Energy Demand Analysis of Instant Noodles Processing Plants of Nepal

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Abstract— There is a large potential of energy saving in the noodles industries as it is still in the traditional state. Nepal produced 103.6 thousand metric tons of Noodles in 2017 with about the total capacity 160 thousand metric tons. The average production growth rate for the past ten years is around 5.6%. In noodles industries, boiler consumes about 61% of the energy with motor drives consuming about 23% followed by process heat with 10% of the energy. Rice husk is used as the fuel in most boilers which provided about 90% of the thermal energy with around 10% being derived from the electricity. After modeling in LEAP, about 176.77 thousand GJ of energy is being used with the prediction of about 363.84 thousand GJ of energy being demanded in 2030 under normal growth rate of 5.6%. Creating different scenarios with the industrial value addition for manufacturing sector, it was found under low growth rate of 3%, 256.59 thousand GJ of energy will be required with 817.31 thousand GJ of energy being demanded in high growth rate of 11.5%. With the various efficiency measures in accordance to sustainable development goals being implemented, the energy demand will be 261.43 thousand GJ, 199.58 thousand GJ and 641.52 thousand GJ under normal, low and high growth efficient scenarios. This accounts for about 21.6 thousand GJ of electrical and 83.85 thousand GJ of thermal energy being saved. Under low growth 29.15 thousand GJ electrical energy and 60.32 thousand GJ thermal energy can be saved with 18.47 thousand GJ of electrical energy and 97.47 thousand GJ of thermal energy being saved from high growth scenario.

Keywords: *Energy Modeling, Energy Demand, LEAP, Instant Noodles Industry.*

I. Introduction

Energy is one of the essential requirements for the economic growth of developing countries. Energy consumption is a key determinant of overall productivity and economy in human society [6]. The conservation of energy is an essential step towards overcoming the mounting problems of the worldwide energy crisis and environmental degradation. Energy conservation is vital for the sustainable development of food industry. Energy efficiency improvement and waste heat recovery in the food industry have been a focus to increase the sustainability of food processing in the past decades [7]. The improvement of energy efficiency in the food industry should be considered to provide not only economic benefit but also the benefits for environmental protection, social sustainability, energy supply security, and industrial competitiveness.

Food manufacturing plants are energy-intensive plants and a significant portion of their operating cost is due to energy use. Wang [7] reported that around 57% of the primary energy inputs into the whole industry are lost before reaching intended processing activities. Estimates from several studies indicate that on average, savings of 20 to 30% energy can be achieved without capital investment, using only procedural and behavioral changes. The improvement of energy efficiency in food processing facilities requires the evaluation of numerous prospective measures to increase the energy usage efficiencies of the utilities such as such as steam, compressed air, and electricity [7]. Therefore, improving energy efficiency has great potential to reduce the operating cost and thereby improve the profitability of food manufacturing plants in Nepal.

A. Noodles in Nepal

Nepal is the third most noodles consuming country per capita only behind Korea and Vietnam [9]. Instant Noodles Industry in Nepal unlike other emerging economy is still very traditional in nature with very poor energy management and is largely controlled by few key players. According to a study, there is a prospect of saving 478 GJ of electrical energy and 52,577 GJ of thermal energy [2] in noodles industries in our country and, the CO_2 savings potential is approximately 2353 kg. It is thus, imperative to investigate future energy demand for the noodle industry and possible ways of curtailing the emission by the use of energy efficient technologies. Hence this study elucidates the situation of Instant Noodles in Nepal in terms of energy demand with the main focus on possible methods to optimize the energy consumption through suitable methods like replacing the existent energy intensive equipments with the Units

efficient ones and thus saving the overall consumption of the energy in Noodle Industry.

B. Production process of Instant Noodles

Figure 1 shows the schematic diagram of the production process involved in the production of the Instant Noodles.

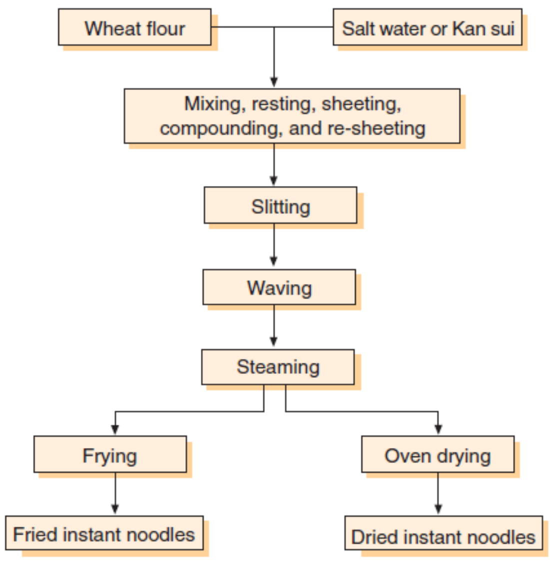

Fig. 1. Production process of Instant Noodles

II. Literature Review

Wang [7] studied about the energy efficiency improvement and waste heat recovery in the food industry with a focus to increase the sustainability of food processing. Replacement of conventional energy-intensive food processes with novel technologies such as novel thermodynamic cycles and non-thermal and novel heating processes provides another potential to reduce energy consumption, reduce production costs, and improve the sustainability of food production. Some novel food processing technologies have been developed to replace traditional energy intensive unit operations for pasteurization and sterilization, evaporation and dehydration, and chilling and freezing in the food industry.

GIZ/NEEP [2] analyzed the energy intensity and estimated the potential electrical and thermal energy savings as well as CO2 emission per unit products of eight different sectors one of them being food sector with noodles as a subsector. Considering four establishments, it was found that the Instant Noodle industries consume both electrical and thermal energy in its production process. Electrical energy is used for drives, compressors, pumps and lighting and thermal energy is required for the operation of boiler to get steam for the cooking of noodles and other hot processes. Fuel used for the boiler was rice husk. It was calculated that the electrical saving potential is 6.15% and thermal saving potential is 11.38%, for Noodle industries.

Pradeep Singh [8] studied the effect of implementation of best available technologies in cement industries of Nepal. He calculated the impact of penetration of best available technology in energy consumption depending on three main factors, viz. penetration of proposed energy efficiency technology, the baseline energy (projected on various growth rates) and environment forecast and the effectiveness of the policy compared to the existing policy. It was found that the potentiality of efficiency improvement in finish grinding is 48% and around 40% of efficiency improvement can be done in motors and fans. Similarly, low temperature for waste heat recovery power generation can be employed in rotary kiln industries, which account the saving of 9% of electricity. Likewise, the fuel energy intensity of saving can be attained in integrated cement industries. The majority of the fuel energy is found to be lost from the kiln surface and the use of better insulating refractories can be used to reduce heat losses up to 37%. Further, the use of alternative fuel can save energy up to 30%.

Bhattarai [9] studied the industrial sectors energy demand projections and analysis of Nepal for sustainable national energy planning process of the country. To project future energy demand, the end-use industrial sector energy demand model based on Long –range Energy Alternative Planning (LEAP) framework was formulated with four GDP growth scenarios namely business as usual (BA), low growth (LG), medium growth (MG) and high growth (HG) respectively. It has been found that the total sectorial energy demand and electricity demand can be reduced from 1.78 and 2.42 times of the base year demand in BA scenario to 1.53 and 2.24 times of the base year demand in 2030 respectively.

III. Methodology

Every methodology begins with the identification of the problem. Problem Formulation is an activity which defines the cognitive gap between what is and what is desirable and delineates the resources for closing it. The lack of concrete study on the energy consumption of the noodles industry was identified as the problem, this study aimed to address. It was followed by the intensive study of existing literature on energy consumption in the manufacturing sector and its various subsectors with major focus on the Noodles processing plants and manufacturing units.

For the further facilitation of the in-depth energy demand analysis, the actual profile of the consumption of energy in the noodles industry was to be determined. For this, a questionnaire was developed to access the energy demand for the end use devices. The total energy consumption was divided into five end-use categories; namely Lighting, Motive drives, Boilers, Process Heat and Other devices. The questionnaire was developed to collect the information regarding the different types of end-use devices, their rated power, number and average hours of operation and fuel used.

The total registered establishments for the production of Instant Noodles in Nepal were found to be 38 and using Chi-square distribution, the sample size was found to be around 20 with 95% confidence interval and 10% margin error. So suitable industries were selected according to the sample size and the primary data of end-use energy devices and their energy consumption was collected through the survey and field visits to various Noodle manufacturing establishments. The secondary data of Noodles production was compiled from various editions of economic survey and various websites. The collected data was then compiled and subjected to further analysis. The annual energy demand for end-use device category was calculated as,

$$E.D_i = N_i * P_i * T_i * U_i * D$$

Where, N_i = Number of end-use devices
P_i = Rated power of end-use device
T_i = Average hours of operation
U_i = Capacity utilization factor
D = Average number of working days in a year [11].

The data on number of end-use devices, their rated power and average hours of operation were retrieved from the information gathered during survey. Average number of working days in a year was assumed to be 300 days, the capacity utilization factor of 0.6 was taken based study done on similar researches [5]. After ensuring the validity of the database, rigorous analysis of the database was performed to get the overview of the energy consumption for the industry. The outcome of the analysis was compared with the WECS data [4] to obtain insights into the national industrial energy consumption.

A. Model Development

Bottom-up end-use LEAP Model was developed to investigate the possibility of demand side management with 2017 as base year and 2018 as first year of projection. Energy used to assess the energy savings potentials under different scenarios which were based on the production rate of the Instant Noodles in Nepal.

1) Lighting

The lighting end-use energy demand has been divided into two categories namely, electricity and diesel to reflect the fuel types used. Four categories with energy intensity named incandescent, fluorescent, CFL and LED were created for both categories and fuel type was specified.

2) Motive Drives

The motive energy end-use energy demand was divided into three categories named motors, pumps and compressors. Motors are the integral part of manufacturing and thus, the energy demand for the motors depends upon industry output.

3) Process Heat

The process heat branch was further divided into two categories; Direct heating and Indirect heating. Direct heating considered the heating of the materials by directly exposing the materials to the heat source whereas indirect heating used some mechanisms of convection to provide heat the noodles. The energy demand for process heat has been modelled for two fuel types used. Under diesel category, electrical heating and diesel heating was created. Under electricity category, electrical heating system category was specified with energy intensity.

4) Boiler

Boiler category with energy intensity was created and it was sub-categorized into rice-husk boilers, firewood boilers, furnace oil boilers and electric boilers based on the use of the fuel in the boilers found across different manufacturing entities. Since, boiler is integral part of the production process; its energy consumption was assumed to be proportional to the industrial output.

5) Other Devices

To accommodate for the energy consumption by other various devices this branch was created and two categories were created to differentiate two types of fuel used for other devices.

To investigate the implication of various policy interventions on energy mix, various scenarios were constructed. Based on the production of Instant Noodles from the year 2001 to 2018, the average production growth rate, the low growth rate and the high growth rate was used to predict the energy demand for different end-use processes.

And considering the government's target of reducing the energy consumption by replacing the existing higher energy consuming devices with the more energy efficient devices as mentioned in Sustainable Development Goal, the efficient scenarios were developed under these various growth rates.

Since the major problem of the power outage is now over from May 2018, from 2019 all the diesel gensets were removed from every manufacturing plant. Further, the government aimed to replace the existing incandescent and fluorescent lights by CFL and LED lights by 50 % in the year 2025 and further by LED lights in the year 2030 [3].

Similarly, through various researches done in the food industries in Nepal, the efficiency in the Motor drives can be reduced by around 7-15%. Hence, 7% efficiency increment was considered for the motor drives. Likewise, around 6% efficiency is expected to be raised in the boilers and process heat. And in the other sectors, replacing the existing energy supply done by diesel gensets to be replaced by electricity and increasing the efficiency by further 6%. So, accounting these different efficiency rates, the business-as-usual (BAU) efficient scenario, low growth (LG) efficient scenario and high growth (HG) efficient scenario were developed which ultimately led to the energy savings potential under these various efficient scenarios.

IV. Result and Analysis

The end-use energy database was developed to investigate energy consumption pattern for the industry as tabulated in table 1.

Table 1. Share of fuel types in Noodle Industries

Branches	Biomass	Wood	LPG	Residual Fuel Oil	Diesel	Electricity (GJ)	Total (GJ)
Lighting	-	-	-	-	0.95	2.23	3.18
Motor Drives	-	-	-	-	12.12	28.29	40.41
Process heat	-	-	2.74	-	4.65	10.86	18.25
Boiler	86.86	3.26	-	16.29	-	2.17	108.6
Others	-	-	-	-	1.9	4.44	6.35
Total	86.86	3.26	2.74	16.29	19.64	47.99	176.8

The demand processes for various processes were tabulated for the base year 2017. Among the end processes, the demand for the lighting was found to be 3.18 GJ. Similarly, the demand for the machine drives and process heat were found to be40.41 GJ and 18.25 GJ respectively. Likewise, the maximum demand was for boilers with about 108.58 GJ and for other equipment it was 6.35 GJ.

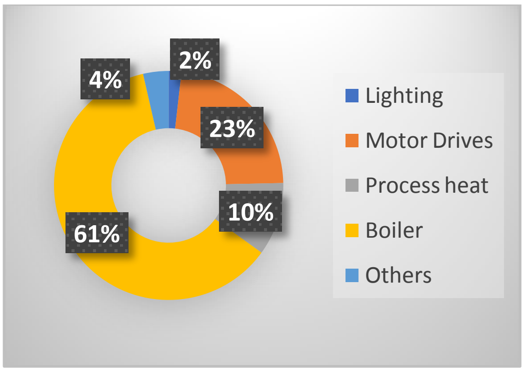

Fig. 2. Share of end use process in Noodles industry

As evident from the figure 2, the share of the boilers is maximum with around 61% followed by machine drives with 23%. About 10% of energy was used for the process heat and the share of energy for the lighting and other equipment was found to be 2% and 4% respectively. Hence, the portion of share of thermal energy i.e., for boiler and process heat is maximum in comparison to that of electrical energy.

The maximum amount of energy was gained from the biomass primarily rice husk which provided for about 85 GJ followed by electricity 48 GJ of energy. The proportion of other fuel were less than 20 thousand GJ. Diesel, residual fuel oil provided significant amount of energy whereas the energy from LPG and wood were very few.

Table 2 Energy Final Demand according to fuel types

Fuels	2018	2020	2022	2024	2026	2028	2030
Electricity	50.73	56.69	63.34	70.79	79.10	88.39	98.77
Diesel	20.76	23.20	25.92	28.96	32.37	36.17	40.42
Residual Fuel Oil	17.22	19.24	21.50	24.02	26.85	30.00	33.52
LPG	2.89	3.23	3.61	4.04	4.51	5.04	5.63
Wood	3.44	3.85	4.30	4.81	5.37	6.00	6.71
Biomass	91.82	102.61	114.66	128.13	143.18	160.00	178.79
Total	186.86	208.81	233.34	260.75	291.37	325.60	363.84

1) Growth rate

The future noodles production in Nepal can be projected as a function of gross value addition in the food and beverage industry sector. Growing youth segment and increasing working population, rising incomes and rising purchasing power, higher brand consciousness, changing consumer preference, growing urbanization and increase in number of middle-class populations are the biggest drivers in the growth of Instant Noodles industry of Nepal. Also, lack of time, fast paced life and changing food preferences are also helping Instant Noodles sector to grow in Nepal. The noodles demand scenario can be classified as the following

- High growth scenario
- Medium growth scenario
- Low growth scenario

Similarly, the energy efficiency scenario can be penetrated as mentioned in different literatures

2) Demand Forecast

The historical noodles production data have been collected from the report of world instant noodles association [12]. The data collected from the survey seem to have slight variation from the actual data. The end-use demand of noodles is estimated using the following equation, as mentioned in different literatures [8], [9], [10], [11].

$(ESDnoodles)_t = (VA_t / VA_o)^{\beta}$ X $ESDnoodles,_o$

$(ESDnoodles)_t$ = end use service demand in year t for food sector

VA_t = value added in the food sector in year t

β = sectoral value-added elasticity of demand for noodles industry.

The future growth of GDP is forecasted using the regression model from the data available from various sources. Hence, growth rate calculated at low growth (LG) rate is considered to be at 3% per year. Similarly, the growth rate for normal (BAU) and high growth rate (HG) is considered to be 5.7% and 12.5% respectively. The forecasted GDP growth rate is used to generate the future growth rate of value addition of food and beverage sector. The sectoral value-added elasticity for noodles sector is calculated using above equation.

The historical data for national level food demand and value addition used is 20 years from 1990 to 2010. The elasticity of demand for food industry was determined to be 1.36. Present production capacity of noodles being 10.3 thousand metric ton is expected to reach approximately 213 metric ton in 2030, with a demand of 152 thousand metric ton in case of low growth rate scenario. Similarly, the demand would rise from 103 thousand metric ton in 2017 to 479 thousand metric ton in 2030 in case of high growth rate scenario. The historical and future noodles demand is shown in figure [3].

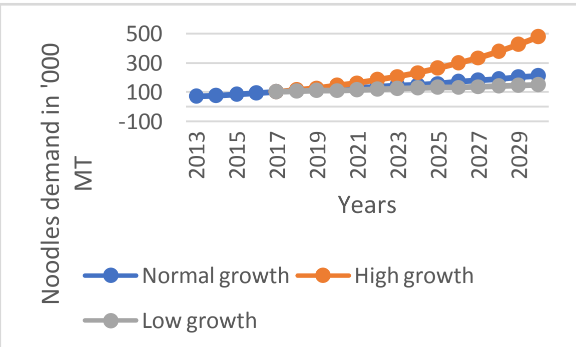

Fig. 3. Historical and Future noodles demand projection

3) General Assumption and Base Year

The following were the assumptions for the reference case scenario

· The base year is considered to be 2017.

· The major energy intensive fuels like electricity from grid and diesel gen-sets were considered for electrical energy.

· Rice husk, furnace oil, fuelwood, LPG and electricity are considered for thermal energy.

· The calculated value of final energy demand in the base year 2017 is 176.77 thousand GJ.

The energy demand for the base year 2017 in LG, BAU and HG is 47.99 thousand GJ. The final energy demand would increase to 70.47, 98.77 and 221.88 thousand GJ in 2030. The energy demand projection for different growth scenarios is shown in figure 4.

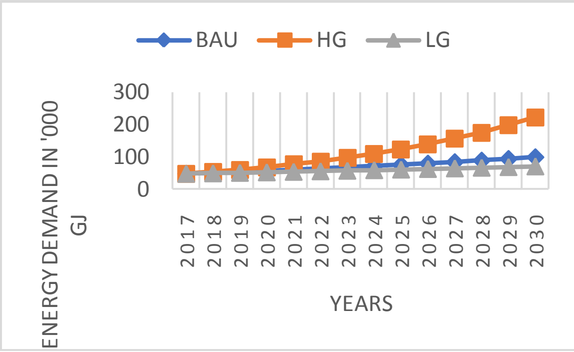

Fig. 4. Final Energy Demand for different growth scenarios (2017-2030)

4) Results of efficiency scenarios

The efficiency scenario is constructed as an efficiency improvement in technology employed in noodles industries. The scenario can be studied as an efficiency improvement in the three growth scenarios. In other words, efficiency scenario studies the effect of technological improvement in three growth scenarios viz. BAU, LG and HG scenario. The efficient BAU, efficient LG and efficient HG scenario projects the total cumulative final energy demand to be at 142, 160.7, and 176.12 thousand GJ, respectively. Compared to the BAU scenario, in EFF BAU scenario, 11% of total cumulative energy consumption can be reduced. Likewise, in MG and EFF MG scenario, 12% of total cumulative energy can be conserved. Finally, EFF HG scenario, 25% of energy can be conserved compared to HG scenario. The energy demand projection in efficiency scenario has shown with comparison to its corresponding growth scenario in Fig. 5, 6 and 7 for BAU, MG and HG scenarios respectively.

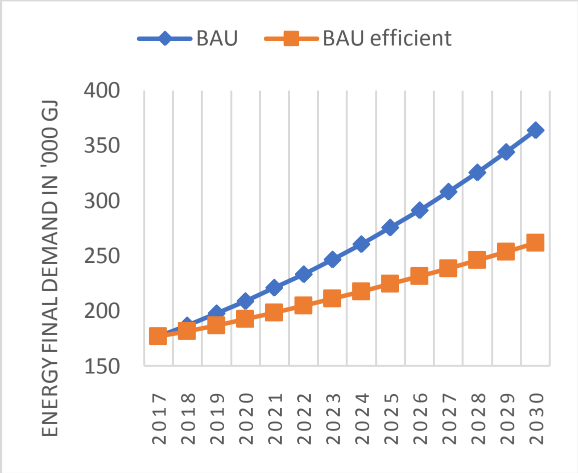

Fig. 5. Final Energy forecast under BAU and BAU efficient scenario

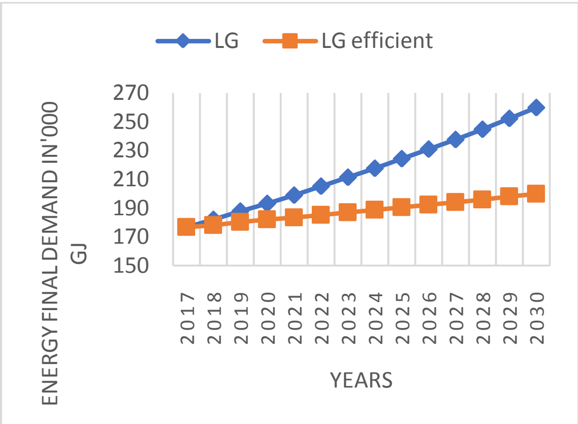

Fig. 6. Final Energy Forecast under Low growth and low growth efficient scenario

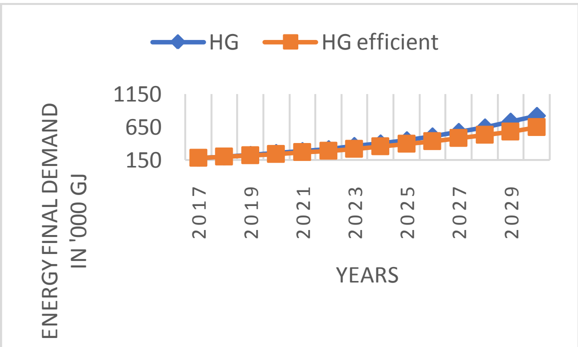

Fig. 7. Final Energy forecast of High growth and high growth efficient scenario

5) Savings Potential

After the creation of the model and generation of various scenarios, the savings potential for electrical and thermal energy was found to be as shown in the figure. Hence, it was found that under high growth the saving potential increases as opposite to that when the growth is low. It is thus imperative to replace the existing devices with efficient one in order to have a lot of energy savings.

Table 3. Saving Potential under Different Scenerios

Scenario	Electrical energy saving potential in'000 GJ	Thermal energy saving potential in '000 GJ
BAU	21.6	83.58
Low Growth	29.147	60.323
High Growth	97.47	182.47

V. CONCLUSION

Nepal is considered third largest per capita consumer of the instant noodles in the world. With the growing popularity Instant noodles not only in domestic circuit but also in the international circuit, as Nepalese noodles are being consumed in more than 40 countries of the world [13], the energy demand is also bound to rise. The increase of the domestic demand and its fulfillment, in future perspective, expects more noodles industries to commence the noodles production.

Currently, Nepal is producing about 103.6 thousand metric tonnes of Instant Noodles every year with the potential of producing 160 thousand metric tonnes of instant noodles. With various industries trying to expand their production capacity, it is quite necessary to evaluate the efficient measures that can be implemented to reach the demand with low energy consumption.

The production of Noodles reaches 213.24 thousand metric tonnes under business-as-usual scenario and under low growth scenario and high growth scenarios, it reaches 152.14 thousand metric tonnes and 479.01 thousand metric tonnes.

For the base year 2017, the final energy demand was 176.77 thousand GJ and it was predicted to become 363.84 thousand GJ in the year 2030 under BAU condition. However, with the low growth and high growth scenarios, it would reach 199.58 thousand GJ and 817.31thousand GJ respectively in the year 2030. Expecting certain improvements in different end-use process and increment in the efficiency of various equipment the demand will subside by a bit in each scenario discussed above. For BAU efficient scenario, the energy demand will become 261.48 thousand GJ, for Low growth efficient 199.58 thousand GJ and for high growth efficient 641.52 thousand GJ. This would lead to a saving of 29.15 thousand GJ of electrical energy in BAU approach with the potential of saving 21.6 thousand GJ of electrical energy under low growth approach and about 97.15 thousand GJ of electrical energy under high growth scenario. In terms of percentage about 8.01% of electrical energy can be saved under BAU with 8.32 % under low growth and about 11.88% under high growth scenario.

Similarly, about 60.32 thousand GJ of thermal energy will be saved under BAU approach with the potential of saving 83.58 thousand GJ of thermal energy under low growth scenario and about 182.47 thousand GJ of thermal energy under high growth scenario. In terms of percentage about 16.5% of thermal energy can be saved in Low growth conditions. Likewise, about 20.6% of thermal energy can be saved under business as usual and about 22.32% of thermal energy can be saved under high growth.

Hence, with the certain improvements in the end-use processes and increasing the efficiency in certain equipment, a significant portion of electrical and thermal energy can be saved in the Instant Noodles Processing Industry and with similar approach a huge amount of energy savings can be achieved in food and beverage sector which may ultimately benefit the country in the long run.

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