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# Sugar Industry-Sustainable Source of Bio-Energy / Renewable Fuel

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***Abstract* — The importance of Bio-energy/Renewable energy is now greatly acknowledged in view of growing awareness about environmental sustainability and fast depleting fossil fuels and other conventional sources of energy. Sugar factories processing sugarcane can be a potential source of bio-energy producing electricity using bagasse & cane trash, bio-ethanol through use of molasses, juice or bagasse and production of bio-gas, compressed bio-methane or bio-CNG utilizing filter cake/ press mud as raw material. Out of these routes, potential of production of bio-energy through use of filter cake/press mud has still not harnessed. To mitigate the energy crisis, conserve natural resources and address environmental issues, there is need for focussing on issue through a holistic approach.**

***Keywords*— *Bio-energy, fossil fuel, press mud, bio-CNG, natural resource.***

## I. INTRODUCTION

Ever increasing consumption of fossil fuels and rapid depletion of known reserves are matters of serious concern in a developing country like India. Growing energy consumptions as a result of rapid urbanization and industrialization has resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil & gas to cope up with the requirement. Rising prices of oil and gas and potential shortages in future lead to concerns about the security of energy supply needed to sustain our economic growth. Increased use of fossil fuels also causes environmental problems both locally and globally.

The overwhelming reliance on fossil fuels, in particular, threatens to effect the Earth's climate to an extent that could have grave consequences for the integrity of both natural systems and vital human systems. Of course, the need for a profound transformation of the world's energy-producing and using infrastructure has been widely recognized in the mounting concern about global climate change. Many reports have been written on the subject of sustainable energy, but few have approached this specifically from the perspective of a developing country [1]. In nations where a significant portion of the population still lacks access to basic energy services, the worry about long-term environmental sustainability is often overshadowed by more immediate concerns about energy access and affordability.

Since 19$^{th}$ century, sugarcane was primarily grown for production of sugar in different countries in the world. With the increasing energy crises and need for sustainable reforms, scientists and researchers have realized the value of sugarcane and it-s by-products (bagasse, press mud (filter cake) and Molasses). Sugarcane is usually processed to sugar and biomass where the available biomass mainly comprises of components like lignin, fibre, pith and pentosans, which have enormous potential to be used in biochemical and microbial field [2]. During the processing of sugar, a number of by-products contain biodegradable matter. Such high value by-products could serve as valuable raw materials for various biotechnology processes for producing produce value-added products. One possibility is using anaerobic or other appropriate technology for biogas production from some such waste or by-products [3].

Biogas generation from a wide range of lignocellulosic biomass is increasing globally. Considering economic and environmental issues this is an ideal movement. Biogas generation technique is very precise and complicated since diverse microbial species are engaged. Anaerobic digestion is considered as an innovative process, which offers the opportunity to utilize wastes as an energy source and meet the demand for a feasible alternative to biofuels production. Biogas production from sugarcane industry solid waste by anaerobic digestion method coupled with pre-treatment process and mixing with other raw materials has huge potential for energy generation [4].

Press Mud (PM) or Filter Cake is a by-product of sugarcane juice filtration process. In general, 100 tons of sugarcane crushed generates 3.0-3.5 tons (3.0-3.5 % of total cane weight) of Press Mud or Filter Cake. The composition of Press Mud depends on agro-climatic zone, cane variety, milling process and methods of clarification etc.

Sugarcane industries from all over the world produces large amounts of Press Mud every year and the disposal of this by-product is a matter of concern. In general, Press Mud is being dumped as garbage in open fields or sold/given to farmers to use as fertilizer, although in some of the cases it is being used for bio-composting with spent wash obtained from the molasses based distilleries. However, these disposal method pauses some environmental challenges such as air pollution due to odour, surface and ground water pollution and overall pollution of the environment. Recently, much attention has been focused on better use of Press Mud and the Government of India has launched a "SATAT" scheme for procurement of bio-CNG/compressed bio-gas produced from press mud from sugar industries at good prices. Indian sugar industry while crushing around 300 million tonnes of sugarcane and producing about 10 million tonnes of press mud annually can offer compressed bio-methane/bio-CNG to the extent of 0.4 million metric tonnes [5].

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## II. ENERGY CONSUMPTION IN INDIA

Over the past decades' energy demand has steadily increased across all sectors, including agriculture, industry, commercial and residential, and is expected to continue to grow. Nonetheless, India's per capita energy consumption stands at 30% of the world's average (0.44 tonnes of oil equivalent [toe] per capita versus the global average of 1.29 toe and the International Energy Agency [IEA] average of 2.9). India was the third-largest energy consumer in the world after China and the United States in 2018, according to the BP Statistical Review of 2019 its need for energy supply continues to climb as a result of the country's dynamic economic growth, population growth, and modernization over the past several years. Primary energy consumption in India has nearly tripled between 1990 and 2018, reaching an estimated 916 million tons of oil equivalent. Coal continued to supply most (58%) of India's total energy consumption in 2018, followed by petroleum and other liquids (26%), and traditional biomass and waste (20%) (figure 1). Other renewable fuel sources make up a small portion of primary energy consumption, although the capacity potential is significant for several of these resources, such as solar, wind, and hydroelectricity [6].

India's total petroleum and other liquids production has hovered at about 1 million barrels/day since 2010. India was the third-largest consumer of crude oil and petroleum products after the United States and China in 2019. India's crude oil imports reached 4.4 million b/d in 2019. The gap between India's oil demand and supply is widening. Demand for crude oil in 2019 reached 4.9 million b/d, compared to less than or around 1 million b/d of total domestic liquids production (figure 2) [6].

The economic slowdown and heavy monsoon season eased the pace of India's oil demand growth, which grew 2% in 2019 compared to the 2018 level. However, due to outbreak of pandemic, Covid-19, the lockdowns and other restrictions have affected the demand of petroleum products, which is to be looked into.

As regards India's crude oil imports, fig. 3 gives an overview of the same indicating that about 60% of the imports are from Middle East followed by almost equal quantities from Western Hemisphere and Africa [7].

Another important fuel which is being used for production of thermal power has remained coal. In 2018, India's coal consumption increased to an estimated 1,037 million short tons, up 3% from 2017 (figure 4). India's coal consumption, the second-largest in the world behind China, is driven by the power sector, which makes up about two-thirds of consumption, iron and steel industries, and cement production. India continues to experience supply shortages and systemic problems with its mining industry. Many coal deposits are located in areas that have environmental challenges or involve potential dislocation of people.

Because coal output cannot keep pace with demand, particularly from the power sector, India has met more of its coal needs with imports than domestic production. In 2019, India purchased 275 million short tons of coal from overseas, making it the second-largest coal importer after China. Coal imports grew by 10% from 2018 levels and have been increasing since 2016.

Indonesia was the largest source of coal imports to India in 2019, accounting for 49% of total coal imports. Other major sources are Australia (20%) and South Africa (16%). Figure 5 presents an overview of India's coal imports from many countries [7].

## III. BIOMASS ENERGY IN INDIA AND ITS POTENTIAL

- Indian climatic conditions offer an ideal environment for biomass production and utilization. Bio-energy has remained critical to India's energy mix. The current potential of surplus agro and forest residues to energy is estimated at 16,881 MW along with an additional "waste-to-energy" potential of 2,700 MW.
- In context of the Indian Sugar Industry, with the setting up of new sugar mills and the modernization of existing ones, the potential of Bagasse cogeneration is estimated at 10,000 MW. With the consideration of cane trash, binding material and high pressure & high temperature power generation cycles, the same is estimated to be +15,000 MW.
- India encourages ethanol as a fuel for automobiles and Regulations provide for the mandatory blending of 10% of ethanol with petrol (to be increased to 20% by 2030). The Government has been encouraging ethanol production through various 1G and 2G routes. As regards, 2G route, bagasse, the ligno-cellulosic material has a role to play.
- The present requirement of ethanol (2020-21) for EBP 10 is estimated to be about 3800 million liters Fuel Ethanol per annum (Table no. 1) which is expected to grow further and further due to increase in vehicular population in the country.

Table no. 1- Ethanol Requirement

| Year | Petrol demand Million litres (M.L) | Ethanol blending requirements Million litres (M.L) | | | |
|---|---|---|---|---|---|
| | | 5 % | 10 % | 15% | 20 % |
| 2015-16 | 30061 | 1353 | 2706 | 4059 | 5412 |
| 2019-20 | 39707 | 1787 | 3574 | 5361 | 7148 |
| 2021-22 | 43361 | 1951 | 3902 | 5853 | 7804 |
| 2024-25 | 49482 | 2227 | 4454 | 6681 | 8908 |
| 2029-30 | 60203 | 2709 | 5418 | 8127 | 10836 |

Table no. 2 – India's Crude Oil Import Bill

**India crude oil import bill since 2006**

| Financial Year | Crude oil import (Million Tonne) | Crude oil import bill ( Rs crore) |
|---|---|---|
| FY 6 | 99.40 | 1,71,702 |
| FY 7 | 111.50 | 2,19,029 |
| FY 8 | 121.67 | 2,72,699 |
| FY 9 | 132.77 | 3,48,304 |
| FY 10 | 159.25 | 3,75,277 |
| FY 11 | 163.59 | 4,55,276 |
| FY 12 | 171.72 | 6,72,220 |
| FY 13 | 184.79 | 7,84,652 |
| FY 14 | 189.23 | 8,64,875 |
| FY 15 | 189.43 | 6,87,416 |
| FY 16 | 202.85 | 4,16,579 |
| FY 17 | 213.93 | 4,70,251 |
| FY 18 | 220.4 | 5,66,450 |
| FY 19* | 228.6* | 8,81,282* |

Source: PNG statistics

*Provisional

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- The Indian government's fuel import bill continues to rise as can be seen from table 2, resulting in 83 per cent of its crude oil requirement being imported and significant amount of foreign exchange being drained. With the political and other uncertainties looming large on oil producing countries on and off, it not only creates apprehension not only about the quantities of crude oil which can be imported but also about the procurement price.
- In addition, as mentioned, the sugar industry can offer about 0.4 million metric tonnes of compressed bio-methane/bio-CNG annually for meeting various requirements. The Promotional policies in vogue are:
    - Besides the Central Financial Assistance, fiscal incentives such as concessional import duty, excise duty, tax holiday for 10 years etc., are available for Biomass power projects. The benefit of concessional custom duty and excise duty exemption on equipment's is also available.
    - In addition, State Electricity Regulatory Commissions have determined preferential tariffs and Renewable Purchase Standards (RPS).
    - Indian Renewable Energy Development Agency (IREDA) provides loan for setting up wind power and Bagasse cogeneration projects.
    - In addition, capital subsidies area also given for the establishment of Bagasse and Biomass based units.
    - Ministry of Petroleum & Natural Gas, Government of India has also pronounced a policy as per details below for setting up compressed bio-methane/bio-CNG unit with sufficiently long term purchase arrangement as per details in figure 6.

## IV. BIOGAS – VALUE-ADDITION IN SUGARCANE VALUE CHAIN

Biogas is produced after organic materials are broken down by bacteria in an oxygen-free environment, a process called anaerobic digestion [10]. Biogas systems use anaerobic digestion to recycle these organic materials, turning them into biogas, which contains both energy (gas), and valuable soil products (liquids and solids) as depicted in figure 7.

Biogas is principally a mixture of methane ($CH_4$) and carbon dioxide ($CO_2$) along with other trace gases. Methane gas, the primary component of natural gas (98%), makes up 55-90% by volume of biogas, depending on the source of organic matter and conditions of degradation. Biogas is produced in all natural environments that have low levels of oxygen ($O_2$) and have degradable organic matter present. Biogas technology permits the recovery of biogas from anaerobic digestion of organic matter using sealed vessels, and makes the biogas available for use as fuel for direct heating, electrical generation or mechanical power and other uses. Biogas is often made from wastes but can be made from biomass energy feed stocks as well. Improvising the quality of bio-gas by scrubbing so as to remove carbon di-oxide and hydrogen sulphide gases thus ensuring methane content to the extent of 95% or more, renders bio-methane which after compressing can be used as automotive fuel also [11].

## V. BIOGAS/COMPRESSED BIO-GAS/COMPRESSED BIO-METHANE FROM PRESS MUD

As several literatures have stated that the disposal of press mud from sugar industry is a tedious task and is usually dumped as waste in open fields which create serious issues with maintaining proper sanitation of the area. Some sugar industries utilize it by converting it into compost. But this compost, along with its disadvantages, that is: it increases the wax content in the soil, the increase in wax reduces the porosity of the soil causing clogging which is not desirable. Therefore, making use of sugarcane press-mud for the production of biogas through the anaerobic digestion is more suitable option for overall benefit for both the farmers as well as the sugar industry [12]. The biogas obtained can be used for many purposes like fuel in kitchen to complement liquefy petroleum gas and save the factories in the electricity used by employees in cooking in their kitchen and also the production of electricity which can be used in the process. The sludge remaining after production of biogas from press mud (filter cake) can be utilized as a fertilizer in the fields. A process flow diagram for the same is depicted in figure 8.

### *A. Quality of Bio-gas*

Biogas is mainly comprising of methane 40-70 vol.%, carbon dioxide 30-60 vol.% and other gases 1-5 vol.% including hydrogen ($H_2$) 0-1 vol.% and hydrogen sulphide ($H_2S$) 0-3 vol.%. The quality of biogas generated by organic waste materials does not remain constant but varies with the period of digestion. The quality of biogas depends mainly on the presence of methane in it. A good quality of biogas has high percentage of methane as detailed in table 3 below [5]. The percentage of methane in biogas may be analysed through gas chromatograph or by means of any suitable apparatus.

Table 3: Characteristic of bio-gas and bio-methane

| **Parameters** | **Biogas** | **Compressed Biogas** |
|---|---|---|
| **Methane (v/v)** | 55-65 % | 92-98 % |
| **$CO_2$ (v/v)** | 35-45 % | 2-8% |
| **$H_2S$ (ppm)** | 500-30,000 | < 20 ppm |
| **Other Impurities** | Present | Mostly removed, Not present |
| **Calorific Value (LCV)** | 19500 kJ/Kg | 52000 kJ/kg |

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*B. Advantages of Bio gas*

Producing biogas gives many advantages for the environment as well as for all the stakeholders involved in the chain. The advantages are as follows:

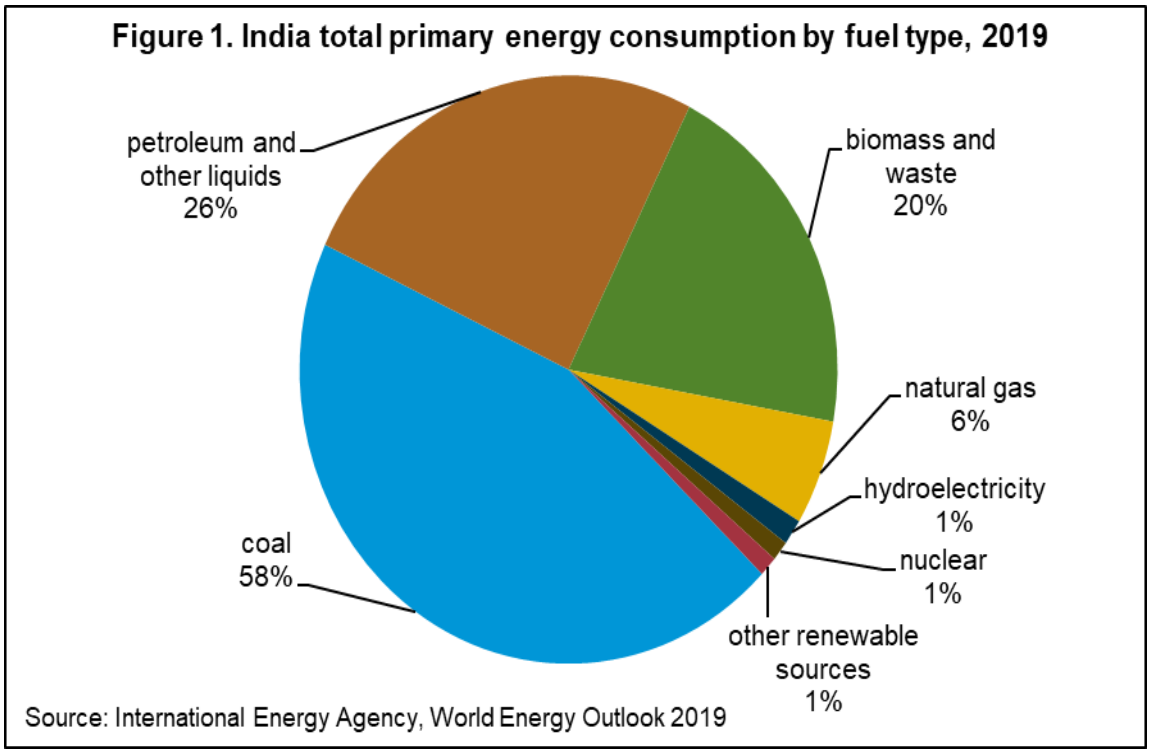
- Considerable environmental advantages - less emission of the greenhouse gasses methane, CO2 and nitrous oxide.
- Environmentally friendly recirculation of organic waste from industry and households.
- Less odour inconveniences when spreading slurry on the fields-fermented slurry smells considerably less than normal slurry and the smell decreases faster.
- Plants absorb fermented slurry better, increasing the yield on the fields.
- Protection of subsoil water - improved nitrogen exploitation reduces leaching and thereby drinking water contamination.
- Reduced costs for artificial fertilizer.

## VI. CONCLUSION

Sugarcane based sugar industry can be an excellent source for sustainable bio-energy. The India Sugar Industry has already gone ahead with export of power through bagasse based co-generation in-spite of various challenges. Ethanol, through molasses or cane juice, has emerged as a bio-fuel which has helped in economic and environment sustainability. However, Press mud which is produced in huge quantities in the Indian Cane Sugar Industry has in-fact no commercial value although it is being used for bio-composting purposes. It's potential needs to be harnessed for producing valuable bio-gas/compressed-bio-methane etc. depending upon the end use through adoption of appropriate technologies.

## REFERENCES

[1] Walker Mark, (2009). Renewable Energy Sustainable biogas production from wastes and energy crops, University of Southampton Anaerobic digestion and energy.
[2] Rolz C., De León R., Cifuentes R. and C. Porres (2010). Sugar Tech 12(1): 15-20, Windrow composting of sugarcane and coffee by-products.
[3] Yadav R.L and Solomon S (2006). Potential of Developing Sugarcane By-product Based Industries in India. Indian Institute of Sugarcane Research, P.O. Dilkusha, Rae Bareli Road, Lucknow-226 002, India Pp. 104-111.
[4] Agrawal, M Karan; Barve, R. B; Shareena Khan, S (2014); Biogas from Press mud IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684, PP: 37-41.
[5] Mohan N & Awasthi S. (2020), Bioenergy from filter cake in Indian sugar industry. International Journal for Scientific Research & Development IJSRD, Vol. 7, Issue 12, ISSN: 2321-0613.
[6] International Energy Agency, World Energy Outlook, (2019).
[7] U.S. Energy Information and Administration (EIA). https://www.eia.gov/international/analysis/country/IND.
[8] Al Seadi, T.; Rutz, D.; Prassl, H.; Köttner, M.; Finsterwalder, T., (2008). Biogas Handbook; University of Southern Denmark: Funen, Denmark.
[9] Anju D., (2015). Bioenergy Biomass to Biofuels Elsevier; ISBN: 978-0-12-407909-0.
[10] Dasgupta A and Nemerow NL (1988), anaerobic digestion of lingo cellulosic residue from sugarcane processing, Energy Biomass Waste, 11: 613.
[11] Ramos, I.; Peña, M.; Fdz-Polanco, M., (2014). Where does the removal of $H_2S$ from biogas occur inmicroaerobic reactors? Bioresour. Technol., 166, 151–157.
[12] Neha G, Sumit T & Chandrajit B (2011). Characterization of press mud: A sugar industry waste, Fuel, 90 (1): 389-394.



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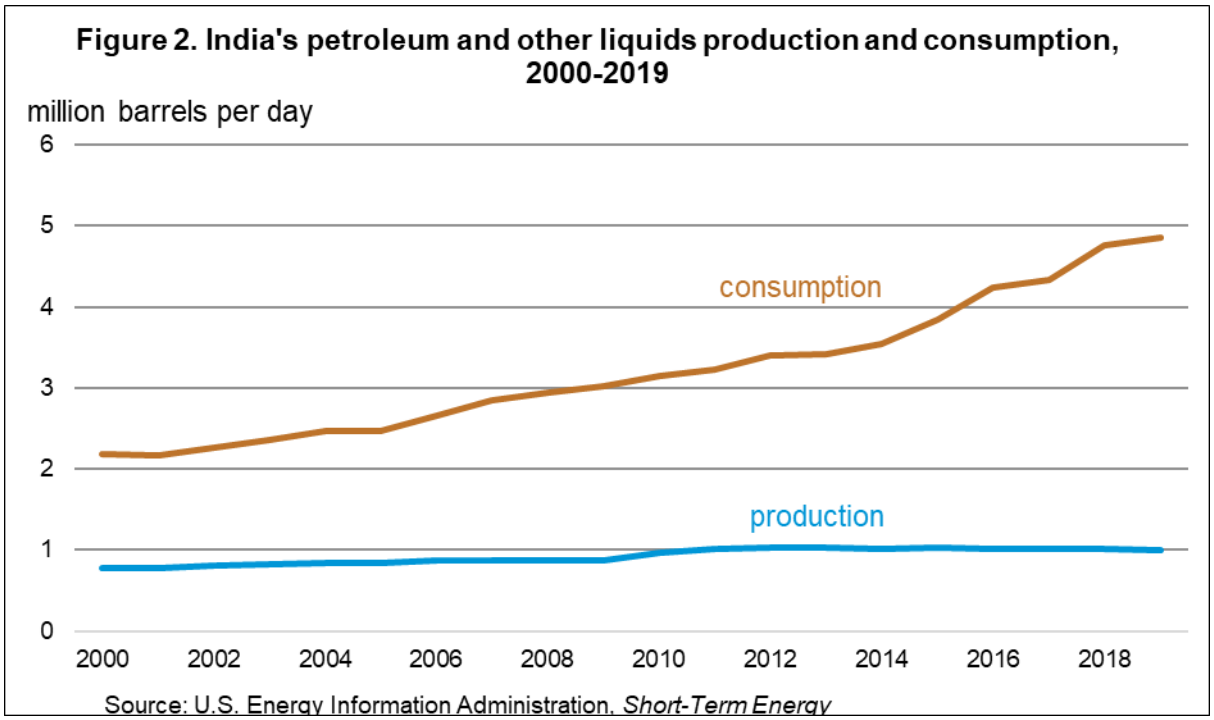


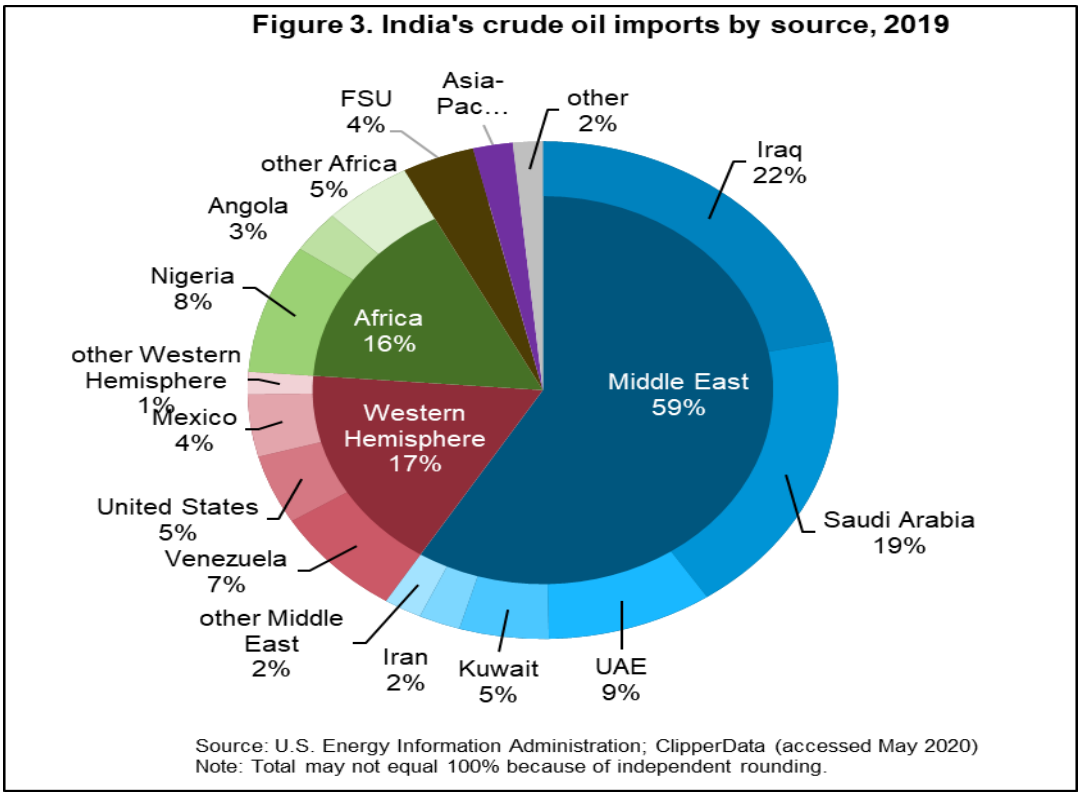

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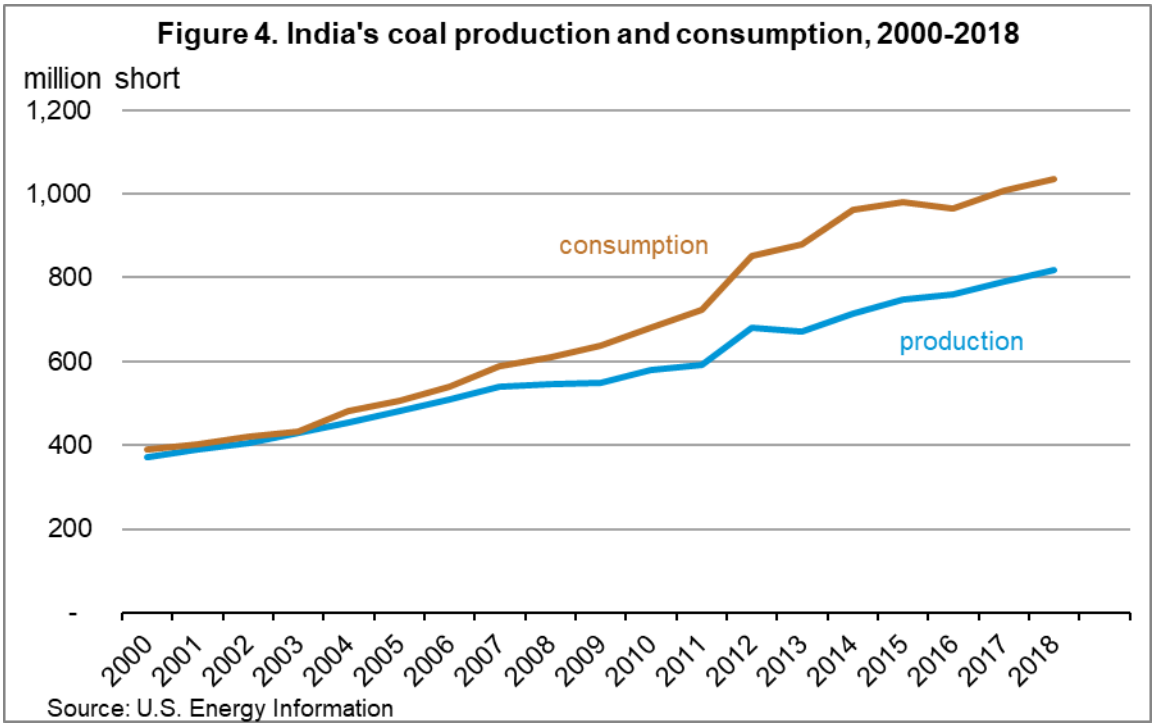


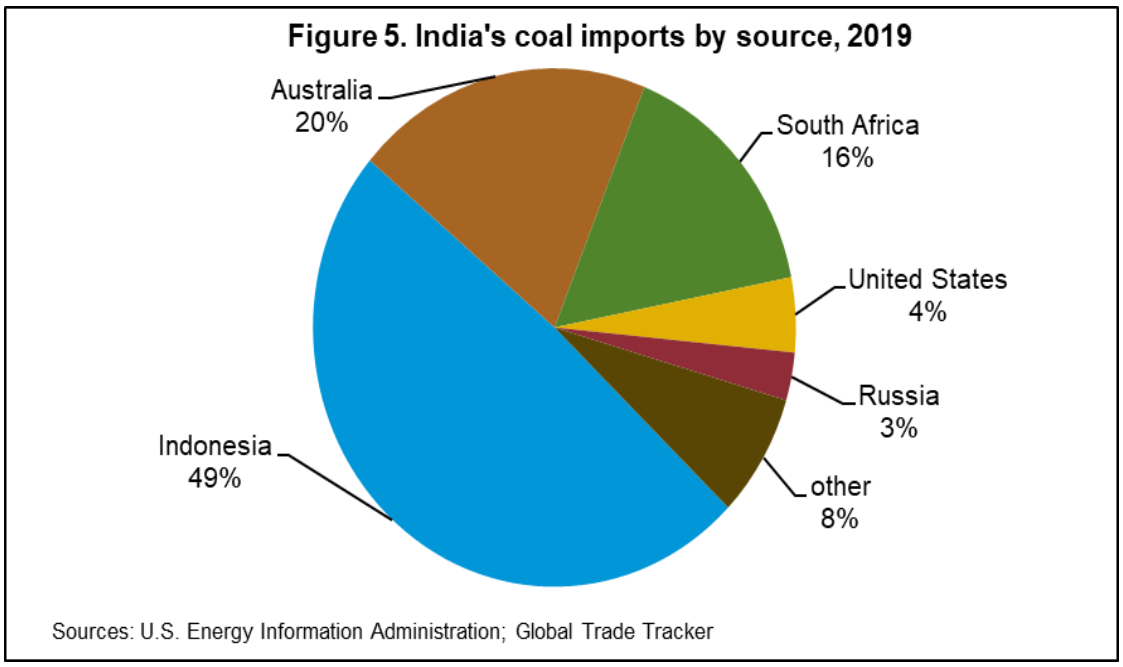


Figure 6: Long term purchase arrangements for setting up compressed bio-methane/bio-CNG unit

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| | |
|---|---|
| Rs. 46 + taxes | •Long term pricing structure from 1.10.2018 - 31.3.2024<br>•floor price from 1.4.2020 - 31.3.2029. |
| 10 years | •Commercial agreement for 10 years, to be extended mutually. |
| Bio-manure | •Inclusion of Bio-manure in FCO notified. |
| Bio-slurry | •Inclusion of Bio-slurry in FCO under consideration. |
| Financing | •Inclusion under priority sector lending in consideration of RBI. |
| Subsidy | •MNRE Central Financial Assistance extended to 2020-21 |

Figure 7: Outline of anaerobic digestion of organic mater

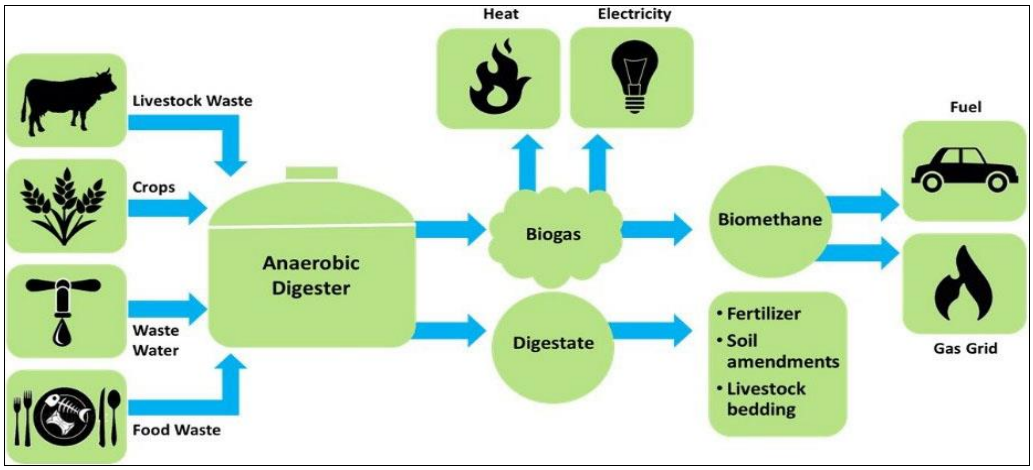


Figure 8: Process for production of biogas from press mud