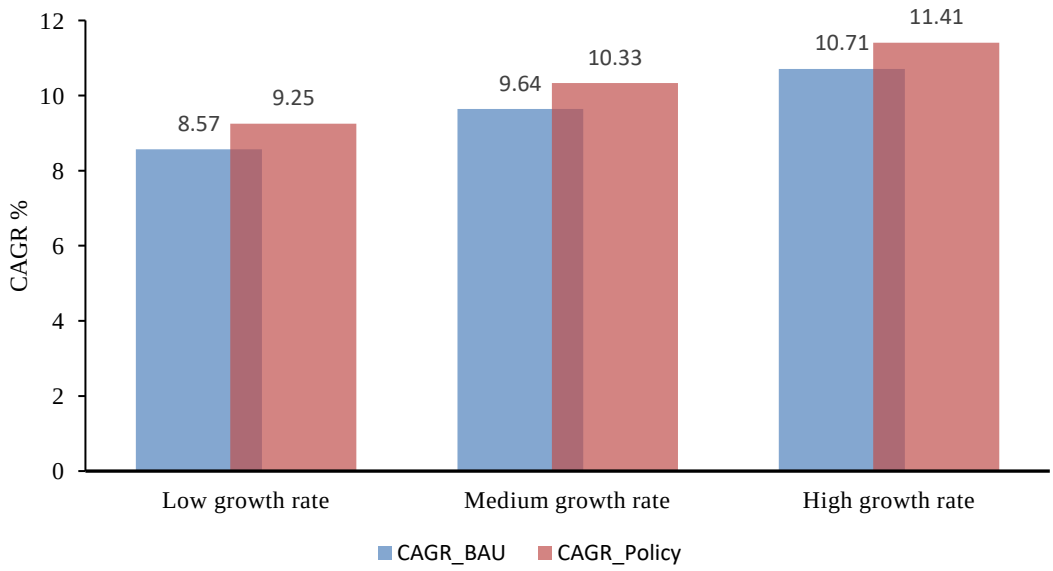

Figure 4. 15 CAGR comparison of mechanical engineering product manufacturing

In Mechanical engineering product manufacturing, it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth are 1,814.18 GWh, 1,365.96 GWh and 1,028.38 GWh in 2050 respectively. This is due to increment of about 0.7% CAGR in Policy compared to BAU where fuel trend is only considered in BAU where in policy there is need of technological intervention possible through electrification where is demand more.

4.6 Paper publication & printing and furniture & fixtures manufacturing:

4.6.1 Business as usual scenario:

The figure 4.16 and provided table in annex I (13) illustrates the projected electricity demand for two sectors, namely paper publication & printing and furniture & fixtures manufacturing, under three different growth scenarios which are low growth rate, medium growth rate, and high growth rate spanning from the base year to 2050.

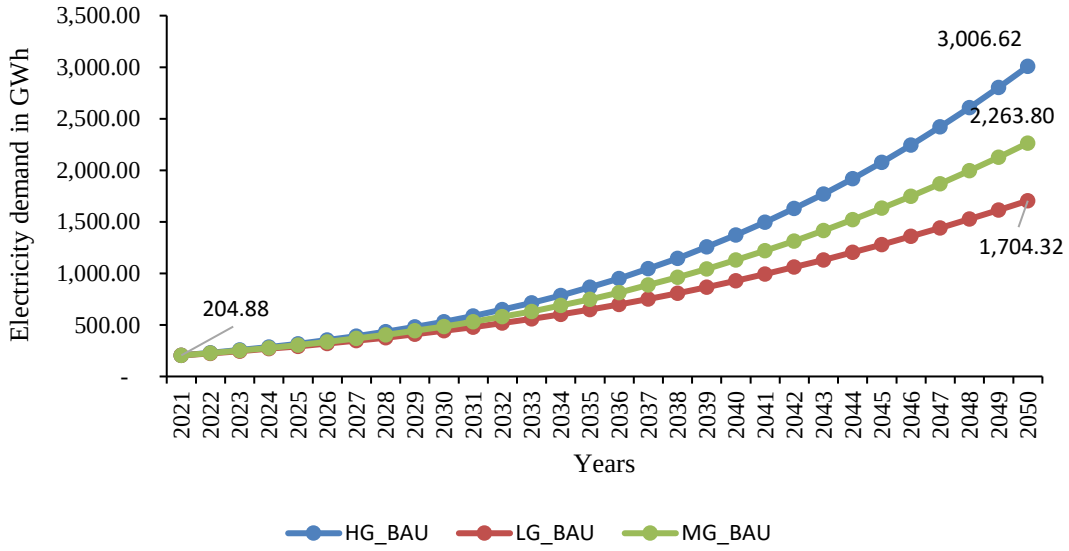

Figure 4. 16 BAU scenario of paper, furniture and fixtures manufacturing

With high growth rate, there will be a substantial surge in total electricity demand for these sectors, starting at 204.88 GWh in the base year and rising to 3,006.62 GWh by 2050. The medium growth rate scenario predicts a growth in total electricity demand from 204.88 GWh to 2,263.80 GWh by 2050. On the other hand, the low growth rate scenario anticipates more gradual growth, with total electricity demand increasing from 204.88 GWh to 1,704.32 GWh by 2050.

4.6.2 Policy Scenario

The figure 4.17 and table in annex I (14) presented shows the projected electricity demand for paper publication & printing and furniture & fixtures manufacturing, under three different growth scenarios - low growth rate, medium growth rate, and high growth rate from the base year to 2050. In the high growth rate scenario, there will be a significant increase in total electricity demand for these sectors, starting at 204.88 GWh in the base year and reaching 4,755.18 GWh.

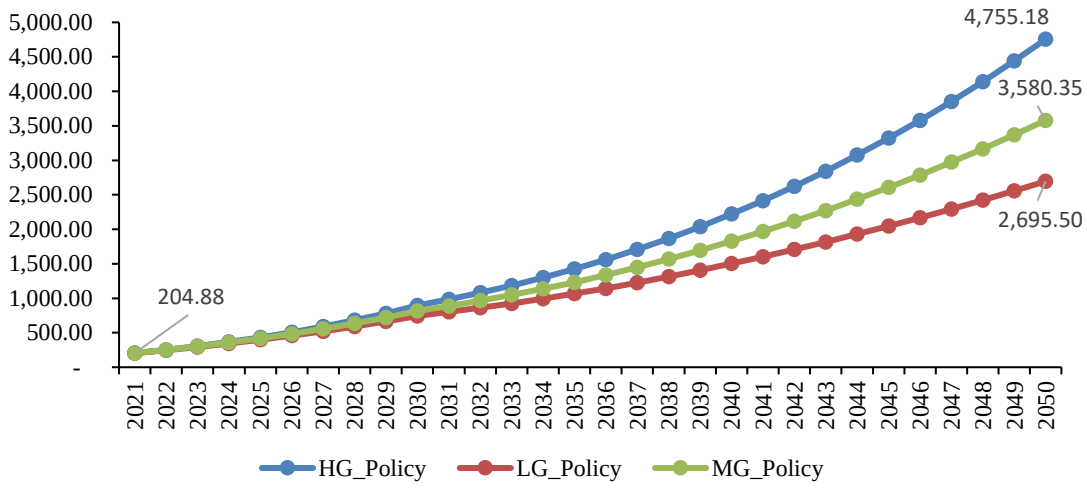

Figure 4. 17 Policy scenario of paper, furniture & fixtures manufacturing

The medium growth rate scenario predicts a growth in total electricity demand from 204.88 GWh to 3,580.35 GWh by 2050. On the other hand, the low growth rate scenario anticipates more gradual growth, with total electricity demand increasing from 204.88 GWh to 2,695.50 GWh by 2050.

4.6.3 Comparison between BAU and policy scenario

Figure 4.18 provides the comparison of CAGR between BAU and policy scenario Paper, furniture and fixture product manufacturing industries under different growth rate until 2050.

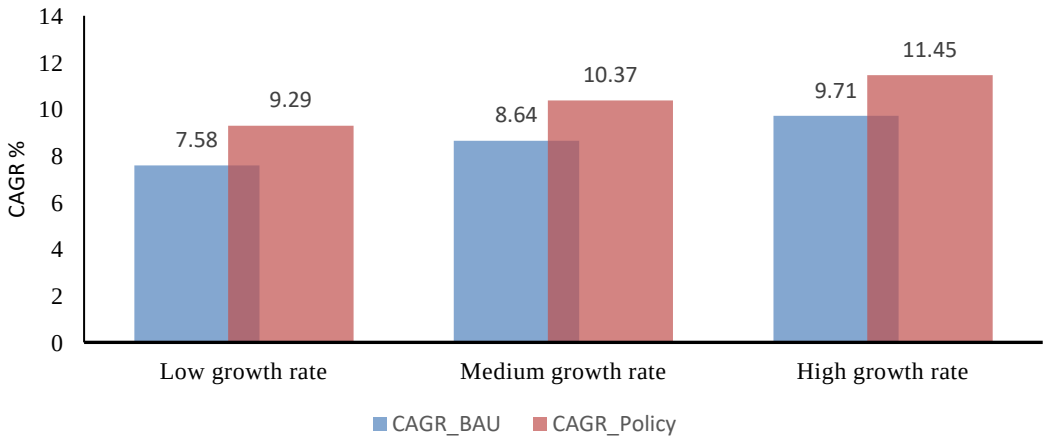

Figure 4. 18 CAGR comparison on paper and Furniture manufacturing

In paper publication & printing and furniture & fixtures manufacturing it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth in 2050 are 1,748.56 GWh, 1,316.55 GWh and

991.18 GWh in 2050 respectively. This is due to increment of about 1.8% CAGR in policy scenario compared to BAU scenario where fuel trend is only considered in BAU where in policy there is need of technological intervention possible through electrification where is demand more.

4.7 Textiles, readymade garment & leather products manufacturing

4.7.1 Business as usual scenario

The figure 4.19 and table in Annex I (15) illustrates the estimated electricity demand for textiles, ready-made garment & leather product manufacturing across three different growth scenarios which are low growth rate, medium growth rate, and high growth rate spanning from the base year to 2050.

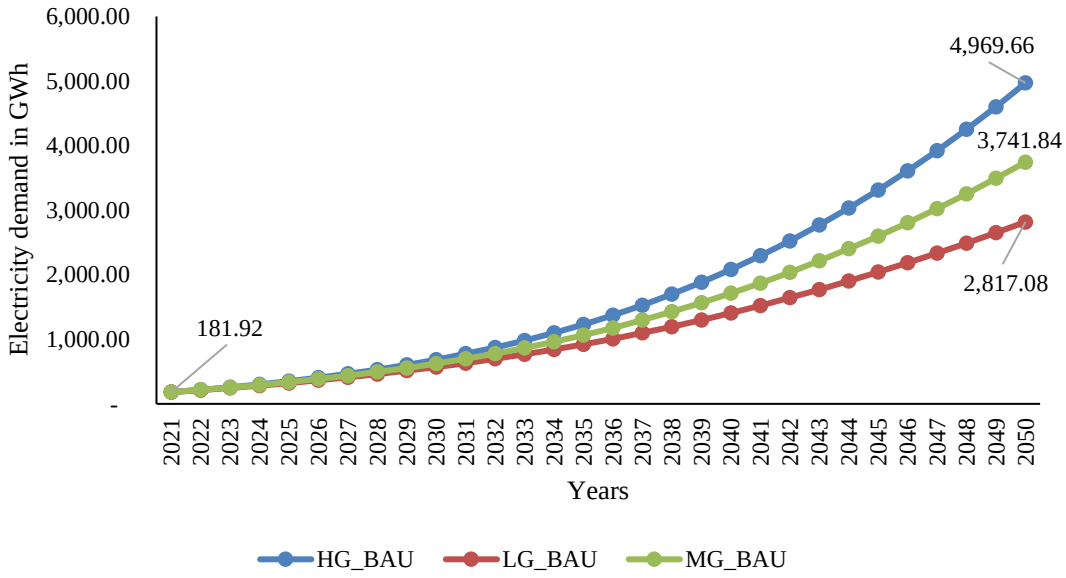

Figure 4. 19 BAU scenario of textiles, readymade & leather products manufacturing

In the high growth rate scenario, there will be a significant increase in the overall electricity demand for these sectors, starting at 181.92 GWh in the base year and surging to 4,969.66 GWh by 2050. The medium growth rate scenario projects a rise in total electricity demand from base year energy 181.92 GWh to 3,741.84 GWh by 2050. In contrast, the low growth rate scenario anticipates a more gradual growth, with total electricity demand increasing from 181.92 GWh to 2,817.08 by 2050.

4.7.2 Policy scenario

The figure 4.20 and table in annex I (16) Annex provided illustrates the projected electricity demand for the textiles, readymade garment & leather products

manufacturing sector under three different growth scenarios low growth rate, medium growth rate, and high growth rate from the base year to 2050.

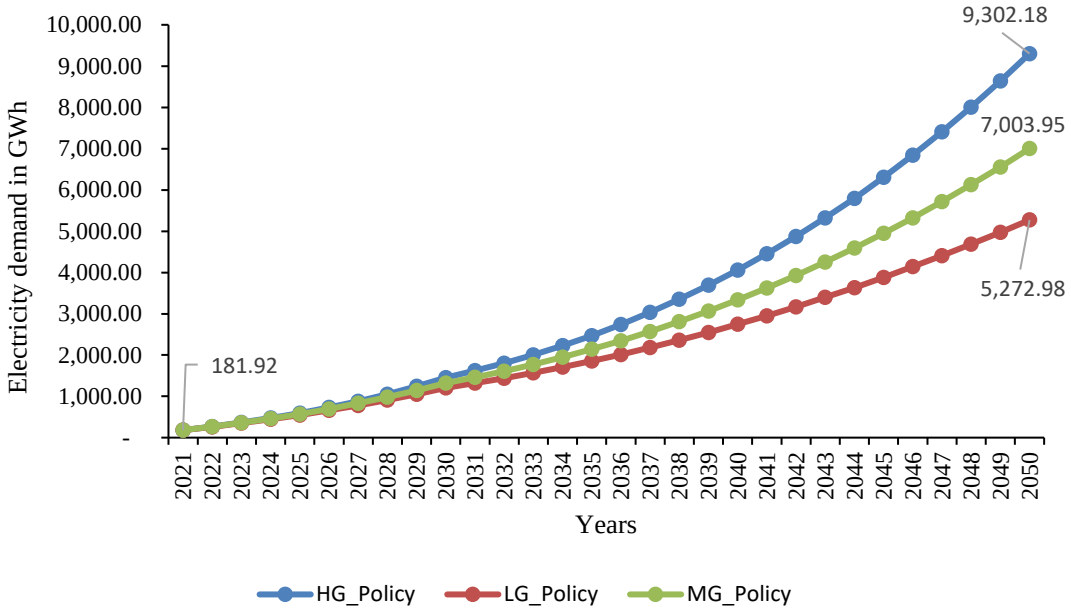

Figure 4. 20 Policy scenario of textiles, garment & leather products manufacturing

In the high growth rate scenario, there will be a significant rise in the overall electricity demand for this sector, starting at 181.92 GWh in the base year and reaching 9,302.18 GWh by 2050. The medium growth rate scenario predicts a growth form base year electricity demand 181.92 GWh to 9,302.18 GWh by 2050. In contrast, the low growth rate scenario envisions more gradual growth, with total electricity demand increasing from 181.92 GWh to 5,272.98 GWh by 2050.

4.7.3 Comparison between BAU and policy scenario

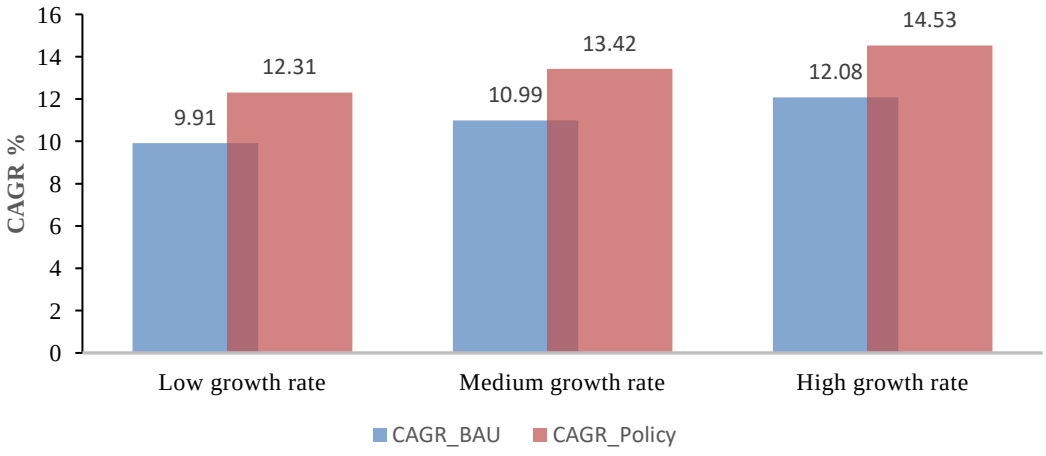

Figure 4. 21 CAGR comparison on textiles, garment and leather Manufacturing

Figure 4.21 provides the comparison of CAGR between BAU and policy scenario of textiles, readymade, leather products manufacturing industries under different growth rate until 2050. In Textiles, readymade garment & leather products manufacturing it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth in 2050 are 4,332.52 GWh, 3262.11 GWh and 2,455.90 GWh respectively. This is due to increment of about 2.4 % CAGR in policy scenario compared to BAU scenario where fuel trend is only considered in BAU where in policy there is need of technological intervention possible through electrification where is demand more.

4.8 Other product Manufacturing:

4.8.1 Business as usual scenario

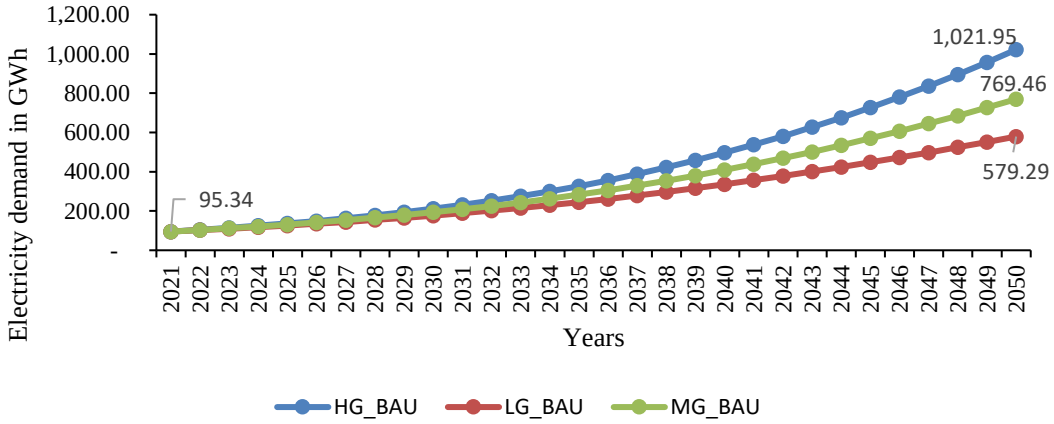

Figure 4. 22 BAU scenario of other product manufacturing

The figure 4.22 and provided table in Annex I (17) presents the projected electricity demand for other product manufacturing across three different growth scenarios - low growth rate, medium growth rate, and high growth rate - from the base year to 2050. In the high growth rate scenario, there will be a significant surge in the total electricity demand for these sectors, starting at 95.34 GWh in the base year and rising to 1,021.95 GWh by 2050. The medium growth rate scenario predicts a growth in total electricity demand from 95.34 GWh to 769.46 GWh by 2050. On the other hand, the low growth rate scenario envisions more gradual growth, with total electricity demand increasing from 95.34 GWh to 579.29 GWh by 2050

4.8.2 Policy scenario

The figure 4.23 and table in annex I (18) shows the projected electricity demand for the other product manufacturing sector under three different growth scenarios - low growth rate, medium growth rate, and high growth rate - from the base year to 2050.

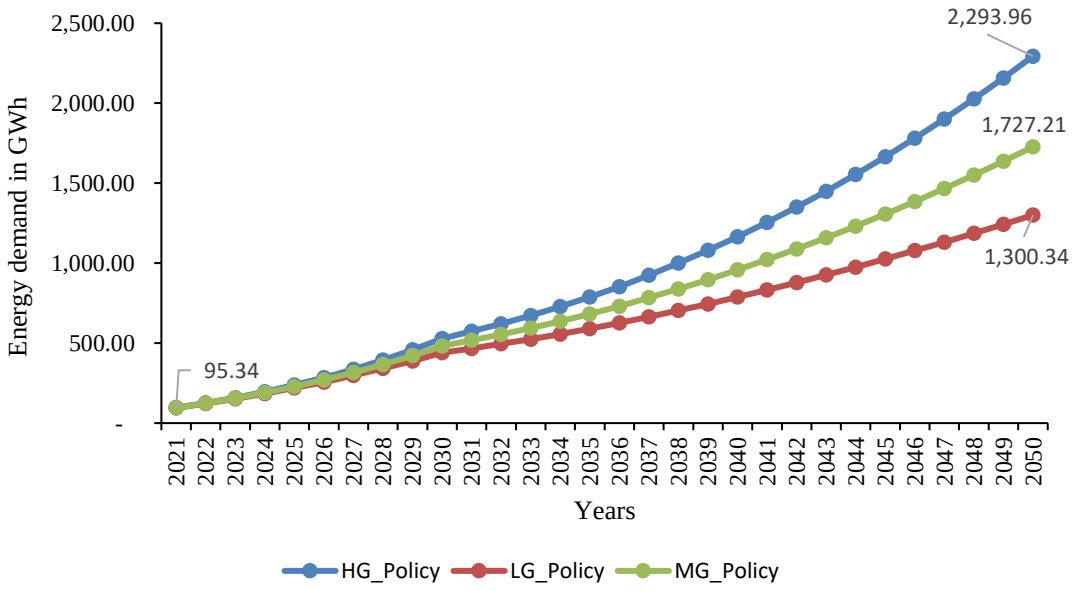

Figure 4. 23 Policy scenario of other product manufacturing

In the high growth rate scenario, there will be a substantial increase in the overall electricity demand for this sector, starting at 95.34 GWh in the base year and rising to 2,293.96 GWh. The medium growth rate scenario anticipates a growth in total electricity demand from base year energy 95.34 GWh to 1,727.21 GWh by 2050. Conversely, the low growth rate scenario envisions more gradual growth, with total electricity demand increasing from base year electricity demand 95.34 GWh to 1,300.34 GWh by 2050.

4.8.3 Comparison between BAU and policy scenario

Figure 4.24 and table in annex I (18) provides the comparison between BAU and policy scenario of others products manufacturing industries under different growth rate until 2050. In other manufacturing it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, low and medium growth in 2050 are 1,272.01 GWh, 957.75 GWh and 721.05 GWh respectively. This is due to increment of about 3% CAGR in Policy compared to BAU where fuel trend is only considered in

BAU where in policy there is need of technological intervention possible through electrification where is demand more.

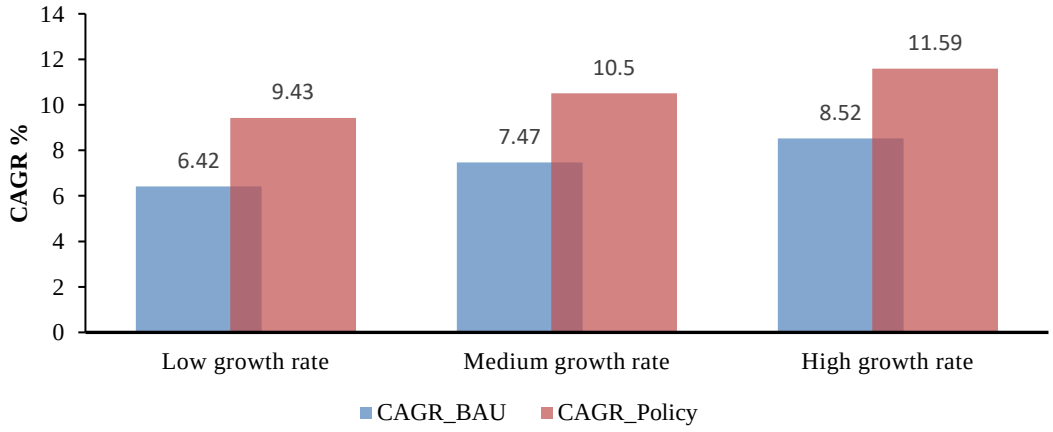

Figure 4. 24 BAU and policy comparison of other product manufacturing

This is due to increment of about 3% CAGR in Policy compared to BAU where fuel trend is only considered in BAU where in policy there is need of technological intervention possible through electrification where is demand more.

Finally overall industry scenario is found,

4.9 Industrial sector

4.9.1 Business as usual scenario

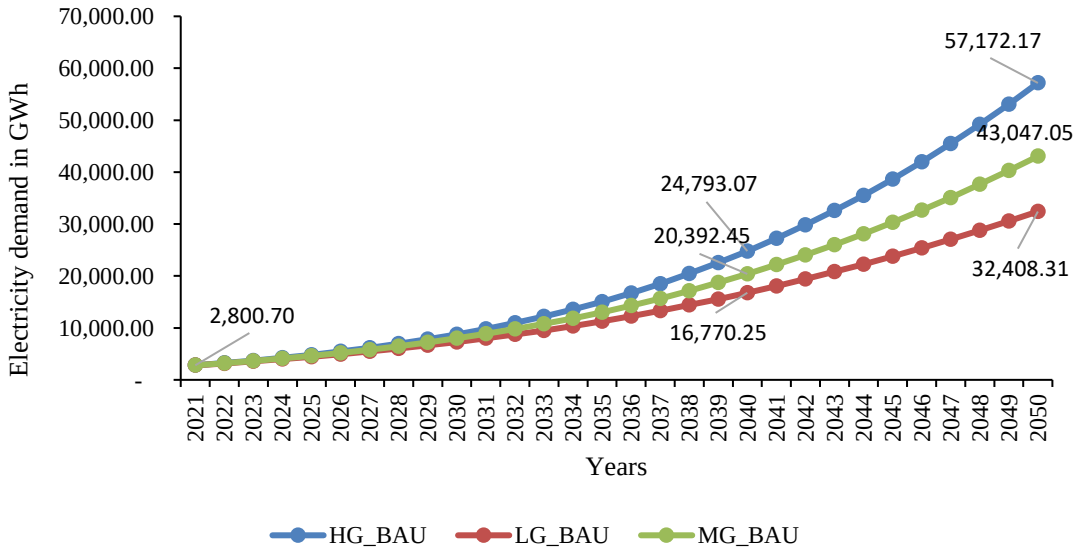

Figure 4. 25 BAU scenario of industrial sector

The figure 4.25 and table provided in Annex I (19) illustrates the estimated electricity demand for the overall industry sector under three different growth scenarios - low growth rate, medium growth rate, and high growth rate from the base year to 2050. In the high growth rate scenario, there will be a substantial increase in the overall electricity demand for this sector, starting at 2,800.70 GWh in the base year and surging to 24,793.07 by 2040. This upward trend will continue, reaching 57,172.17 GWh by 2050. The medium growth rate scenario projects a rise in total electricity demand from 2,800.70 GWh to 20,392.45 GWh in 2040 and further to 43,047.05 GWh by 2050. Conversely, the low growth rate scenario envisions more gradual growth, with total electricity demand increasing from 2,800.70 GWh to 16,770.25 GWh in 2040 and 32,408.31 GWh by 2050.

4.9.2 Policy scenario

The figure 4.26 and table in annex I (20) depicts the projected electricity demand for the industry sector across three different growth scenarios - low growth rate, medium growth rate, and high growth rate from the base year to 2050.

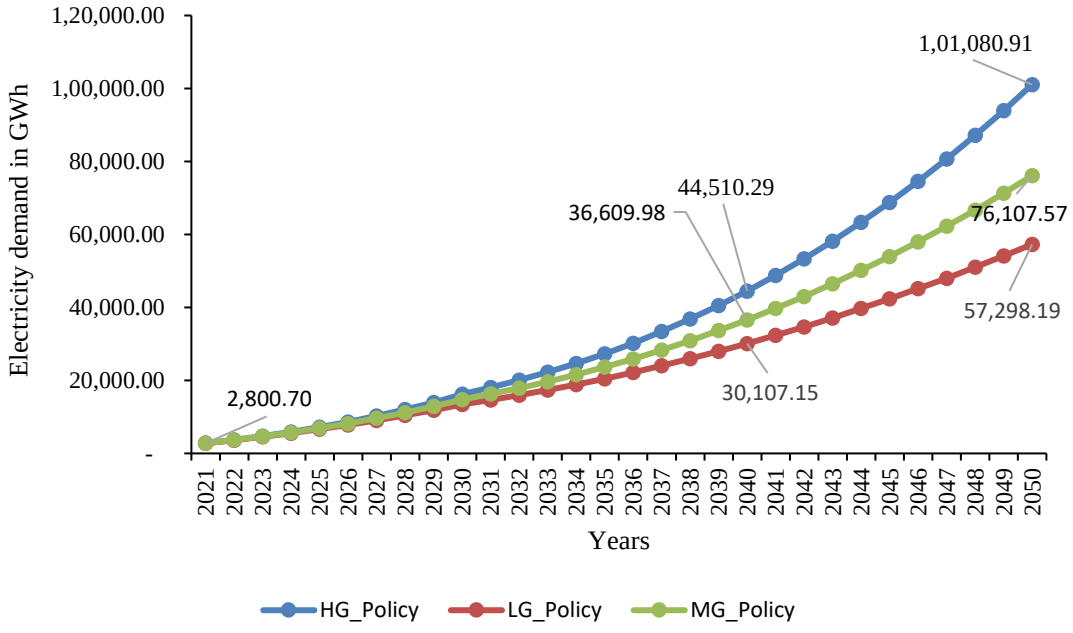

Figure 4. 26 Policy scenario of industrial sector

In the high growth rate scenario, there will be a significant surge in the overall electricity demand for this sector, starting at 2,800.70 GWh in the base year and rising to 44,510.29 GWh by 2040. This upward trend will persist, reaching 1,01,080.91 GWh by 2050. The medium growth rate scenario anticipates a growth in total electricity

demand from 2,800.70 GWh to 36,609.98 GWh in 2040 and further to 76,107.57 GWh by 2050. In contrast, the low growth rate scenario envisions more gradual growth, with total electricity demand increasing from 2,800.70 GWh to 30,107.15 GWh in 2040 and 57,298.19 GWh by 2050.

4.9.3 Comparison between BAU and policy scenario

The figure 4.27 shows the projected electricity demand for the other product manufacturing sector under three different growth scenarios - low growth rate, medium growth rate, and high growth rate from the base year to 2050.

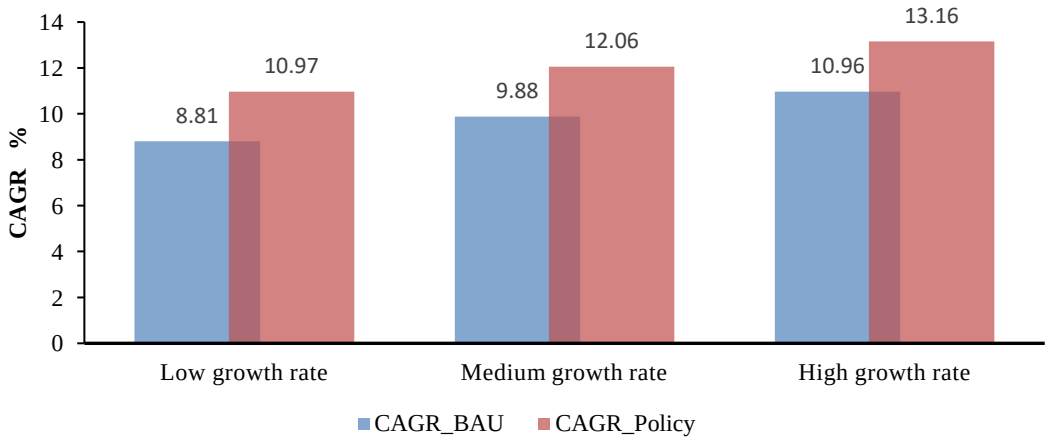

Figure 4. 27 BAU and policy comparison of industrial sector

In industrial sector, it is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth in 2040 are 19,717.22 GWh, 16,217.53 GWh and 13,336.90 GWh followed by increment in 43,908.74 GWh, 33,060.52 GWh and 24,889.88 GWh in 2050 respectively. This is due to increment of about 2.2% CAGR in Policy scenario compared to BAU scenario where fuel trend is only considered in BAU scenario where in policy scenario there is need of technological intervention possible through electrification where is demand more.

4.9.4 Result validation

Figure 4.28 illustrates a comparison between the electricity consumption of the industrial sector in Nepal. This comparison includes various scenarios, each presenting a different projection of electricity consumption. These scenarios are juxtaposed with the actual electricity consumption data provided by the Nepal Electricity Authority (NEA) for the year 2022.

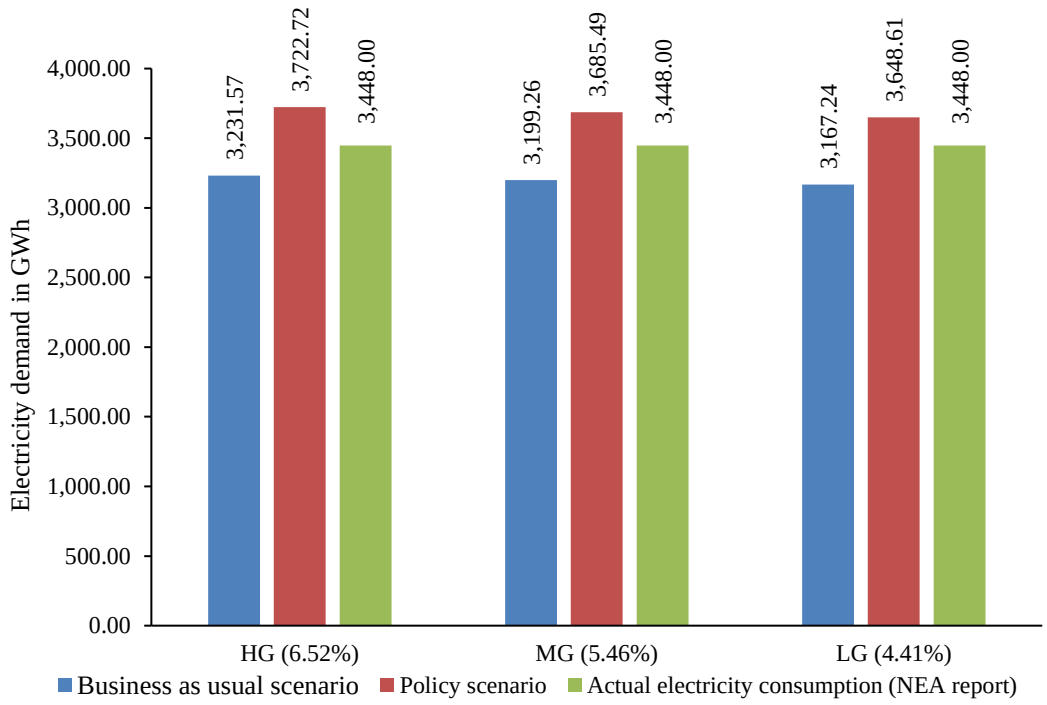

Figure 4. 28 Comparison on electricity consumption by industrial sector in 2022

In the Business-as-usual scenario, which includes High Growth, Medium Growth, and Low Growth rates, the electricity consumption values in 2022 are 3,231.57 GWh, 3,199.26 GWh, and 3,167.24 GWh respectively.

There is a Policy scenario which also considers High Growth, Medium Growth, and Low Growth rates. In this case, the electricity consumption values in 2022 are 3,722.72 GWh, 3,685.49 GWh, and 3,648.61 GWh respectively.

Additionally, the actual electricity consumption for the industrial sector in 2022, as reported by the Nepal Electricity Authority (NEA), is 3,448.00 GWh. In the categorization of electricity consumption by the Nepal Electricity Authority (NEA), industries that utilize a single-phase connection with a capacity of 30 amps or below are considered as domestic consumers at present time. This distinction is made based on the lower capacity and single-phase connection, aligning these industries with the characteristics typically associated with residential or domestic electricity consumption. It is noted that the Business-as-Usual scenario with a high growth rate and the Policy Scenario with a low growth rate are quite close to the actual electricity consumption by the industrial sector. This suggests that these particular scenarios are more accurate or representative of the real-world consumption patterns in the industrial sector of Nepal.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Following conclusions has been drawn from the study

- In overall industrial sector, it is found that electricity demand increases from 2,800.70 GWh in the base year to 57,172.17 GWh, 43,047.05 GWh and 32,408.31 GWh for high, medium and low growth rate respectively at Business-as-Usual Scenario by 2050. For policy scenario, overall demand increases from 2,800.70 GWh in the base year to 1,01,080.91 GWh, 76,107.57 GWh and 57,298.19 GWh for high, medium and low growth rate by 2050. There is increment by about 12, 15 and 20 times in BAU and 20, 27 and 36 times in policy for low, medium and high growth respectively from base year to 2050.

- Overall, in industrial sector is observed that the increment in electricity demand in policy scenario compared to BAU scenario for high, medium and low growth are 43,908.74 GWh, 33,060.52 GWh and 24,889.88 GWh in 2050 respectively. This is due to increment of about 2.2 % CAGR in Policy scenario compared to BAU scenario where fuel trend is only considered in BAU scenario where in policy scenario there is need of technological intervention possible through electrification where is demand more. In food, beverage & tobacco Manufacturing it is observed that there is more electricity demand compare to other sub-sector. There is less demand in electrical & electronic products manufacturing industry. The research examines the rising trend in electricity consumption under Business-as-Usual and policy-driven scenarios in the coming years especially in industrial sector.

- Notably, the Business-as-Usual scenario with a high growth rate and the Policy Scenario with low growth rate closely align with actual consumption figure for the industrial sector in 2022. This suggests that these particular scenarios are more accurate or representative of the real-world consumption patterns in the industrial sector of Nepal.

5.2 Recommendations and future study

This research study focuses on analyzing the factors contributing to the growth of electricity demand in different industrial sectors in Nepal, covering the period from the base year to the year 2050. To address the escalating electricity demand, various strategic planning and interventions like need to be implemented. These strategies may include:

- Technology transformation: Promoting the adoption of electric end-use appliances over conventional fuel-based appliances.
- Industrial tariff rate: To encourage consumption of electricity in the industrial sector, it is essential to review the electricity tariff rates. Lowering or optimizing the electricity tariff rates for industries can incentivize higher electricity consumption and encourage businesses to use electricity more efficiently.
- Demand-Side Management: Implement demand-side management programs to regulate electricity consumption during peak periods and promote load balancing.
- Long-Term Planning: Develop long-term energy plans that anticipate future electricity demand and ensure a reliable and sustainable energy supply.

By implementing these strategic initiatives, Nepal can better prepare for the increasing electricity demand in its industrial sectors, aligning with both Business-as-Usual and policy-driven scenarios and fostering a more sustainable and resilient energy future.

This research study focuses on projecting electricity demand in different industrial sectors in Nepal up to the year 2050. However, there is scope for additional research to investigate electricity demand creation in various other economic sectors, including residential, transport, commercial, agriculture, construction, and mining sectors. This extended research can encompass different administrative levels, such as local, provincial, and federal systems, providing a comprehensive understanding of electricity usage throughout the country. Also, the growth trend of share of different industries is not considered which can be consider in upcoming studies.

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ANNEXES

1. Energy consumption in industrial sector (fuel wise)

Industry	Firewood	Agricultural residue	Coal	LPG	Diesel	Gasoline	Furnace oil	Electricity	Total
Industrial Food Beverage and Tobacco	5.48	6.24	0.08	0.39	10.26	0.00	4.77	1.64	28.84
Industrial Textile and Leather Goods	0.45	3.88	0.00	0.01	1.38	0.00	0.00	0.49	6.23
Industrial Chemical Rubber and Plastic	0.44	0.50	0.70	0.19	3.37	0.75	0.54	1.25	7.74
Industrial Mechanical Engineering and Manufacturing	0.00	0.00	0.55	0.09	4.13	0.58	4.32	1.32	11.00
Industrial Electrical Engineering Products	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.37	0.48
Industrial Wood Products and Paper	3.01	2.15	0.39	0.01	1.18	0.19	0.00	0.77	7.70
Industrial Bricks & Structural Clay	1.16	1.26	14.3	0.01	3.04	0.00	0.08	0.49	20.35
Industrial Cement & Nonmetallic	3.02	0.06	9.64	0.00	1.72	0.01	0.05	1.22	15.73
Industrial Other Manufacturing	0.21	0.35	0.04	0.00	1.05	0.00	0.03	0.25	1.93
Total	13.7	14.44	25.7	0.71	26.24	1.54	9.80	7.79	100.0

2. Share of electrical consumption in different sector (oxford policy,2019)

Parameters	GDP growth (5%)		GDP growth (7%)		GDP growth (10%)	
	2025	2030	2025	2030	2025	2030
Total Electricity Demand (GWh)	21,567	33,437	23,521	38,299	27,217	48,706
Agriculture	1%	1%	1%	1%	1%	1%
Construction mining and manufacturing	30%	32%	34%	37%	40%	46%
Commercial	7%	9%	7%	9%	8%	8%
Transportation	8%	8%	7%	8%	8%	10%
Residential	54%	51%	50%	44%	43%	35%

3. Electricity demand (GWh) for cement, bricks, concrete, and clay products manufacturing industries under different growth rate for BAU

Scenario/Year	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	667.85	741.27	1,006.38	1,645.18	2,627.73	4,114.36	6,166.28	8,846.48
LG_BAU	667.85	726.52	928.04	1,367.87	1,969.86	2,782.99	3,798.80	5,014.67
MG_BAU	667.85	733.86	966.43	1,500.19	2,275.27	3,384.08	4,840.25	6,660.84

4. Electricity demand for cement, bricks, concrete, and clay products manufacturing industries under different growth rate for policy scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	667.85	935.90	1,950.04	4,590.24	7,989.23	13,299.28	20,869.46	31,031.68
LG_Policy	667.85	917.26	1,798.25	3,816.51	5,989.09	8,995.75	12,856.83	17,590.45
MG_Policy	667.85	926.54	1,872.63	4,185.69	6,917.65	10,938.73	16,381.58	23,364.91

5. Electricity demand for under different growth rate for chemical products, rubber, glass & plastics manufacturing industries at BAU

Scenario/Year	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	471.85	535.71	769.10	1,343.60	2,247.59	3,641.21	5,601.97	8,205.44
LG_BAU	471.85	525.04	709.24	1,117.12	1,684.90	2,462.95	3,451.15	4,651.29
MG_BAU	471.85	530.35	738.57	1,225.18	1,946.13	2,994.92	4,397.29	6,178.18

6. Electricity demand for under different growth rate for chemical products, rubber, glass & plastics manufacturing industries at policy scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	471.85	575.57	962.41	1,946.87	2,919.29	4,342.19	6,236.43	8,631.32
LG_Policy	471.85	564.11	887.49	1,618.71	2,188.43	2,937.10	3,842.01	4,892.70
MG_Policy	471.85	569.82	924.20	1,775.29	2,527.73	3,571.48	4,895.32	6,498.84

7. Electricity demand for under different growth rate for electrical and electronic product manufacturing industry at BAU scenario

Scenario/Year	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	107.05	114.57	140.72	199.44	282.54	399.11	546.81	724.72
LG_BAU	107.05	112.29	129.76	165.82	211.80	269.96	336.87	410.81
MG_BAU	107.05	113.42	135.13	181.86	244.64	328.27	429.22	545.67

8. Electricity demand for under different growth rate for electrical and electronic product manufacturing industry at policy scenario

Scenario/Year	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	107.05	115.75	146.46	217.37	301.51	417.19	560.12	727.77
LG_Policy	107.05	113.45	135.06	180.73	226.02	282.19	345.07	412.54
MG_Policy	107.05	114.60	140.65	198.21	261.07	343.14	439.67	547.96

9. Electricity demand for food, beverage & tobacco manufacturing industry under different growth rate for at BAU scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	598.88	746.89	1,300.88	2,718.74	5,039.30	8,727.64	14,073.84	21,347.52
LG_BAU	598.88	732.02	1,199.62	2,260.47	3,777.69	5,903.45	8,670.33	12,100.94
MG_BAU	598.88	739.42	1,249.24	2,479.12	4,363.39	7,178.53	11,047.33	16,073.34

10. Electricity demand for food, beverage & tobacco manufacturing industry under different growth rate for at policy scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	598.88	870.02	1,897.89	4,581.94	8,233.63	13,991.57	22,274.38	33,474.86
LG_Policy	598.88	852.70	1,750.15	3,809.61	6,172.31	9,464.02	13,722.35	18,975.38
MG_Policy	598.88	861.32	1,822.55	4,178.11	7,129.27	11,508.15	17,484.38	25,204.47

11. Electricity demand for mechanical engineering product manufacturing industry under different growth rate for at BAU scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	472.94	542.00	795.39	1,423.21	2,417.86	3,959.61	6,140.64	9,049.78
LG_BAU	472.94	531.21	733.48	1,183.31	1,812.54	2,678.32	3,783.00	5,129.91
MG_BAU	472.94	536.57	763.82	1,297.77	2,093.56	3,256.80	4,820.12	6,813.92

12. Electricity demand for mechanical engineering product manufacturing industry under different growth rate for at policy scenario

Scenario	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	472.94	578.95	974.58	1,982.43	3,187.52	5,016.24	7,548.09	10,863.96
LG_Policy	472.94	567.43	898.72	1,648.27	2,389.51	3,393.03	4,650.07	6,158.29
MG_Policy	472.94	573.16	935.89	1,807.71	2,759.98	4,125.89	5,924.91	8,179.88

13. Electricity demand for paper publication & printing and furniture & fixtures manufacturing industry under different growth rate for at BAU scenario

Scenario/Year	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	204.88	229.20	317.43	531.84	864.67	1,372.13	2,078.12	3,006.62
LG_BAU	204.88	224.63	292.72	442.19	648.20	928.12	1,280.25	1,704.32
MG_BAU	204.88	226.90	304.83	484.96	748.69	1,128.58	1,631.23	2,263.80

14. Electricity demand for paper publication & printing and furniture & fixtures manufacturing industry under different growth rate for at policy scenario

Scenario/Year	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	204.88	253.15	433.56	894.27	1,422.81	2,221.10	3,320.92	4,755.18
LG_Policy	204.88	248.11	399.81	743.53	1,066.60	1,502.37	2,045.89	2,695.50
MG_Policy	204.88	250.62	416.35	815.45	1,231.97	1,826.87	2,606.77	3,580.35

15. Electricity demand for Textiles, ready-made garment & leather product manufacturing industry under different growth rate for at BAU scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	181.92	217.60	350.16	685.43	1,227.77	2,082.17	3,310.19	4,969.66
LG_BAU	181.92	213.27	322.91	569.89	920.39	1,408.40	2,039.28	2,817.08
MG_BAU	181.92	215.42	336.26	625.02	1,063.09	1,712.60	2,598.35	3,741.84

16. Electricity demand for textiles, ready-made garment & leather product manufacturing industry under different growth rate for at policy scenario

Scenario/ Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	181.92	268.12	595.15	1,450.00	2,471.87	4,057.66	6,303.58	9,302.18
LG_Policy	181.92	262.79	548.82	1,205.58	1,853.03	2,744.64	3,883.38	5,272.98
MG_Policy	181.92	265.44	571.52	1,322.20	2,140.32	3,337.45	4,948.03	7,003.95

17. Electricity demand for other product manufacturing industry under different growth rate for at BAU scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	95.34	104.35	136.51	212.53	326.94	496.86	726.81	1,021.95
LG_BAU	95.34	102.27	125.89	176.70	245.09	336.08	447.76	579.29
MG_BAU	95.34	103.30	131.09	193.80	283.09	408.67	570.51	769.46

18. Electricity demand for other product manufacturing industry under different growth rate for at policy scenario

Scenario/Years	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	95.34	125.25	237.89	528.92	787.82	1,165.06	1,664.87	2,293.96
LG_Policy	95.34	122.76	219.37	439.76	590.59	788.06	1,025.66	1,300.34
MG_Policy	95.34	124.00	228.45	482.30	682.15	958.27	1,306.85	1,727.21

19. Electricity demand for overall industrial sector under different growth rate for at BAU scenario

Scenario/Year	2021	2022	2025	2030	2035	2040	2045	2050
HG_BAU	2,800.70	3,231.57	4,816.57	8,759.95	15,034.39	24,793.07	38,644.66	57,172.17
LG_BAU	2,800.70	3,167.24	4,441.65	7,283.38	11,270.47	16,770.25	23,807.42	32,408.31
MG_BAU	2,800.70	3,199.26	4,625.37	7,987.91	13,017.85	20,392.45	30,334.31	43,047.05

20. Electricity demand for overall industrial sector under different growth rate for at policy scenario

Scenario/ years	2021	2022	2025	2030	2035	2040	2045	2050
HG_Policy	2,800.7	3,722.7	7,197.9	16,192.0	27,313.6	44,510.2	68,777.8	1,01,080.9
LG_Policy	2,800.7	3,648.6	6,637.6	13,462.7	20,475.5	30,107.1	42,371.2	57,298.1
MG_Policy	2,800.7	3,685.4	6,912.2	14,764.9	23,650.1	36,609.9	53,987.5	76,107.5

21. Result validation

Industrial sector electricity consumption (GWh) in 2022	HG (6.52%)	MG (5.46%)	LG (4.41%)
Business as usual scenario	3,231.57	3,199.26	3,167.24
Policy scenario	3,722.72	3,685.49	3,648.61
Actual electricity consumption (NEA report)	3,448.00		