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# Feasibility Assessment of Converting Sugar Industries to Bioethanol Production in India

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**Abstract—***Bioethanol demand for blending in transport fuel has increased globally. Biofuels are renewable and clean source of energy which could help in enhancing the energy security of a nation and minimizing dependence on imported crude-oil. Towards this endeavor, the Government of India has initiated Bioethanol Blending Programme with 5% blending target and scale up to 20% by 2030. This would need 15 billion litres of bioethanol for 20% blend in year 2030.*

*Bioethanol production in India mainly comes from the Molasses, which is not sufficient to meet 20% blend target. In this work the authors' have studied the ethanol production potential form the sugar industry i.e. molasse and bagasse combined. The main aim of the current study is to quantified the ethanol production potential and identified new locations for ethanol production facility. The authors have analyzed the country preparedness for meeting 20% ethanol blending target in year 2030. Results showed that 464 new distillation units would be required to process the waste from the sugar industry and it has a cumulative potential to produce 12.9 billion of ethanol. Bioethanol production not only help to meet 20% blend target but also contribute in meeting Intended Nationally Determined Contributions Nationally. commitments. Analysis showed that 20 % ethanol blended fuel would result in 11.85 million metric tonnes CO2 equivalent emission reduction.*

**Keywords***: Bioethanol, Distillation, Infrastructure, Sugar Industries*

## 1. INTRODUCTION

Today, India holds 17.84% of the global human population; however, it has only 2.4% of global surface area accounting for about 30.5% of primary energy consumption. Projection says that by 2030, India will be the most populous country with 1.5 billion populations and 430 million vehicles on road [1]. To meet the future demand, India has to import crude oil. Heavy dependence on imported oil poses serious threat to energy security. According to Niti Aayog's, country 81-85% of the total demand is met by the import only as indicated in Table 1[2].

**Table 1: Crude Oil demand and import contribution in India**

| Years | Total Crude Oil Demand (MMT) | Demand met by Import (%) |
|---|---|---|
| 2009-10 | 193.0 | 83% |
| 2010-11 | 201.7 | 81% |
| 2011-12 | 210.0 | 82% |
| 2012-13 | 222.9 | 83% |
| 2013-14 | 227.0 | 83% |
| 2014-15 | 226.9 | 83% |
| 2015-16 | 240.0 | 85% |

To meet future oil demand and reduce its dependence on imported crude oil, the country is looking for alternative options with additional benefits to mitigate climate change. Biofuels have emerged as a potential alternative solution. To integrate bioethanol into energy system, Government of India has started ethanol-blending program in 2003 with 5% blending target. Under Ethanol Blending Programme (EBP), the central government has scaled up blending targets from 5% to 20% to promote blending of ethanol with petrol and its use as alternative fuel [3]. Post COP 21, the energy dynamics in the country has changed. India committed in an Intended Nationally Determined Contribution to reduce carbon emissions relative to its GDP by 33% to 35% from 2005 levels by 2030 [4]. EBP has been revised and set the 20% blending target for 2030-31. Bioethanol blending programme not only will reduce India's dependence on fossil fuel imports, but also ensures clean energy.

Authors in his previous study, a reality check of fuel blending program has done for Pan India [5]. The previous study analyzed the raw material availability for ethanol production (i.e. molasses), infrastructure for the raw material processing (i.e. distillation capacity) and ethanol demand in current and future market. Authors have observed that Infrastructure for available molasses processing to ethanol is the main bottleneck for blending program. Previous study also observed that to meet 20% blend target in near future, country need to

look for the raw material sources and infrastructure both. Today, Ethanol is mainly produced from the molasses, which is a by-product of sugar industry. Sugar industry plays an important role in contributing to the renewable energy pool of the country. Sugar industry can be considered as a multi-product industry producing not only sugar but also industrial/ potable alcohol, bioelectricity, fuel ethanol, biogas etc.

To achieve the 20% blend target in near future, authors have studied the ethanol production potential from the sugar industries (considered bagasse and molasses both). However, literature has also reported the ethanol production potential from the bagasse [6; 7]. So, the authors have studied ethanol production form molasses and bagasse both. The main aim of the current study is to quantified the raw materials (i.e. bagasse and molasses) and infrastructure availability for meeting the blending target in near future. The new locations were also identified for ethanol production for the unprocessed raw materials from sugar industries considering the distance from the raw material sources (i.e. sugar mill).

The outcome of the study will not only help to identifies the new infrastructure capacity for ethanol production for Pan India but also help to quantify the carbon reduction. The outcome of the study will help policy maker to take necessary actions for meeting 20% blending target in near future and also meeting the India commitment made in its Intended Nationally Determined Contribution (INDC) in COP 21.

## 2. SUGAR INDUSTRIES ROLE IN EBP

Sugar Industry is one of the largest agro-based industry of the country after textiles with a worth of more than INR 80,000 crore (from sugar and allied activities). Sugar industries have been established in large sugarcane growing states like Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Bihar and Gujarat and these six states contributing more than 85% of total sugar production in the India while, over 60% of total production is together contributed by Uttar Pradesh (UP) and Maharashtra [8].

In 2014-15, 362 lakh tonnes of sugarcane production were achieved which was observed as maximum sugarcane producing year in last one decade [9; 10]. 66-74% of harvested sugarcane is used by sugar mills to produce sugar remaining 26-34% is used to produce for other purpose like Gur, khandsari and feed/chew/seed etc. About 529 sugar factories worked during 2014-15 with average crushing capacity of 4000 TCPD as mentioned in Table 2.

**Table 2: Number of sugar mills in 2014-15 in India based on Capacity**

| Capacity | Numbers of sugar mills |
|---|---|
| Higher than 10000 TCPD | 16 |
| 5001 to 10000 TCPD | 94 |
| 3501 to 5000 TCPD | 92 |
| 2001 to 3500 TCPD | 241 |
| Up to 2000 TCPD | 86 |

Today, the main source of the bioethanol in India comes mainly from sugar industries (i.e. molasses). Molasses, a by-product from sugar industries, is collected and used by distilleries to produce ethanol. Approximately 95% of total molasses is directed to ethanol production and rest is mainly used as cattle feed [11]. The yield of molasses (by product from sugar industry) per ton of cane is in the range of 4 to 4.5% [12]. Bagasse, also a by-product from sugar industries, mainly use for the electricity generation. It also has the good potential for ethanol production. As per standard, 30% of per tonnes sugarcane is collected as bagasse which has 50% of moisture content [13].

Currently, India has around 356 distilleries for alcohol production. 162 distilleries out of the 356 distilleries are for ethanol processing from molasses mainly. The annual installed capacity of the ethanol-based distilleries in India is approx. 2.2 billion liters per annum. Maharashtra and UP together accounts for nearly 64% of total ethanol production capacity in the country [14]. The capacity of distilleries based on molasses varies from 2,000 to as high as 60,000 kL (kilo liters) of RS (Rectified spirit) per annum. Currently, all the distilleries are either adjacent to sugar mills or are standalone facilities produces the ethanol from molasses only. No bagasse has been processed for the ethanol production. New infrastructure locations for ethanol production from bagasse are also suggested in the current study

## 3. METHODOLOGY

The current study has two main objectives; one is to quantify the ethanol production potential from bagasse and molasses both and second is to identify the infrastructure (fermentation and distillation unit) new location (for ethanol processing only) considering raw material from sugar industries i.e. molasses and bagasse both with minimum distance travelled. The data source for the molasses and bagasse both produced in 2014-15, was used for the new fermentation and distillation unit identification (mentioned in Figure 1).

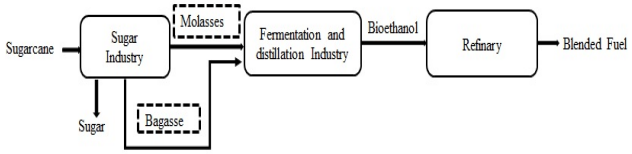


**Figure 1: Supply chain of Bioethanol from Sugar Industries in India**

The infrastructure contributes in complete supply chain of bioethanol blending include 529 sugar industries, 162 distillation facilities and 22 refineries units which is mapped by authors with capacity size (Figure 2).

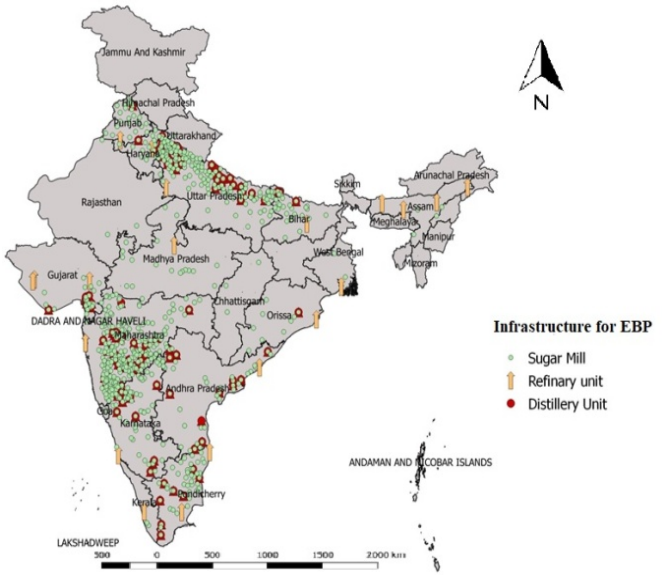


**Figure 2: Infrastructures includes for Ethanol blending Program in India**

### 3.1 Approach for the study

All the 529 sugar mill integrated with distillery unit or standalone were identified and the amount of molasses and bagasse generated from these units were quantified. Sugarcane production from 2014-15 session has been considered during this study because this session has been identified as maximum sugarcane producing session in last 10 years.

i. To carry out this study, secondary data source has been used. All the data were collected from sugar mills annual reports, journals and various websites. All states data with its unprocessed molasses sugar units were mapped as spatial data using a GIS tool (ESRI, 2011, ArcGIS Desktop: Release 10, Redland CA, USA). All the data were collected in the standard World Geodetic System 1984 (WSG 84) and projected in UTM zone 43 North coordinates.

ii. A geometric buffer with fixed distance i.e. 50 km for all mapped point layer has been generated. For the buffer construction, 50 km distance has been assumed because as per government policy, there should be a minimum 25 km distance between two sugar mills [15]. The boundaries of overlapping buffer zones are dissolved to produce a single coherent buffer zone for the entire spatial feature. [16].

iii. The data extracted from the buffers vector point layers was used to calculated the weighted median center. Weighted median center calculation uses an iterative algorithm to find the point that minimizes Euclidean distance to all weighted features (ethanol production potential at that point) in the dataset [17].

### 3.2 Data assumption for the study

i. Approximately 95% of total molasses is directed to ethanol production. The remaining portion is mainly used as cattle feed and same is considered for the calculation for all the states [18]. According to the sugar industry, 240 litres of ethanol produced from 1 tonne of molasses and same is considered for the calculation.

ii. Theoretically, all the available bagasse was assumed to be used for the bioethanol production. As per standard, per tonne of sugarcane produces 30% of bagasse which has 50% of moisture content. As per literature, theoretical 415 liters of ethanol is produced from one tonne of dry bagasse. To get the realistic results from bagasse to ethanol, actual production of ethanol i.e. 60% of theoretical yield data has been considered for the current study.

iii. The capacity of new distillery has been decided by the statistical analysis and observed that all the states need to construct the new capacity in the range of the 45-60 KLPD i.e. based on the national average.

iv. As per the CPCB guidelines, distillery unit should be operational for 270 to 300 days. So, current study had used maximum days for the calculation.

## 4. RESULT AND DISCUSSION

India is world second largest sugarcane producer and one of the greatest leaders in production of ethanol from the molasses. In 2014-15 season, about 26.54 million tons of sugar,1.15 million ton molasses and 78.84 million tonnes of bagasse was generated by 529 sugar factories with average sugar recovery of 10% [19]. Sugarcane in India is utilized for not only processing of sugar but also to produce Khandsari, Gur and others purpose like feed, seed and chewing. However, on an average for last 10 years, around 70-74% of the sugarcane produced in the country is utilized by sugar mills [20].

In India, molasses (by-product of sugar industry) is mainly sources for the ethanol production Authors in the current study, have analyzed the ethanol production potential from the sugar industries waste materials. Bagasse which has been mainly used for the electricity generation, has the potential to produce 10 billion liters of the ethanol as shown in Figure 3.

As per the realistic scenario, where molasses has the potential produce 2.9 billion liters of ethanol, utilized for various application. Sugar industries with 12.9 billion liters of ethanol production potential from bagasse and molasses, can meet the 20% target even in 2030-31 years. i.e. 13 billion liters. Today, country require 4.95 billion liters of bioethanol for meeting its 20% blending demand i.e. 38% of total ethanol production potential.

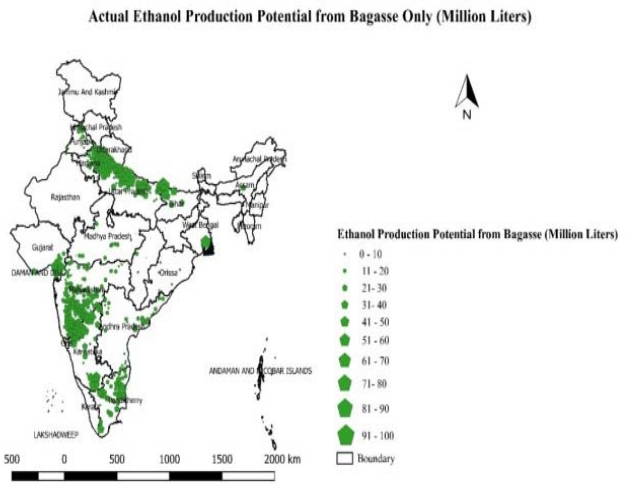


**Figure 3: Ethanol production Potential from Bagasse in India**

The new infrastructures for bagasse and unprocessed molasses both were identified with minimum weighted distance from sugar mills. 464 new distillation unit were identified with capacity range of 45-306 KLPD as depicted in Figure 4. Out of 464, 13 distillation units are in capacity range of 200-300 KLPD, 83 units in 100- 200 KLPD Capacity size, 151 units in 50-100 KLPD and rest 282 units were defined with capacity range of 45-50 KLPD. Out of 529 sugar mills, 247 mills will have their integrated distillation unit with capacity range of 50-300 KLPD. Rest 287 distillation units were mapped and identified with weighted minimum distance travelled from sugar industries.

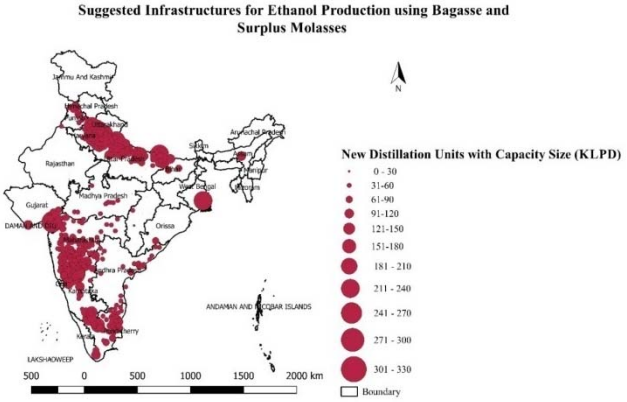


**Figure 4: New Infrastructure for Ethanol Production form Sugar Industries**

## 5. CONCLUSION

The study showed that Indian sugar industry has the potential to meet 20 % ethanol blending target in year 2030. However, the country blending only 3.5 % of its fuel because the established ethanol market takes out a major share of ethanol and only 25% of ethanol is available in the market for blending purpose. Therefore, bagasse as an additional source of feed was analyzed for the study to ramp up the ethanol production capacity of the country, without disturbing the market equilibrium.

The potential of the sugar industry waste (Molasses and Baggase combined) to produce ethanol is about 15 billion liters. India has infrastructure to produce 2.2 billion liters of ethanol, however to process the available feed, it will require 464 new distillation units either as standalone facility or as integrated facility with sugar mills. Bioethanol production not only help to meet 20% blend target but also result in 11.85 million metric tonnes $CO_2$ equivalent emission reduction.

| List of Acronyms | |
|---|---|
| COP | Conference of the Parties |
| CPCB | Central Pollution Control Board |
| EBP | Ethanol Blending Program |
| KLPD | Kilo liters per day |
| MoA | Ministry of Agriculture |
| TCPD | Tonnes Capacity Per Day |

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