Energy Demand and Green House Gas Emission Forecast and Scenario Analysis of Dharan Industrial Sector, Nepal

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Abstract: In this study the energy demand and Green House Gas emission for Dharan Industrial sector have been forecasted by using Long Range Energy Alternative Programming as research tool. Data were taken from twenty two industries of this sector. The Business As Usual and Clean Energy Technology scenarios have been developed for both energy demand and Green House Gas emission for their forecast. The year 2013 has been taken as the base year, 2015 as first scenario year and forecasting has been done up to the year 2030. For scenarios, the national population growth (1.4%), the regional population (21% of national population) and industrial Gross Domestic Product growth (4.3%), the sector industrial Gross Domestic Product (3.3% of national industrial Gross Domestic Product) has been taken. The National population, Regional population, National and Industrial Gross Domestic Product were taken as key assumption for the programming and Industrial growth was keyed to Industrial Gross Domestic Product. The Clean Energy Technology scenario has been so developed that the boilers and Furnaces (the category-thermal power) using fossil fuels are completely replaced by electric boilers and electric furnaces by 2030. The total industries of this sector were categorized into seven categories. For each category demand were categorized as Energy for thermal power and Energy for Motive power. The large amount of Green House Gas was found to be reduced and also energy demand would reduce after implementation of CET scenario. The electricity supply was found be surplus even when the sector goes through Clean Energy Technology scenario. For financial analysis the Internal Rate of Return and Net Present Values were calculated and showed the feasible of the project. Similarly, the Risk analysis showed the almost 99% certainty for the values calculated for the financial analysis.

Keywords: Energy demand, GHG emission, BAU scenario, CET scenario, GDP.

1. Introduction

This industrial sector lies in Dharan, a major city in eastern Nepal, in the Sunsari District, and is situated on the foothills of the Mahabharat Range in the north with southern tip touching the edge of the Terai region at an altitude of 1148 ft (349m). This sector is a part of Sunsari-Morang industrial corridor of the eastern development region of Nepal. The Sunsari-Morang industrial corridor led the country towards industrialization and accounts for almost one-third of the nation's total production is facing difficulties in implementing industrial development strategies due to energy crisis, policy hurdles. As government has planned to build special economical zone in this corridor, the industries in such zone will have to export their product in the foreign market, which in turn help in reducing the trade deficit. This will also reduce the operating cost of the industries and thus can compete the international markets. The construction of the Nijgadh-Kathmandu and Bagmati corridor will reduce the distance between the Dharan to Kathmandu and imported goods can be easily transported to Kathmandu at cheaper cost. Also Dharan- Biratnagar gets connected through broad-gauge railway, so the transportation charge will be low. One very important thing is that the Rohanpur, the bordering area of Bangladesh is just 230 km from the Jogbani border and Mangala port of the Bangladesh is 606 km from the Rohanpur, so the goods can be easily imported via this port at lower cost.

The Dharan industrial sector houses almost 33 small and big scale industries. Out of which 22 are in running phase and 6 industries are in construction phase. This sector had established in B.S. 2029. It is located in beautiful city Dharan of ward number 8 and is 36 km north to the nation's biggest industrial sector, Biratnagar. The area of Dharan industrial sector is 16 Bigaha (202 ropani). In the east of this sector is IOE, Purwanchal Campus; in the west Radio Nepal, in the north Dharan market and in the south jungle area. It has more opportunities, but has also much more threats. The boilers and furnaces are completely relied on fossil fuels even though there is 700 KVA power supplied by the NEA at least for 16 hours entire year, which in turn increases the green house gas emission. Industries of this sector are run for two shifts. So, it is important to find the energy demand and Green House Gas (GHG) emission due to the fossil fuel used in this sector for BAU scenario and their reduction when go through Clean Energy Technology (CET) scenario so that it can give clear figures of the energy requirement and GHG emitted and can be helpful for developing the green energy strategies.

According to German's energy policy the Greenhouse gas reduction is targeted 80–95% by 2050 .Renewable energy targets 60% share by 2050 (renewable broadly defined as hydro, solar and wind power) and energy efficiency: electricity efficiency up by 50% by 2050.

The energy policy targets of Nigeria are 18% of electricity from renewable by 2025, 20% of electricity from renewable by 2030, 100 MW of small hydro capacity by 2015 and 760 MW by 2025, 300 MW of solar photovoltaic capacity by 2015, 4,000 MW in 2025, 40 MW of wind capacity by 2025, 5 MW of biomass-fired capacity by 2015 and 30 MW by 2025.

Lithuania's main policy is to use local resources to fulfill the demand, discard import of polluting fuels, be energy independence and reduce the green house gases emission by increasing the use of Renewable Energy Sources (RES). The renewable energy consumption in 2011 was 18.3%, Biomass- 86.5%, Liquid bio-fuel-4.4%, hydropower- 3.9%, wind energy-3.9%, biogas-1.0% and geothermal-0.3%. Increasing the use of RES is the main national reform program of the Lithuania. Its target is to increase the use of RES to 23% by 2020. Energy produced from RES in 2011 was 20.3% and in 2010 it was 19.8%. Production of energy from RES is supported by the nation

China's green energy policy is found somewhat different in the sense that its policies are not seeking to replace the fossil fuel. China aims to develop new and renewable energy (hydro, solar, wind, biomass, nuclear, etc) so developed energy can be used for more production and to meet the future demand.

According to China's detailed study for its future development, Chinese communist party and the state council predicts that renewable energy accounts 12-18% of total energy consumption. This will increase 16-24% in 2030 and 23-40% in 2050.

According to China's assumption, the total energy consumption will be doubled in 2050 compare to base year 2006 and the contribution of renewable energy will be 38-69% by 2050 (project group 2011:28)

China's 11th five year plan (2006-2010) focuses on the investment to green sector to introduce green energy. According to this plan the energy consumption would decrease by 20% compare to 2005. And also Government's commitment to produce 16% of its primary energy from renewable energy source by 2020.

Nepal's Tenth Five Year Plan (2002-2007) emphasizes on increasing the consuming capacity of rural families by developing and extending the alternative energy sources, seen as a powerful tool for poverty alleviation ,supplying energy for commercialization of the domestic needs and the professions of rural population by developing alternative energy technologies based on local resources and tools , reducing dependency on imported energy sources and reducing negative environmental effects by the proper use of resources and tools of local energy and improving and increasing the energy use competency and increasing the access of rural people by reducing the cost of development and installation of alternative sources of energy.

According to WECS energy strategy-2012 for Clean Energy Clean Energy Technology (CET) scenario the fossil fuels should be decreased by 20% by 2020 and by 30% by 2030.

2. Methodology

The activity level data and energy intensity data were interpreted into the Long Range Energy Alternative Programming (LEAP) tool. For LEAP modeling the National population, Regional population, National GDP and Industrial GDP were taken as the key assumption and their values and growth were rate taken in the modeling are shown in table 1 below.

Table 1: Key assumption

Branch	2013 value	Expression	Scale	Unit
National population	26.5	Growth (1.4%)	Million	Person
Regional population	5.81	National population X 0.21	Million	Person
National GDP	613.9	Growth (4.3%)	Billion	NPR
Industrial GDP	20.26	National GDP X 0.033	Billion	NPR

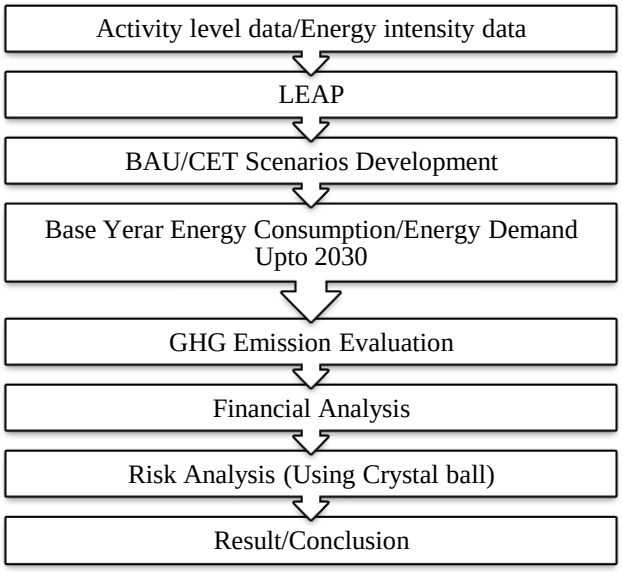
In the LEAP modeling, the total running 22 industries of this sector were branched into seven categories and they are Plastic industry, Metal industry, Tobacco based industry, Chemical industry, Steel industry, Food industry and Dairy industry.

Each branch has categorized into thermal power and motive power. Thermal power means the power used for boiling or heating. Thus, thermal power has further categorized into boiler power and furnace power. The boilers and furnace have further categorized according to fuels they used. The motive power has categorized into power from hydropower and power from diesel generator. The power from hydropower has denoted by motor and that of from diesel generator by generator.

The industry demand has keyed to the industry's GDP. The national population has taken 26.5 Million and the regional population 5.81 million (21% of the national

population). The industrial GDP has taken 20.26 Billion of Nepalese Rupees (3.3% of the national GDP, 613.9 Billion of Nepalese Rupees).

In the current account the activity data and energy intensity were used whereas in CET scenario the energy intensity data for end year and scenarios for fossil fuel reduction were considered. The BAU and the CET scenarios have developed for both energy demand and GHG emission from the base year 2013 to end year 2030. The results have analyzed for both BAU and CET scenarios.



3. Result and discussion

3.1 Energy demand (BAU scenario)

The energy demand of the sector has been forecasted using Business As Usual scenario (BAU), as below. The BAU scenario is that in which the current scenario of the industries are considered. There is no introduction of new technologies and also the fossil fuels are not replaced by electricity.

3.1.1 Total energy demand

The total energy demand of the sector according to BAU scenario found is shown in figure 1 below.

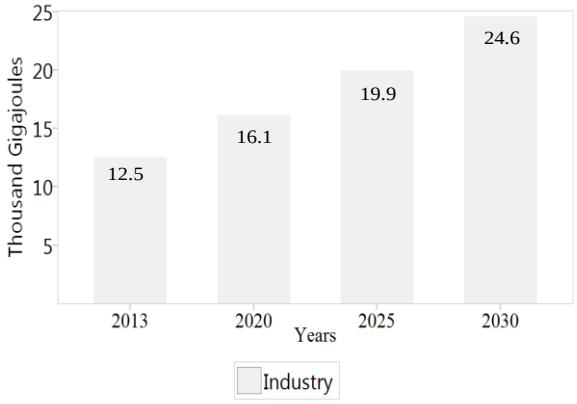


Figure 1: Energy demand of industry (BAU)

This shows energy demand of this industrial sector in the base year 2013 is 12.5 thousand of Gigajoules, in the year 2020 will be 16.1 thousand of Gigajoules, in the year 2025 will be 19.9 thousand of Gigajoules and that in the end year 2030 it will be 24.6 thousand of Gigajoules. That is from base year 2013 to end year 2030 the energy demand is increased by 96.8%.

3.1.2 Energy demand- Industry wise

The industries wise energy demand of the sector for the base year 2013, for the year 2020, for the year 2025 and the end year 2030 are tabulated in the table 2 below. The table 2 shows that the energy demands of plastic industry and metal industry have high values compared to other industries of the sector.

Table 2: Energy demand industries wise (in GJ)

Year/ Industry	2013	2020	2025	2030
Plastic Industries	5055.6	6508.8	8033.8	9916.1
Metal Industries	5046	6496.4	8018.6	9897.3
Tobacco based Industries	1734.4	2232.9	2756	3401.8
Chemical Industries	14.2	18.3	22.6	27.9
Steel Industries	47.8	61.5	75.9	93.7
Food Industries	405.3	521.8	644.1	795
Dairy Industries	236.4	304.4	375.7	463.7
Total	12539.7	16144.1	19926.7	24595.6

3.1.3 Energy demand-fuel wise

The fuel- wise energy demand for the sector is shown in the table 3 for the years 2013, 2020, 2025 and 2030.

Table 3: Energy demand fuel wise (in 1000 GJ)

Year/ Fuel	2013	2020	2025	2030
Coal Bituminous	2.2	2.8	3.5	4.3
Diesel	1.8	2.3	2.9	3.6
Electricity	6	7.7	9.5	11.7
Oil	2.3	3.0	3.7	4.6
Wood	0.2	0.2	0.3	0.4
Total	12.5	16.1	19.9	25.6

The table 3 shows more than 50% of energy demand is met by fossil fuels. Among these, the consumption of oil, coal and diesel are high.

3.2 GHG emission (BAU scenario)

The GHG emission of the sector has found using the LEAP as a research tool and forecasted it from base year 2013 to end year 2030. The forecasting values have been shown for the base year 2013, for the year 2020, for the year 2025 and the end year 2030.

3.2.1 GHG emission-sector

The figure 2 shows the GHG emission for the sector. The values are located in the figure. The values for base year and end year and between these two years, the values for the years 2020 and 2025 are shown in figure 2. The term industry in the figure represents the total industry of the sector.

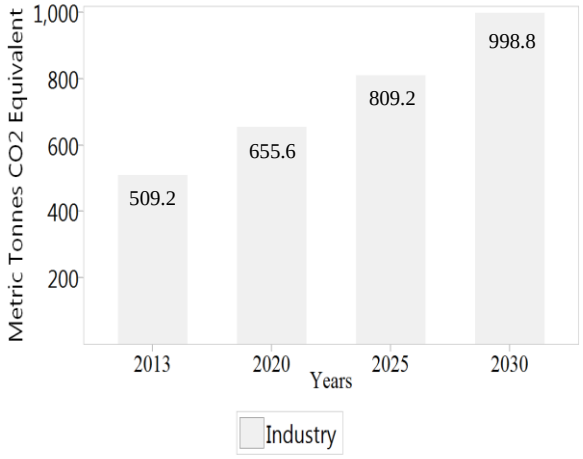


Figure 2: GHG emission for the sector

It is seen from above figure that the GHG emission in the base year is 509.2 Metric ton of CO_2 equivalent and that for end year 2030 it will be 998.8 Metric ton of CO_2 equivalent. The same value for the years 2020 and 2025 will be 655.6 and 809.2 Metric ton of CO_2 equivalent respectively. The growth rate of GHG emission in the end year compare to base year has found to be 96.15%.

3.2.2 GHG emission-Industries wise

The industries wise GHG emission shows that Metal industry of this sector produces more emission. The value in base year for the metal industry is 402.5 Metric ton of CO_2 equivalent and that in the end year it will be 789.4 Metric ton of CO_2 equivalent (table 4). The same value for the metal industry for the years 2020 and 2025 will be 518.2 and 639.6 Metric ton CO_2 equivalent. The second highest position will be taken by tobacco product based industries. The base year and end year values for the tobacco based industry would be 101.9 and 208.5 Metric ton of CO_2 equivalent respectively. The others industries of the sector have less GHG emission compared to metal and tobacco based industries as shown in the table 4, below.

Table 4: GHG emission industries wise (in Mt CO_2 equivalent)

Year/ Industry	2013	2020	2025	2030
Plastic Industries	0.4	0.5	0.6	0.7
Metal Industries	402.5	518.2	639.6	789.4
Tobacco based Industries	101.9	131.2	161.9	199.9
Steel Industries	0.6	0.8	1	1.2
Dairy Industries	3.9	5.0	6.2	7.6
Total	509.2	655.6	809.2	988.8

3.2.3 GHG emission-Fuel wise

The fuel wise GHG emission is shown in the table 5. The GHG emission will be high in case of coal fuel whereas oil and Diesel will occupy second and third position in emitting GHG. The GHG emission by the wood fuel has found to be the least.

Table 5: GHG emission Fuel wise (in Mt CO_2 equivalent)

Year/ Fuel	2013)	2020	2025	2030
Coal Bituminous	206	265.1	327.3	404.0
Diesel	132.3	170.3	210.2	259.5
Oil	170.6	219.7	271.1	334.7
Wood	0.3	0.5	0.6	0.7
Total	509.2	655.6	809.2	998.8

3.3 Energy demand (CET scenario)

Clean Energy Technology (CET) scenario is that in which clean energy technologies are introduced thereby reducing the use of fossil fuels gradually.

3.3.1 Total energy demand

The total energy demand for the sector (industry) is shown in the figure 3. The base year consumption has found 12.5 thousand of Gigajoules and for end year the energy demand will be 22.7 thousand of Gigajoules. In this scenario the year 2015 was taken as the first scenario year. The coal, oil, diesel boilers and furnaces were reduced by 50% by 2020 and by 100% by 2030. The wood boilers and furnaces were replaced by 70% by 2020 and 100% by 2030. The diesel generators were replaced by 20% by 2020 and by 70% by 2030.

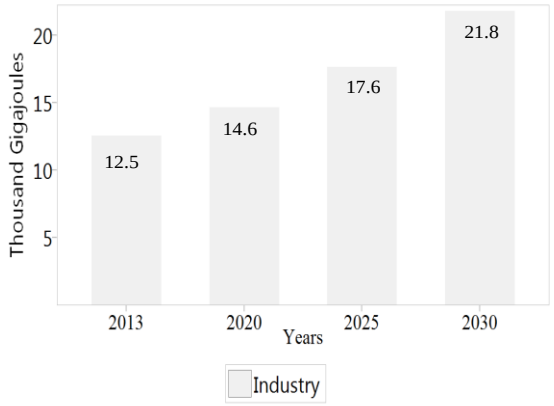


Figure 3: Total energy demand (CET)

The industry demand for energy as shown in figure 4 shows that the demand will decrease if go through the CET scenario. In the end year the demand will decrease by 2.8 thousand of Gigajoules. This is due to the fact that the efficiency of fossil fuel boilers and furnaces and also generators being less.

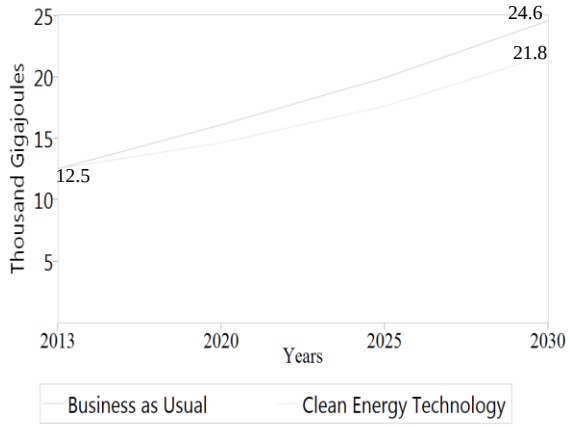


Figure 4: comparison of energy demand for BAU and CET scenarios

3.3.2 Energy demand-industries wise

The industry wise demand shows that the demand for the industries when replaced by Clean Energy technology get decreased, as shown in table 6.

Table 6: Energy demand industry wise (in GJ)

Year/Industry	2013	2020	2025	2030
Plastic Industries	5055.6	6547.7	8142.0	10123.9
Metal Industries	5046.0	5222.1	6261.5	8042.0
Tobacco based Industries	1734.4	1964.3	2093.3	2188..8
Chemical Industries	14.2	18.3	22.6	27.9
Steel Industries	47.8	64.5	84.1	109..5
Food Industries	405.3	521.8	644.1	795.0
Dairy Industries	236.4	307.7	397.8	520.0
Total	12539.7	14646.5	17645.4	21807.2

3.3.3 Energy demand-Fuel wise

The fuel wise energy demand shown in table7 shows that demand for fuels- coal, oil and wood will be zero in the end year 2030 and are totally replaced by electricity. The demand for the diesel for generators will not be zero in the end year as it is not completely replaced by electricity. It is only replaced by 20% and 70% by the years 2020 and 2030 respectively.

Table 7: Energy demand fuel wise (in 1000 GJ)

Year/Fuel	2013	2020	2025	2030
Coal Bituminous	2.2	1.5	0.9	0
Diesel	1.8	1.9	1.6	1.1
Electricity	6	10.2	14.8	21.7
Oil	2.3	1.6	1	0
Wood	0.2	0.1	0	0
Total	12.5	15.3	18.4	22.7

3.4 GHG emission (CET)

The GHG emission from the sector when CET will apply will reduce from 509.3 Metric ton of CO_2 equivalent from base year 2013 to 75.9 Metric ton of CO_2 equivalent in the end year 2030, as shown in figure 5. The comparison of GHG emission for both scenarios is shown in the figure 6. It is seen from figure 6 that 922.9 Metric ton of CO_2 equivalent GHG

emission will reduce when CET scenario is applied in the end year 2030. The GHG emission industries wise and fuels wise are shown in tables 8 and 9 respectively.

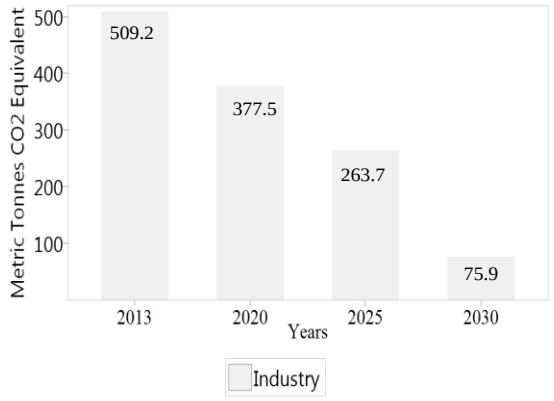


Figure 5: GHG emission of sector

From the table 8 & 9, it is clear that GHG emission will reduce to 75.9 Metric ton of CO_2 equivalent in the end year from the base year value 509.2 Metric ton of CO_2 equivalent.

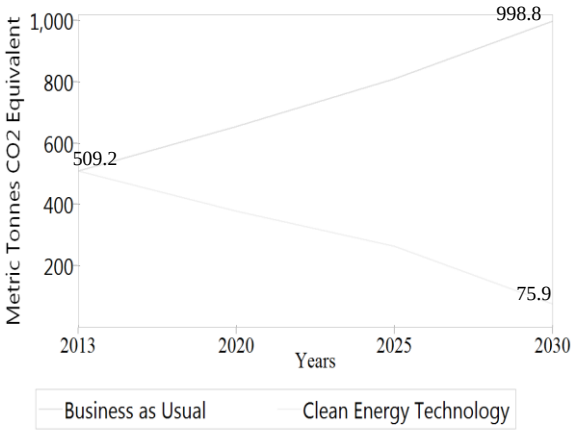


Figure 6: comparison of GHG emission for BAU and CET scenarios

Table 8: GHG emission Industries wise (in Mt CO_2 equivalent)

Year/Industry	2013	2020	2025	2030
Plastic Industries	0.4	0.4	0.3	0.2
Metal Industries	402.5	269.0	172.2	15.2
Tobacco based Industries	101.9	104.8	88.9	59.8
Steel Industries	0.6	0.6	0.5	0.4
Dairy Industries	3.9	2.7	1.8	0.3
Total	509.2	377.5	263.7	75.9

Table 9: GHG emission fuel wise (in Mt CO_2 equivalent)

Year/Fuel	2013	2020	2025	2030
Coal Bituminous	206	132.6	81.8	0
Diesel	132.3	135.0	114.1	75.9
Oil	170.6	109.8	67.8	0
Wood	0.3	0.1	0.1	0
Total	509.2	377.5	263.7	75.9

3.5 Electricity Demand and supply

The figure 7 shows the demand, supply and surplus of electricity in the sector. The supply of the electricity to the industrial sector is 700 KVA and as per WECS energy strategy 2012, the supply is increased by 10% per year and it can be seen that when fossil fuel devices are replaced by electrical devices (CET scenario), there will be even surplus electricity to the sector.

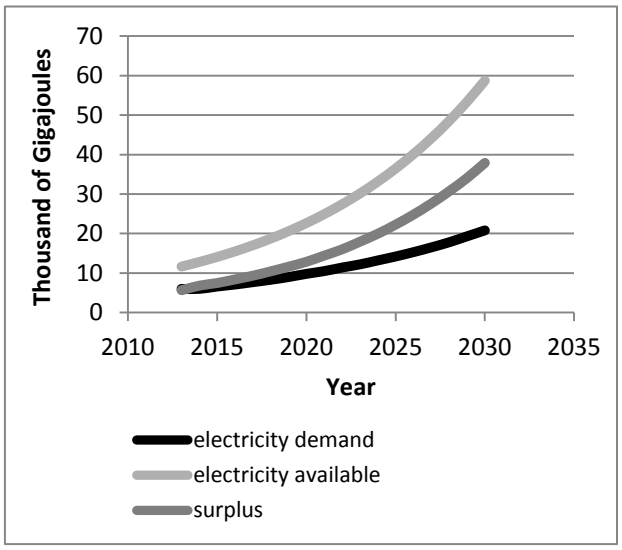


Figure 7: Demand and supply of electricity

3.6 Financial Analysis

Financial analysis has been carried out and the Internal Rate of Return (IRR) and Net Present Value were found as

IRR=26%

NPV=NRs. 4,411,803.563

The internal rate of return (IRR) value came to be 26%. In financially IRR value more than 10% is supposed to be good sign for a project. Thus 26% IRR shows that the project would feasible. The net present value (NPV) has come to be NRs 4,4, 11803.563. This shows the present worth of the net cash inflow. The positive NPV means the project is feasible.

3.7 Risk Analysis

Simulation has carried out for risk analysis using Cristal ball tool. For that the total cost of the new electric furnaces and boilers were taken as project cost and the saving from the fuels were taken as cash inflow. The cost of the project was made assumption and IRR and NPV were forecasted for this analysis

The results found are shown in figures 8 & 9. Figure 8 shows that 99.33% certainty is for the project having NPV between Rs 44, 11,803.50 and Rs 54, 00,000.00.

From figure 9, it is clear that 99.85% certainty is for IRR between 27 – 31%.

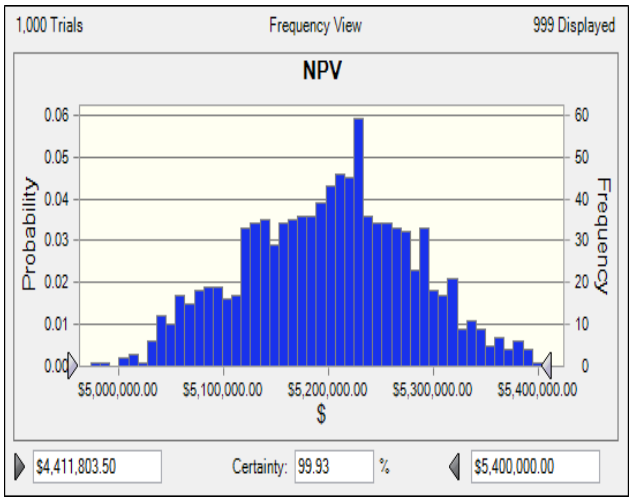


Figure 8: NPV Analysis

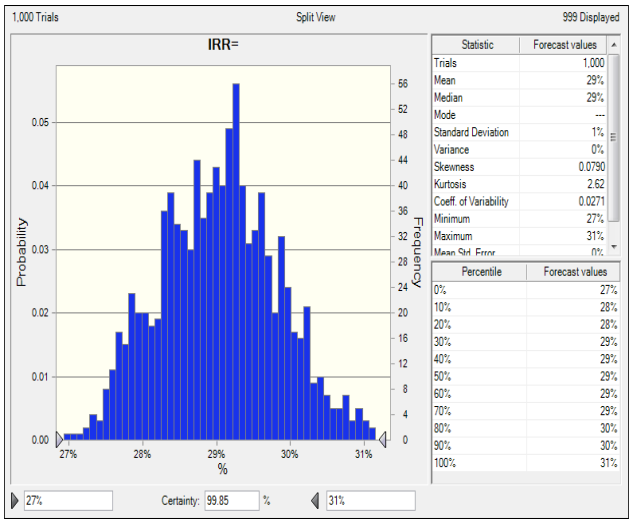


Figure 9: IRR Analysis

4. Conclusion

The total energy demand can be decreased. For example, in the end year 2.8 thousand of Gigajoules of energy demand can be reduced through CET scenario.

The boilers and furnaces of the sectors can be totally replaced by electric boilers and electric furnaces by the year 2030.

The GHG emission can be reduced by 85.09% in the end year compared to base year.

The sector can be made green as there will be surplus of electrical energy even though the fossil fuels devices will be replaced by electric devices.

The project will be feasible as IRR value has come 26% and NPV value NRs. 4,411,803.563.

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