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Analysis of Green House Gas Emissions Through Cogeneration with Special Reference to Sugar Industry

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Abstract—*Anthropogenic activities are the important cause of Greenhouse Gases (GHGs) emissions to the atmosphere. The industry sector focused to conduct GHGs inventory assessment in order to know the critical area of GHGs emissions and to find the options for reducing the GHGs emissions. This research uses for estimating the GHGs emissions in a sugar factory through Bilan Carbone method. The emission factors related especially to the sugar factory and India were reviewed and estimated. The research takes into description all the main actions leading to GHGs emissions in the factory. The consequence of GHGs emissions showed in term of tons CO_2 eq. (equivalent). The activity data was collected at the M/s Panipat Cooperative Sugar Mills Ltd., Gohana Road, Panipat, Indiafor the session 2017-18. The current capacity of the sugar plant in Panipat is 1800 TCD (Tons of cane per day) (on 24 hours crush/day) 231198 TPA (Tons per annum) of raw sugar per year. A total of approximately 6.000 million tons of carbon are released annually (one ton of carbon equals 366 Tons of CO_2); and on the order of 3000 million tons remain and build up in the air.*

Keywords:— *GHG emission, Sugar Industry, Biomass, Cogeneration, Bilan Carbone method, Power production.*

1. INTRODUCTION

Biomass has always been an important energy source for the country. Biomass accounts for 32% of the total primary energy use in the country and more than 70% of the country‘s population depends upon it for its energy needs. The Biomass produce more than 6000 million units electricity per year also provide employments of greater than 12 million peoples in rural area in India. In India Biomass available is about 500 million metric tons per year. After the study we find 120–150 million metric tons per annum biomass is converted energy potential of about 18,000 MW. Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, and groundnut shells, saw dust etc. In India the total accessibility of biomass is estimated at about 500 million metric tons per year. Biomass availability at about 120–150 million metric tons per annum covering agricultural and forestry residues corresponding to a potential of about 18,000 MW.

1.1 GHG Emission and energy consumption in India

Although India’s per capita energy consumption is one of the lowest (and much lower than developed countries) India still ranks 4th largest energy consuming nation in the world according to the latest report released by U.S Energy Information & Administration.

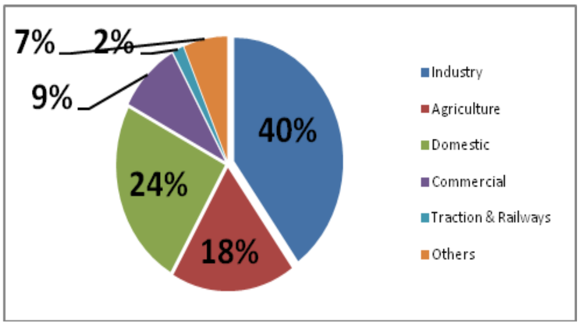

Figure 1: Sector wise electricity consumption in India

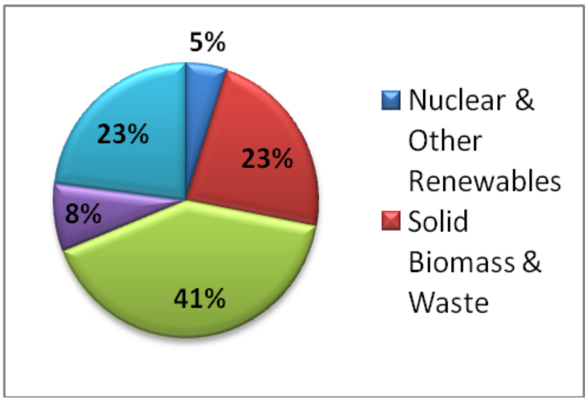

Figure 2: Total energy consumption in India, 2018 (Source: EIA US)

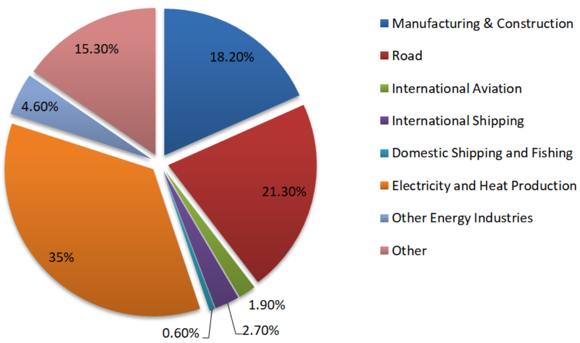

Figure 3: Global CO_2 Emission by Sectors

The following key results emerge from the studies.

India‘s per capita GHG emissions in 2030-31 vary from 2.77 tons to 5 tons per capita. This may be compared to the 2005 global average per capita GHG emissions of 4.22 tons of CO_2 per capita.

In India‘s GHG emissions in 2031 vary from 4.0 billion tons to 7.3 billion tons of CO_2.

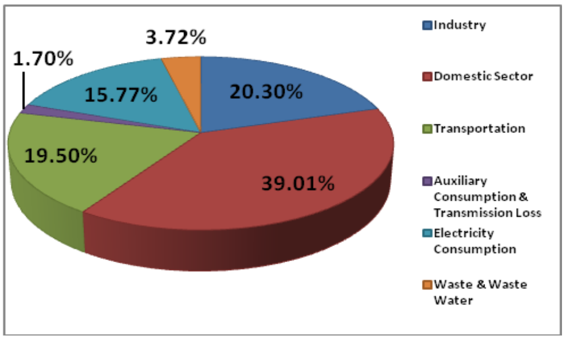

Figure 4: Sector wise CO2 Emission in India

1.2 Overview of India's sugar sector

Sugar industry in India after textile is the second largest agriculture based industry. Currently about 4 million hectares of land in India is under sugarcane with an average yield of 70 tons per hectare. Out of total 566 sugar mills, 315 are in co-operative sector and 251 in the private sector. There are 15 sugar mills in operation in Haryana alone, with an annual capacity of 4825 tons of sugarcane crushing capacity. The sugar sector is an important pillar of the Indian economy as it provides livelihood to 50 million farmers and to 5 million workers directly employed in sugar factory. Sugar mills in India are heterogeneous in terms of ownership, technology, size etc. Based on ownership structure mills can be classified into three categories private mills, public mills and cooperative mills.

1.3 Energy situation and Government Policy

The projected energy shortage in N-E will be 7.7 per cent, compared to 11 per cent in the western region. Cogeneration, as the name suggests, produces multiple forms of energy such as electricity, steam, shaft power or other forms of energy from a single source of fuel. Due to its ability to produce energy in more than one form, its uses significantly less fuel then what would be needed to produce those forms of energy separately. It is possible to achieve overall efficiency levels of more than 70% through cogeneration. According to CEA statistics, captive generation capacity of 20000 MW (for 1 MW and above plants) exists. MERC recently instituted a mechanism in the city of Pune to tap about 90MW of liquid fuel-based captive capacity. The Central Government has recognized the urgent need for capacity addition in the power sector and has offered several incentives such as waiver of import duty on capital equipment and material to be used for mega ultra-mega power projects. As cogeneration facilities with the higher efficiencies use fuel resources more efficiently, the Central Government should consider exemption or at-least lower rates of taxes and duties to be applicable for fuel used by cogeneration facilities. Bagasse cogeneration is a now a well understood and matured technology in the country. In the eleventh five year plan (2007-2012) 1369.7 MW of electricity against target of 1200 MW has been added from bagasse cogeneration.

1.4 Statement of the problem

Greenhouse Gases (GHGs) including CO2 emissions from human activities are the major cause of global warming which make many impacts on human being. Selection of goods and services which have less GHGs emission is the way that makes consumer‘s participation in GHGs emission management. Evaluation of carbon footprint evaluation also will increase the market potential of Indian products in the world market.

1.5 Objectives of the study

- Specific objective of the study are as follows:
- To estimate GHGs emissions for sugar industry by using the Bilan Carbone method.
- To analyze the main causes and critical areas of GHGs emissions and to suggest possible options for reducing GHGs emissions.

2. LITERATURE REVIEW

Lisperguer et al (2018) draws on the findings of a case-study on electricity generation through cogeneration in Jamaica to provide some key messages that may be useful for policy-makers and the private sector to make electricity generation by cogeneration a more competitive option the for investors.

De Souza et al (2018) conducted a study at a sugar-alcohol plant located in Brazil, with the objective to discuss the economic viability of electricity cogeneration using sugarcane bagasse for sale of surplus electricity for concessionaires.

Diaz et al (2018) makes a technical and economic evaluation of incorporation of reheating and regeneration, as a way to increase efficiency of energetic systems and bagasse surplus, in cogeneration systems of Brazilian sugar and ethanol sector.

Aldair Gongora et al (2018) review the state of bagasse cogeneration in Belize and assess its potential for further expansion.

Gopinath et al (2018) provides a comprehensive review of literature on the properties of sugar industry waste, their varied uses in energy and construction sector, performance and limitations.

Carpio et al (2017) presents a bi-objective optimization model to decide efficiently the percentage of the available sugarcane bagasse that should be allocated to each of these options in order to maximize the average return and, at the same time, minimize the risk inherent in price level volatilities.

Arshad et al (2016) explored Electricity generation through sugarcane bagasse in Pakistan through the sugarcane crop can provide food, feed, fuel, fibre, fodder, and fertilizer for future generations.

Moreira et al (2016) assesses the potential and cost effectiveness of negative emissions in the joint production system of ethanol and electricity based on sugar cane, bagasse, and other residues in Brazil.

Thitanuwat et al (2016) evaluated and recommended an optimum Urban Green Space (UGS) area for the Bangkok

Metropolitan Administration (BMA); and quantified potential renewable resources including electricity generation and potential nutrient recovery from generated ash.

Gnansounou et al (2015) addresses the economic and environmental performance of integrated bio refineries based on sugarcane juice and residues.

Turner et al (2015) presented for the first time a comprehensive, scientifically robust, fully trans-parent, and clearly documented series of GHG (greenhouse gas) EFs (emission factors) for the recycling of a wide range of source-segregatedmaterials.

Yasar et al (2015) performed waste to energy analysis of a large scale sugar industry i.e. Shakarganj Sugar mills.

Badami et al (2014) compared the nominal design data and the experimental data of eleven industrial cogeneration power plants, based on different prime mover technologies and actually in operation in Italy. The aim of the study is to compare the expected energetic and economic results with the real performance and economic profitability of the plants in operation.

A. Khoodaruth et al. (2014) Bagasse, a by-product of sugar cane is burnt in high temperature and pressure boilers to produce superheated steam to be used for combined heat and power generation.

Sathitbun-anan et al (2014) assesses the potentials for energy saving and GHG emission reduction in sugar production in Thailand.

Jeff Smithers (2014) estimated that 1.353 million tons of trash is available annually for cogeneration in South Africa, which could potentially produce 180.1 MW over a 200 day milling season assuming 50% trash recovery efficiency as reported in the literature.

Deshmukh et al (2013) compared different cogeneration system scenarios for efficient energy production from bagasse fuel in an Indonesian sugar and ethanol factory.

Mashoko et al (2013) develops the life cycle inventories for bagasse power production in South Africa. The life cycle inventory can help to evaluate the environmental impacts of the cogeneration throughout the life cycle.

Maylier et al (2013) aimed to evaluate and compare the environmental impacts of the life cycle of different cogeneration technologies currently used in the Cuban sugar industry.

2.1 Raw sugar production process

The raw sugar production process can be divided into 5 steps namely;

- Juice extraction
- Juice purification
- Evaporation
- Crystallization
- Centrifugaling

2.2 Refined sugar production process

For refined sugar production process, the raw sugar will be melted again and go through 5 more steps as below:

- Affinated Centrifugaling
- Clarification
- Crystallization
- Centrifugaling
- Drying

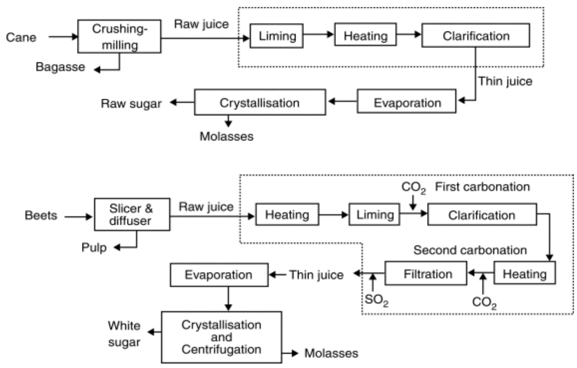

Figure 5: Sugar production process

3. Bilan Carbone Method

Bilan Carbone was developed by the French Agency for Environment and Energy management (ADEME) in 2003. This tool takes into account all of the six GHGs mentioned by Kyoto Protocol as well as chlorofluorocarbons (CFCs) and water vapour. Moreover, the Bilan carbon tool estimates the GHGs emissions from both combustion and upstream process of the fuel used. However, the emission factors are from French and it will be updated regularly. The tool considers all of the relevant activities, which are both direct and indirect activities, which can cause the GHGs emissions. In addition, the guidance is provided the detail of methodology used and the use of the tool. The Bilan Carbone method is transparent and it can easily faster adapt the tool to be used for different locations and requirements.

This tool is based on Microsoft Excel then it is very transparency for the equation used for estimation and it is very adaptable tool for different situation. In addition, the Bilan Carbone is compatible to ISO-14064 whichis the specification with guidance for GHGs emissions estimation. Step to approach Bilan Carbon and details are as follows:

3.1 GHGs approach

- This study will consider the following processes:
- Manufacture of all types of material used.
- Production of all types of energy used.
- The combustion process.
- Chemical reaction.
- Leakage of cooling liquids and gases.
- Performance.
- All types of transportation involved.

3.2 Definition of the scope of the study

During this phase, the parameters to take into account are determined, such as:

- Direct and indirect energy use
- IT (e.g. Internet use, emails sent)
- Transport use for goods
- Input material
- Capital Assets
- Direct and indirect wastes produced.

3.3 Data collection

To carry out the carbon footprint calculation phase, many data and information are required.This phase depends on the site boundary defined into the previous phase.

3.4 Result exploitation

Study the outcome and draft a report, explaining the findings and including suggestions on potential objectives of greenhouse gas emissions reduction. It is fundamental to involve the Carbon Footprint Leader, key managers, and staff during the definition of the emissions reductions objectives and potential of cutting energy cost. This assessment provides a clear overview on how extensive the company relies on fossil fuels.

3.5 Reduction actions for implementation

The proposed action plan can be classified into 3 categories:

- Immediate actions to cut energy cost and reduce GHGs emissions without requiring investment.
- Priority actions to undertake on a short term and have a high potential for reducing emissions;
- Strategic actions, involving a marked change in the activity.

3.6 Launching reduction actions

Support the company to launch their reduction action plan and to communicate their objectives to the outside world with a workshop.

4. METHODOLOGY

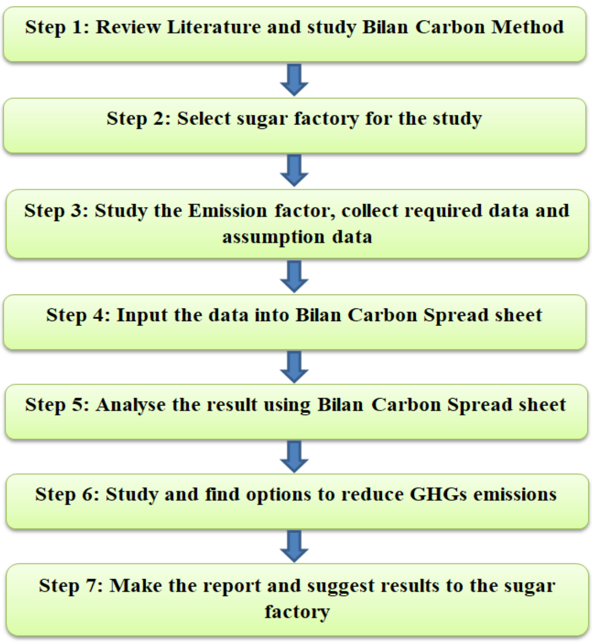

Figure 6: Overall methodology for this study

4.1 Study the emission factor

The details of data collection can be listed as below:

- **Internal energy use**
  - ∗ Electricity use
  - ∗ Fuel use
- **Excluding energy use**
  - ∗ Refrigerant leakages
  - ∗ Incoming materials
  - ∗ Raw materials
  - ∗ Packaging material
  - ∗ Materials
- **Freight**
  - ∗ Transportation from suppliers
  - ∗ Transportation to customers
  - ∗ Internal transport of goods in the company
  - ∗ Passenger travel
  - ∗ Home -work travel
  - ∗ Employee business travel
  - ∗ Visitor travel to factory
- **Wastes generated**
- **Assets**
  - ∗ Computers and office equipment
  - ∗ Buildings, roadways and car parks
  - ∗ Machines and vehicles

5. ESTIMATION OF GHGs EMISSIONS

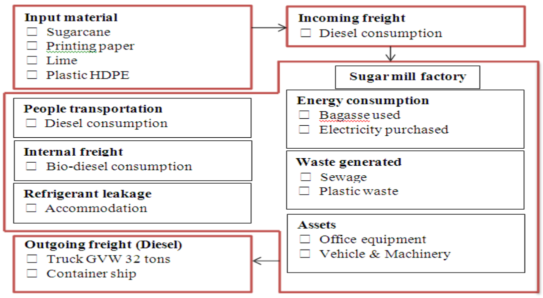

Figure 7: System boundary of the study

6. RESULTS

6.1 Emission from energy use

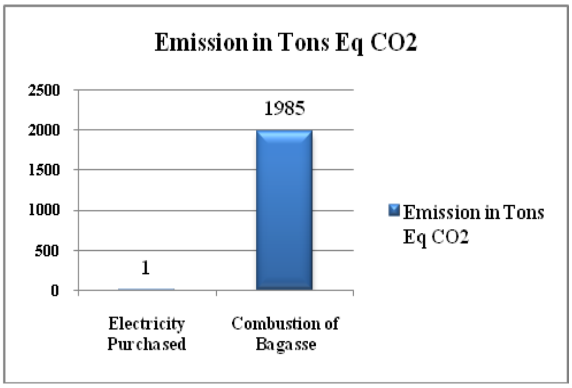

Figure 8 : Emission from energy use

6.2 Emission from incoming materials

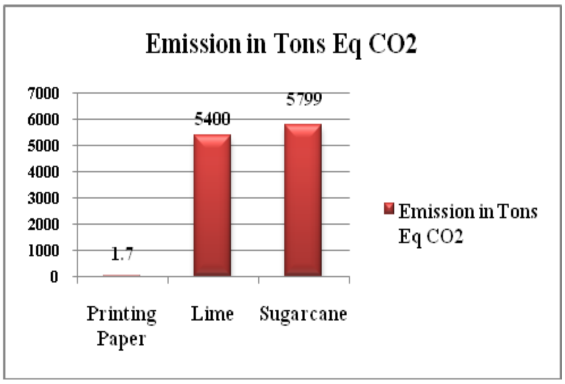

Figure 9: Emission from incoming materials

6.3 Emissions from each freight type

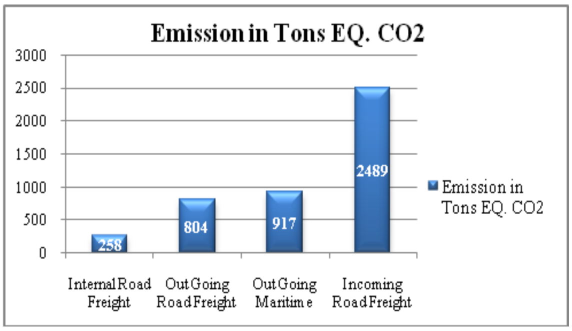

Figure 10: Emissions from each freight type

6.4 Annual GHGs emissions by source for this factory

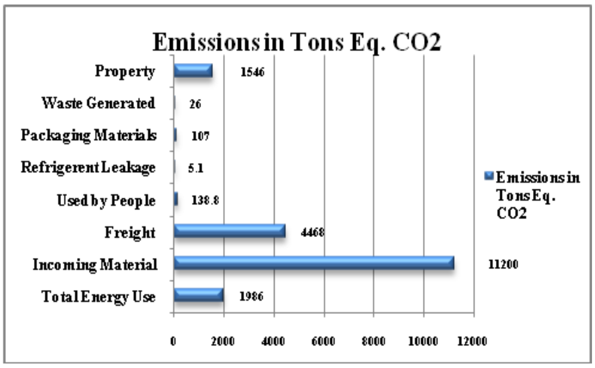

Figure 11: Annual GHGs emissions by source for this factory

7. POSSIBLE OPTIONS FOR GHGs EMISSIONS REDUCTION

7.1 Incoming sugarcane

The N-fertilizer application is the main cause of the emissions because the synthetic N fertilizer can emit GHGs emissions account for around 70% of total fertilizer used. The use of nitrification inhibitors is suggested to adopt as an option to reduce the use of N-fertilizer application because nitrification inhibitors can keep the N content into the soil. Nowadays, the advances technology of mechanical equipment for harvesting encourages the farmer to use instead of burning. By switching the burning harvesting to harvesting without burning, the huge amount of GHGs emissions can be achieved.

7.2 Freight transportation

Diesel is the major type of fuel used for incoming freight by truck. By encouraging people to switch the use of diesel to use biodiesel. The GHGs emissions can be reduced about 20%. Moreover, the route management can affect the reduction of GHGs emissions because it can minimize the distance leading to minimizing fuel consumption.

7.3 Energy consumption

For demand side, one of the options to increase cogeneration power in a sugar industry is to replace the conventional low efficient turbine (25-30%) with DC motors or hydraulic drives which have higher efficiency. As a result of this, the steam saved can be utilized to generate additional power. In addition, installation of the advanced technology of evaporator which is free flow falling film evaporators can be the option to reduce energy consumption.

For supply side, the more efficiency of boiler and turbine can lead to reduction of bagasse used to produce a unit of electricity or increasing of electricity generated per a unit of bagasse. Moreover, the same sugar milling but the improvement of boiler, power turbine and sugar production process can cause the higher steam production with higher steam pressure and lower process steam consumption. As a result, the saved steam can be utilized for more electricity generation.

7.4 Travelling of people

For people transportation, the using of compressed natural gas (CNG) and liquefied petroleum gas (LPG) could be the alternative fuel for bus, minibus and pickup car. By using the CNG, the GHGs emission can be reduced around 40% as well as the utilization of LPG can cause to GHGs emissions reduction around 50% compared with diesel. The other option for reduction of GHGs emissions for travelling of people is to switch the using of bus to minibus for home-work travelling because the bus has high specific fuel consumption which leads to consuming high level of fuel and emitting high level of GHGs emissions. By using two minibuses instead of one bus, the specific fuel consumption can reduce 44% which also can cause the reduction of GHGs emissions around 44%.

8. CONCLUSION AND RECOMMENDATION

This study estimates the GHGs emissions from a sugar factory in India in 2017-2018 seasons by using the Bilan Carbone method. The activities considered for GHGs emissions estimation are energy use, refrigerant leakage, input material to factory, transportation of goods and people, waste generated and assets owned by the factory. For accurate estimation of GHGs emissions, the emission factors used are supposed to relate to the specific factory and country. However, for some of emission factors are not available and observed to not vary much for different regions, the emission factors from Bilan Carbone tool are used.

Some of the emission factor for India should be estimated further such as the emission factor of sugarcane, waste generated, office equipment, vehicle, machinery and the industrial metal building and parking space.The methodology for getting the carbon reduction label or carbon footprint label should be suggested to the factory.

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