Biomass Energy And CONservation (BEACON) – An Eco-friendly business solution

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Abstract **- Burning of agricultural crop residue/biomass is one of major problems haunting the agricultural fields, leading to environmental pollution and soil deterioration. It results in serious health problems, air pollution and destruction of soil nutrients (like nitrogen, phosphorus, potassium and sulfur), moisture and microbes from the top layer of soil. In this paper, we are presenting an innovative business and technical solution to address this issue.**

Keywords **- agriculture, crop residue, sugarcane, biomass, air-pollution, soil-degradation**

I. INTRODUCTION

In the recent past, the issue of crop residue burning or biomass burning brought to limelight when smog covered the nation capital region (NCR - New Delhi). It is claimed that burning of paddy stubble in neighboring states Punjab and Haryana is one of major causes for the rising air pollution in the capital region. In the similar lines, burning of sugarcane biomass has been increasing these days, if not addressed it can grow into a bigger cause for the environmental pollution.

A. Biomass burning - A vicious cycle

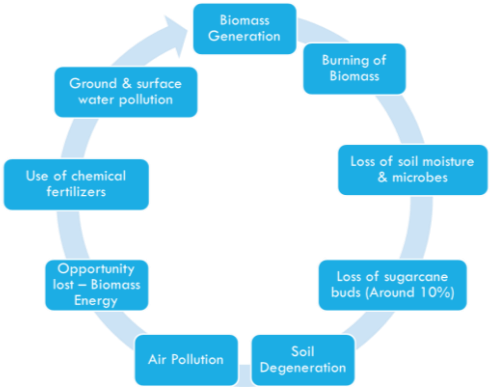

Figure 1 Vicious cycle of biomass burning

Burning of agricultural biomass in the field leads to loss of soil moisture and microbes which are crucial contributors for soil fertility and soil structure. Loss of soil fertility demands for excessive use of chemical fertilizers. Excess use of chemical fertilizers results in surface water pollution initially and then affect ground water in long run. And in case of sugarcane crop (where 2 to 3 ratoons are allowed), burning of biomass also leads to burning of ratoons and thereby reduces the yield. The uncontrolled and incomplete combustion of biomass leads to air pollution. As shown in Figure 1, these demerits of biomass burning forms an endless vicious cycle. And Figure 2 shows the burnt sugarcane biomass in an agricultural field of Haliyal region.

Figure 2 Sugarcane biomass burnt in the agricultural field

B. Biomass recycling - A virtuous cycle

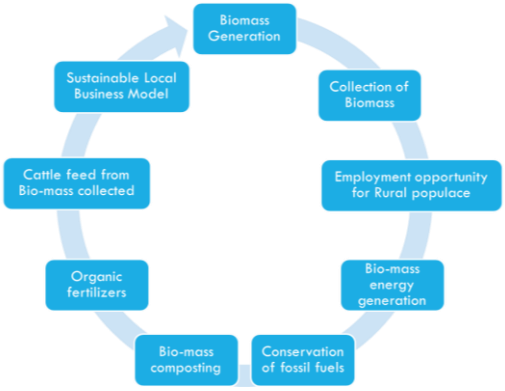

Figure 3 Virtuous cycle of biomass recycling

Conversion of biomass burning vicious cycle into biomass energy generating virtuous cycle starts with collecting the biomass from agricultural field. Based on its chemical compositions and physical geometry, this collected biomass shall be used for biomass composting, cattle feed production and biomass briquettes, biomass gas generation and industrial boiler fuel production. The process of biomass collection to production of value-added product generates rural employment. Considering the current market demands:

- Current growing trend of organic farming
- Growing need of cattle feed from dairy industry.
- Use of biomass briquettes for industrial application in place fossil fuels.

We shall conclude that the virtuous cycle of biomass recycling shown in Figure 3 continues to get stronger with time.

Further in this paper, we present how sugarcane biomass (leaves and sheath) is converted into industry grade boiler fuel called briquette.

II. ROOT CAUSE AND SOLUTION

With the time window being limited for next cultivation, the feasible options to farmers for quick removal of the sugarcane biomass are either employing expensive agricultural rotavator machines to cut and mix the sugarcane biomass with the soil and wait for composting of the residue or burning the sugarcane biomass on the field itself. Of the two, latter one is opted as it is inexpensive and less time consuming.

Considering the amount of sugarcane biomass generated (around 3 – 5 tons per acre), solution for such a huge problem needs a well-coordinated organizational effort from different stake holders of the society. Organizational efforts in bringing awareness among the farmers and simultaneously generating a commercial value for sugarcane biomass results in a self-sustainable solution.

KLE Tech University joined hands with CherYsh Trust and EID Parry's India Limited, in order to develop a self-sustainable solution to address sugarcane biomass burning issue. The solution results in additional income for farmers, increases rural employment, and entrepreneurial opportunities for village youth along with its prime objective of reducing environment (air) pollution. This strategic partnership initiative is named as BEACON - Biomass Energy And CONservation and the details of the initiative are as following –

A. BEACON - Vision

Develop a sustainable business solution to

- Stop burning of sugarcane biomass and thereby avoid the air pollution.

- Generate additional revenue for farmers from selling of sugarcane biomass.
- Generate entrepreneurial opportunities and employment for village youth from processing of sugarcane biomass.

B. BEACON - Goal

Generate a value for Sugarcane biomass by

- Converting the sugarcane biomass into pellets or briquettes which are used as fuel in steam generation applications.
- Converting the sugarcane biomass into organic compost.
- Converting the sugarcane biomass into animal feed.

C. BEACON - Biomass briquette Making process

Biomass briquette is a densified biofuel made with or without additives by the densification of raw materials. The raw materials include agricultural waste, forestry waste, agriculture industrial processing residues, plantation residue, wood industry waste and etc. Additives are used to enhance and maintain briquettes' compaction and are rich in starch content. Examples include rice flour, mashed sweet potato, Indian gum, molasses and etc.

The schematic biomass briquetting process is as shown in Figure 4.

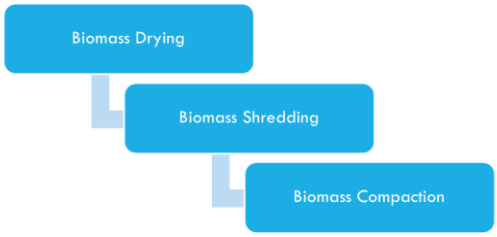

Figure 4 Schematic biomass briquette making process

- Biomass drying
  Considering the optimum operation of briquette making machines, maximum 30% moisture content is allowed in the raw material. And in case of more moisture content, raw material is dried.

- Biomass shredding
  Since, wide variety of raw material is available for briquette making, geometrical uniformity of raw material is not consistent and hence before briquetting, the raw material is shredded to small pieces (max length 25mm) to achieve geometrical uniformity. However, biomass shredding is optional for example in case of saw dust-based briquettes it is not needed.

- Biomass compaction
  It is a pure densification process where compaction forces resulting high pressure and temperature (friction induced) are applied on the (lignocellulosic) biomass resulting in the softening of lignin and causing natural binding of biomass. Mainly three different technologies [5] are used for compaction and they are –

  1. Piston Briquetting or impact densification
     Compaction forces are exerted by a piston driven by flywheel on raw material collected in cylinder.

  2. Screw Briquetting or Extrusion densification
     Compaction forces are exerted by a screw driven by prime mover on raw material collected in cylinder with reducing cross section.

  3. Hydraulic or Pneumatic densification
     Very much similar to piston briquetting but compaction forces are applied by cylinder operated by hydraulic or pneumatic system.

III. EXPERIMENTAL EXECUTION

BEACON project was executed at pilot level in Mundwad village near Haliyal, Uttar Kannada district of Karnataka state with the help of CherYsh Trust and EID Parry's sugar plant. The project team collected and supplied around 10 tons of shredded sugarcane biomass to initially identified Briquette making vendor at Belur Industrial Area, Dharwad.

Brief information of activities executed are as following -

A. Biomass Collection

Generally, sugarcane biomass is uniformly distributed in the sugarcane field after sugarcane harvesting as shown Figure 5

Figure 5 Sugarcane Biomass in agriculture field

On 3rd or 4th day after sugarcane harvesting, team collected this uniformly distributed dried biomass into small heaps using a specially designed (by KLE Tech Uni.) device called Rake as shown in Figure 6.

Figure 6 NGO Worker using rake for biomass collection

Bales were formed out of these small heaps using simple ropes and carried into central/any identified location (most suitable for biomass shredding and loading activities) in the agricultural field as shown in Figure 7 and Figure 8.

Figure 7 NGO Worker forming the biomass bales

Figure 8 NGO Worker Carrying the biomass bale

With the help of these baled biomass big heaps/stacks were formed at the identified location in the agricultural field as shown

in Figure 9.

Figure 9 Biomass heaps in agriculture field

B. Biomass Shredding

Stacked sugarcane biomass was shredded into small pieces in a shredder machine driven by PTO shaft of a tractor as shown in Figure 10.

Figure 10 Tractor operated biomass shredder

Shredding of dried sugarcane biomass was done as it's easy to transport shredded biomass from one place to another place. The shredded form of biomass is as shown in Figure 11.

Figure 11 Shredded Sugarcane biomass

C. Biomass Loading, Transportation and Unloading

Shredded biomass was loaded into canter/lorry using bamboo crate, cloth sacks and big baskets with capacity of 3kg, 10kg and 40kg respectively as shown in Figure 12.

Figure 12 Loading of shredded biomass into Lorry

After loading into the vehicle, a group of workers uniformly plodded it so as to accommodate more biomass per trip of transport. The sequence of sugarcane biomass loading into the vehicle and covering it with tarpaulins held in place by ropes is as shown in Figure 13.

Figure 13 Sequence of biomass loading

These vehicles loaded with sugarcane biomass transported and delivered it to an identified vendor at Belur Industrial Area, Dharwad for making pellets and briquettes.

D. Biomass Briquette making

Sugarcane Biomass Briquettes (90mm in diameter) are made out of this shredded sugarcane biomass with/without a special binding material. These briquettes are used as a fuel for generating steam/hot water in the industry or commercial complexes like hotels, lodges and boarding.

Figure 14 Biomass Pellets (only for reference) [1]

Figure 15 Biomass Briquettes (only for reference) [2]

IV. RESULTS AND DISCUSSIONS

A. Pilot level execution results

In pilot level execution of BEACON project, the team was successful in supplying around ten tons of shredded sugarcane biomass to briquette making plant. In order to check the viability of this sugarcane biomass for boiler fuel, Calorific Value (CV) estimation experiment was carried out at KLE Tech University using Bomb calorimeter instrument and found the value as 19511.42 kJ/kg or 4663.34 kCal/kg. And found this is suitable fuel for boiler/industrial application based on the CV of commercially available biomass briquettes in the market [3]

Please note that the estimated CV of shredded sugarcane biomass is more than the CV of bagasse [4] (17582.2 kJ/kg or 4202.25 kCal/kg.) is mostly because of following reasons -

- Sample was completely free from moisture.
- Sample was created from fine shredded sugarcane biomass ➔ high densification was achieved during sample preparation.

Another important aspect which decides the viability of this biomass for industry fuel is the 'cost economics' associated with conversion of this sugarcane biomass (currently called as sugarcane crop residue or waste) into feasible raw material for briquette making plant and made available at the briquette making plant. Actual cost details are not discussed here as it varies with availability of advanced machineries, labors, distance between raw material source and briquetting plant. But overall findings are that the sugarcane biomass collection, shredding, transportation, and loading to vehicle are the major factors influencing the overall cost of execution.

B. *Engineering solutions to reduce the cost associated with sugarcane biomass recycling*

Pilot level execution of BEACON project, thrown light on the major factors influencing the project cost. After careful study of the factors, the study concluded that the technology or the product available for recycling of sugarcane biomass was not efficient and economic. Hence CIPD came up with new set of solutions enlisted below to improve the sugarcane biomass recycling efficiency and reduce the process cost -

- Sugarcane Biomass collection cost shall be reduced by the automation of process. CIPD addressed this requirement in the business model developed for entrepreneurs (considering the confidentiality of the information, it is not provided here).
- Sugarcane biomass shredding cost can be reduced by improving the shredding efficiency of the machine. CIPD has come up with a new design for shredding machine and registered the Indian design patent (Application number 310284). Most of the demerits associated with existing shredding machine are eliminated in the new design and proposed prototype testing in Dec 2018 will confirm the improvements.
- Shredded sugarcane biomass cost shall be reduced with the reduction in transportation distance and increase in bulk density. In order to increase the bulk density of biomass, CIPD is working on a biomass compactor concept. As of now, concept is ready but detailed design and prototyping is expected to be completed by mid of 2019.

V. CONCLUSIONS AND FUTURE SCOPE

With this BEACON project pilot execution, we have proved that sugarcane biomass, instead of burning in the agricultural field, can be converted into industry grade boiler fuel and the conversion process will be an entrepreneurial entity resulting in rural employment.

CIPD has come up with a business solution for this BEACON project and many entrepreneurs have joined the team to generate the rural employment. Along with the business solution, CIPD will also backup entrepreneurs continuously the with design and development of feasible machineries/tools for the betterment of the business.

Currently, CIPD is in talks with District Industries Center (DIC), Dharwad towards reaching a greater number of entrepreneurs and provide BEACON business model to work with.

VI. REFERENCES

[1] Image courtesy: https://www.123rf.com/

[2] Image courtesy: https://dir.indiamart.com

[3] Information is taken from indiaMART.com at the following link: https://dir.indiamart.com/impcat/biomass-briquettes.html

[4] Calorific Value is taken for bagasse with Moisture- 5%, Ash – 5% and Brix 2% from website given at the following link: http://www.sugartech.com/extraction/bagasseCV/index.php

[5] Solano, David. "Briquetting plant: process and standards."