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Study on the Effect of Implementation of Best Available Technologies in Steel Rolling Mill Sector of Nepal

Sudan Neupane[1]*, Sanjeev Maharjan[2], Harish Chandra Dhital[3]

[1, 2] *Department of Mechanical Engineering, Institute of Engineering, Pulchowk Campus, Tribhuvan University, Nepal*
[3] *Nepal Electricity Authority*
***Corresponding author**: neupanesudan@ioe.edu.np

Abstract
Energy accounts for a significant share of the manufacturing cost. Nepalese industries are found to be using both electrical and thermal energy inefficiently and so there are huge possibilities of improvement in the consumption of energy in the industrial sectors. This obviously helps in reducing the production cost of the products and at the same time it enables the industry to come up with more profit and to compete with other foreign industries. Steel rolling industry being an energy intensive industry have numerous areas for increasing energy efficiency and reducing emission. This study consists of calculating present potential energy saving and developing future energy demand using Long range Energy Alternative Planning (LEAP) for the steel rolling mills of Nepal.
Present demand of 500 thousand MT is expected to reach 2.145 million MT in 2030 with a cumulative demand of 18.28 million MT from 2015 to 2030 in case of BAU growth scenario. The energy demand for the base year 2015 in BAU, MG, and HG is 906.5 Tera Joule (TJ). The final energy would increase to 2906.4, 3703.4 and 4889.3 TJ respectively in 2030 and the cumulative energy demand for BAU,MG and HG scenario would be respectively 33.14PJ, 40.289PJ and 50.85PJ. Compared to the BAU scenario, the cumulative energy demand rise would be 21.5% for MG and 53.4% for HG scenario. The CO2 emission for the base year 2015 in BAU, MG and HG is 63.8 thousand MT. The final CO2 emission would increase to 273.7, 370.5 and 524.4 thousand MT in 2030. The cumulative emission for BAU, MG and HG scenario would be respectively 2.33, 2.83 and 3.57 million MT. Compared to BAU scenario, the cumulative scenario would rise by 21.5% for MG and 53.4% for HG scenario.

Keywords
Energy efficiency – best available technology – steel rolling – energy demand – LEAP

1. Introduction

Iron ore is the basic raw material used in the iron and steel rolling industry. It is one of the most common materials found on earth and is mined in open pit mines and transferred by sea and rail to iron and steel plants in several parts of the world [1]. Due to its characteristics and its wide versatility ,steel plays an essential role in our everyday life. It has applications in the construction of buildings, bridges roads and railways, the manufacturing of vehicles, energy-producing technologies, means of transferring energy etc. Rolling is an important steel manufacturing process to provide a wide range of products used in automotive, construction and engineering works. History reveals that steel was discovered by China under the reign of Han Dynasty (202 BC – 220 AD) [2]. In Nepal Himal Iron and Steel (P) Ltd was established in 1961. In order to lead Nepal into self-sufficiency and to accelerate Nepal's infrastructure growth, Maniharsha Jyoti built the first Nepalese iron and steel factory in the jungles of Parwanipur, Parsa. At present, according to expertise there are twenty rolling mill in the different parts of country producing about 400 thousand tonne of TMT bars per year. The catastrophic earthquake of April 25, 2015 and the subsequent aftershocks have resulted in the huge loss of human, physical infrastructure and natural resources. Likewise 507,107 houses have been completely destroyed while 269,190 are partially damaged [3]. The demand of steel is expected to grow in coming days. This increase is consistent with the trend in the increase in its energy consumption. Ever-increasing consumption of energy has gone hand in hand with rising concerns about its conservation. Apart from being expensive and prone to sudden price fluctuations, the overwhelming majority of energy sources are non-renewable. Therefore, the conservation of energy is considered vital not just to avoid wastage of a precious resource, but also to slow down the rapid depletion of coal, oil, and natural gas resources. Energy audit and energy efficiency projects make good business sense now and even better in the future. There is huge demand of energy (electricity) in the industrial sector of Nepal but due to the crisis the demand has not been fulfilled. Industrial sectors account for 7.9% share of energy [4]. The GDP Share is 15.2% and the growth rate of industry is 2.7% from 2000 to 2014 AD [5]. Energy efficiency is the most cost effective way to reduce energy consumption and industrial greenhouse gas(GHG) emission in short to midterm [6]. The focus on energy efficiency is not only good for the environment but also profitable for industries, as it increases competiveness and productivity.

2. Literature Review

2.1 Industrial Policy 2010

The Industrial Policy, 1993 was framed with the objective of accelerating industrial sector. However, there has been no significant progress in our state of industrial development even after the passage of a long time of framing of the policy. Industrial development is rapidly going on all over the world including neighbouring countries one after another, however, this sector could not have progressed in its expected pace in Nepal [7]

2.2 Steel manufacturing process and energy saving potential

The industrial sector is the most important energy end-use sector in developing countries, and was responsible for 50% of primary energy use and 53% of associated carbon dioxide emissions in these countries [8]. The industrial sector is extremely diverse, encompassing the extraction of natural resources, conversion into raw materials, and manufacture of finished products. Iron and steel production consumes larger (1800 MJ / MT) quantities of energy, especially in developing countries and countries with economies in transition where outdated, inefficient technologies are often still used to produce iron and steel. Production of steel in developing countries has grown in recent years and is expected to continue to grow at similar levels. Greenhouse gas emissions in the steel sector are primarily the result of burning fossil fuels during the production of iron and steel.

3. Methodology

Literature review of different articles and corresponding industrial policy was performed. Different rolling industries of Nepal were visited for the primary data collection. Few data were taken from the secondary sources from GIZ, WECS, World Bank, CBS. The potential amount of saving has also been calculated. Data analysis and scenario analysis will be performed under different scenario.

3.1 Questionnaire Design

Standardized questionnaire requesting for specific information about the plant, production process, energy consumption rate, market etc was prepared and filled up during field visit. Similarly the questionnaire requested for energy audit and the implementation of best available technologies as found in different literatures.

3.2 Expert Interviews

Expert interviews were conducted to crosscheck data inputs and key assumptions made in the modelling process. Key assumptions included exhaust gas temperatures and penetration levels of BATs and existing waste heat to power technologies in Nepalese industry. Interviewees are international energy experts, industry experts, professors, and researchers working in the field of cogeneration, iron and steel sector, cement industry and energy services consulting. During the interview, barriers to implementing energy efficiency projects in industrial companies and barriers to invest in waste heat to power projects were discussed as well. Opinions of industrial experts were documented and used as an important source for identifying the most important barriers, in parallel to the survey results.

3.3 Growth Rate

The future steel TMT production in Nepal can be projected as a function of gross value addition in the rolling industry. The demand scenario can be classified as following:

- Business-as-usual (BAU) scenario (4.45%)
- Medium growth (MG) scenario (5.4%)
- Higher growth (HG) scenario (6.5%)

3.4 Demand Forecast

The end use of demand of steel TMT is estimated using the following equation, as mentioned in different literature [9]

$$ESD_{steel,t} = (\frac{VA_t}{VA_0})^{\beta} \times ESD_{steel,0} \quad (1)$$

where,
$ESD_{(steel,t)}$ = end use service demand in year t for steel sector
VA_t = Value added in steel sector in year t
β = Sectoral Value added elasticity of demand in steel industry in year
$\beta = 2.23$ for rolling industrial sector (calculated)

3.5 Scenario Assumption

To meet the objective of the research, the LEAP model is used to analyse and forecast energy demand and its related emission under alternative strategies in the steel rolling mill sector of Nepal for planning period of 2015-2030. Imagining the future is a challenging task. One method widely used to foresee the future consists of setting a baseline, usually a business-as-usual scenario and then evaluating alternative strategies by comparing them to that baseline. This study also followed this strategy in which three scenarios are considered to study the fuel consumption and different policy initiatives that would reduce total emissions in the rolling mill sector of Nepal. These scenarios are defined below

3.5.1 Business-as-Usual Scenario (BAU)

In the BAU scenario 2015 is selected as the base year and this scenario is selected as base scenario. The current trends of parameters in industrial sector are assumed to be increasing continuously. By extrapolating these trends values are projected to 2030 without any change.

3.5.2 Efficient scenario (EF)

The efficient scenario is constructed with the objective to observe the energy consumption pattern on decreasing the energy intensity determined by benchmarking the international standard. The specific fuel is 20-25 litre of oil (970-1040 MJ/T) and 60-85 kWh electricity (216-306MJ/T) in case of developed countries. Therefore total Specific Fuel Consumption (SEC) is 1786MJ/T for Indian Standard and 1274 MJ/T for developed countries [10]. So the following energy intensity improvement has been assumed for the planning period.

Table 1: Assumed energy intensity

Scenario	Energy	Final energy intensity after technology intervention in year			
		2015	**2020**	**2025**	**2030**
Efficient	Thermal (MJ/MT)	1425	1200	1050	975
	Electrical (kWh/MT)	105	85	80	70

3.5.3 Fuel switching scenario (FS)

Fuel switching scenario observes the effect on the environmental emission due to the alternative fuel penetration. In case of Nepal despite of very limited hydroelectric power, no petroleum and natural gas deposit has been found till the day. Despite of having abundant water resources and huge hydroelectric potential, Nepal has the lowest per capita electricity consumption in Asia i.e., 93 kWh vs. Asia average of 806 kWh (The World Bank, 2014). Assuming the big hydro power plant will be installed during the planning period. So the following fuel share has been assumed for the planning period.

Table 2: Assumed fuel share

	Fuel share (%)			
Year	2015	2020	2025	2030
Thermal Energy				
Furnace Oil	40	20	5	0
Coal	60	70	40	20
Hydro Electricity	0	10	55	80
Electrical Energy				
Hydro Electricity	80	95	98	100
Diesel	20	5	2	0

4. Result and Analysis

4.1 Energy efficient measure applicable in steel industries of Nepal

Energy accounts for a significant share of the manufacturing cost. Nepalese industries are found to be using both electrical and thermal energy very inefficiently and so there are huge possibilities of improvement in the consumption of energy in the industrial sectors. Baseline study conducted by GIZ shows that there is the electrical saving potential of 6.17% and the thermal saving potential is 22.97% (GIZ/NEEP, 2012:). This research shows that 8.14% in electrical energy can be saved by improving power factor and 10% fuel can be saved by using the waste heat recovery system. Also the thermal energy can be saved by proper insulation of furnace, recuperator, coal feed pipe, burner cover etc. So these values are comparable with baseline study report. Due to the extensive use of motors in steel rolling mill, the efficiency of plant can be improved by the use of energy saving and efficient motors. The use of variable frequency drive can also be used.

4.2 Result of growth scenario

4.2.1 Energy demand projection

The energy demand for the base year 2015 in BAU, MG, and HG is 906.5 Tera Joule (TJ). The final energy would increase to 2906.4, 3703.4 and 4889.3 TJ respectively in 2030. The cumulative energy demand for BAU,MG and HG scenario would be respectively 33.14PJ, 40.289PJ and 50.85PJ. Compared to the BAU scenario, the cumulative energy demand rise would be 21.5% for MG and 53.4% for HG scenario.

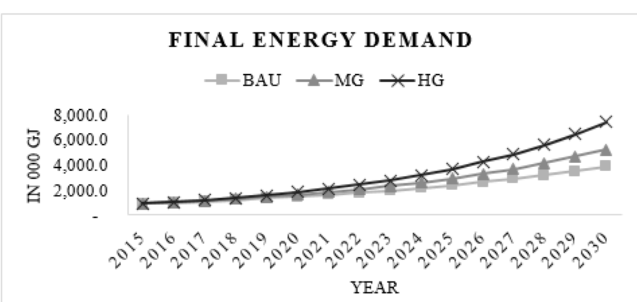

Figure 1: Final Energy Demand Forecasted under different growth scenario

4.2.2 Emission projection

The CO2 emission for the base year 2015 in BAU, MG and HG is 63.8 thousand MT. The final CO2 emission would increase to 273.7, 370.5 and 524.4 thousand MT in 2030. The cumulative emission for BAU, MG and HG scenario would be respectively 2.33, 2.83 and 3.57 million MT. Compared to BAU scenario, the cumulative scenario would rise by 21.5% for MG and 53.4% for HG scenario.

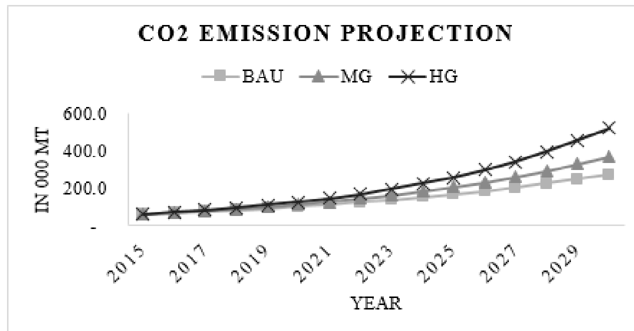

Figure 2: CO2 Emission forecasted under different growth scenario

4.3 Result of Efficient Scenario

The efficient scenario is constructed as an efficiency improvement in the technology employed and accordingly decrease in the fuel intensity in steel rolling mill. The efficient scenario studies the effect of technological improvement in the BAU, MG and HG scenario. The EF BAU, EF MG and EF HG scenario projects the total cumulative final energy demand to be 25.34 PJ, 30.52PJ and 38.14PJ respectively. Compared to the BAU scenario EF BAU scenario, 23.5% of total cumulative energy consumption can be reduced. Similarly in MG scenario and EF MG scenario, 24.25% of total cumulative energy can be saved. Again comparing HG scenario with EF HG scenario 25.1% can be saved.

4.4 Result of fuel switching scenario

The result of fuel switching is considered only for emission reduction assuming that the penetration of alternative fuel in long run substitute the use of furnace oil and bituminous coal from the base year till the planning period (2015-2030). With the switching of fuel, its effect can be summarized in emission reduction in different growth scenario viz. FS BAU, FS MG and FS HG.

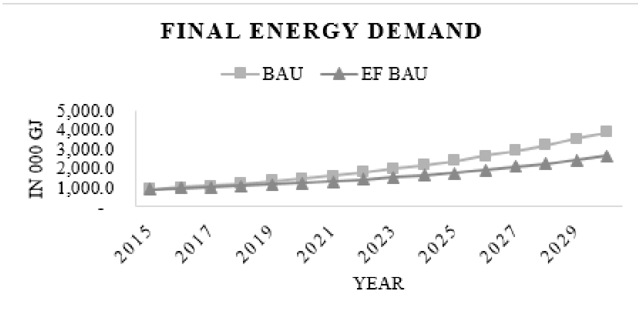

Figure 3: Comparison of energy demand in EFBAU and BAU

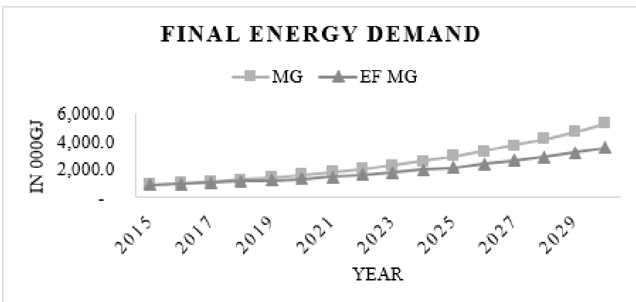

Figure 4: Comparison of energy demand in EF MG and MG

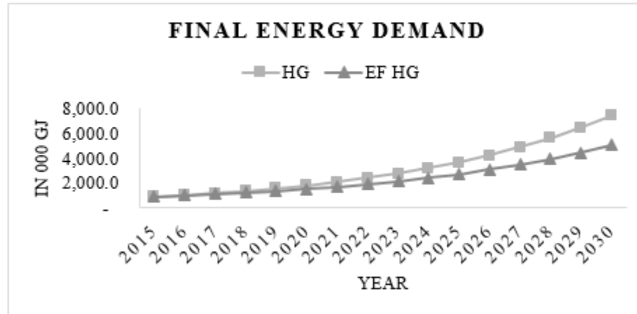

Figure 5: Comparison of energy demand in EF HG and HG

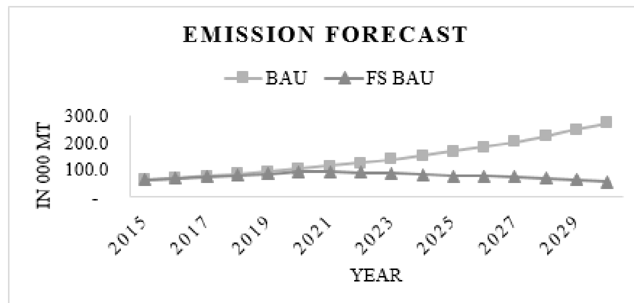

Figure 6: Comparison of CO2 emission in BAU and FS BAU Scenario

5. Conclusion

Nepal is a developing country with huge potential of investment in the sector of Hydropower. Industrial development is at a pre mature state and requires a lot of technical and financial investment along with a strong industrial policy. Due to the increasing construction work and developmental activities, Steel rolling mill has a potential to grow in future. At present the annual demand for the steel rod is 500 thousand metric tonne, with domestic industries fulfilling up to 80%. The demand of steel is expected to grow in coming days. The growth of steel rod demand is studied in growth scenario as business as usual (BAU), Medium Growth (MG) and High Growth (HG) with a growth rate of 4.45%, 5.4% and 6.5% respectively. The historical data for steel rod demand and the value addition of the manufacturing sectors from different sources has been used to calculate the elasticity of demand for steel rod. After the log-linear regression method the value of elasticity is calculated to be 2.23.

Present demand of 500 thousand MT is expected to reach 2.145 million MT in 2030 with a cumulative demand of 18.28 million MT from 2015 to 2030 in case of BAU growth scenario. Long-range Energy Alternative Planning (LEAP) modelling tool was used to conduct the scenario analysis for the planning period of 2015-2030. Three different scenarios were used viz. Business as usual, Efficient Scenario and Fuel Switching Scenario.

The energy demand for the base year 2015 in BAU, MG, and HG is 906.5 Tera Joule (TJ). The final energy would increase to 2906.4, 3703.4 and 4889.3 TJ respectively in 2030. The CO2 emission for the base year 2015 in BAU, MG and HG is 63.8 thousand MT. The final CO2 emission would increase to 273.7, 370.5 and 524.4 thousand MT in 2030. The EF BAU, EF MG and EF HG scenario projects the total cumulative final energy demand to be 25.34 PJ, 30.52PJ and 38.14PJ respectively. Compared to the BAU scenario EF BAU scenario, 23.5% of total cumulative energy consumption can be reduced. Similarly in MG scenario and EF MG scenario, 24.25% of total cumulative energy can be saved. Again comparing HG scenario with EF HG scenario 25.1% can be saved. The FS BAU, FS MG and FS HG scenario projects the total CO2 emission to be at 1.2 million MT, 1.74 million

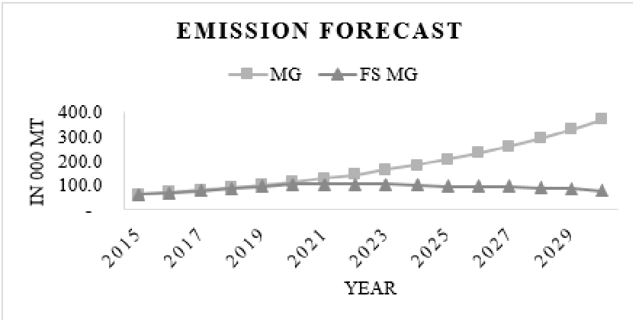

Figure 7: Comparison of CO2 emission in MG and FS MG Scenario

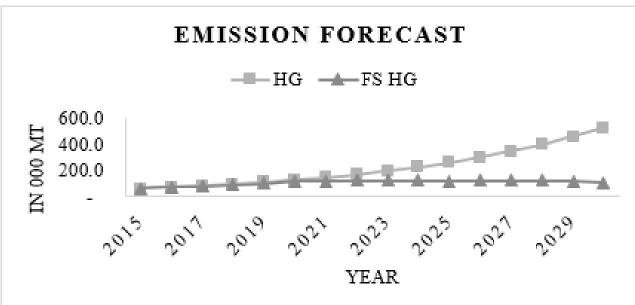

Figure 8: Comparison of CO2 emission in HG and FS HG Scenario

MT and 1.45 Million MT respectively. Compared to the BAU scenario, in FS BAU scenario 46% of total cumulative emission can be reduced. Similarly, in FS MG and MG scenario, 38.3% of emission can be reduced. Again comparing HG scenario with FS HG scenario, 59.3% of emission can be reduced.

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