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BI0MASS UTILIZATION THROUGH BIOREFINERIES

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Abstract.

Agricultural feed stocks are the new sources of chemicals and energy, as fossil reserves become increasingly expensive for manufacture [12]. Biomass already contributes significantly to the world's primary energy supply, probably accounting for around 12600 TWh a year (9–13% of world energy supply). Photosynthesis, driven by solar energy, provides a sustainable means to make complex chemical products in large quantities. A bio refinery is a facility that integrates biomass conversion process and equipment to produce fuels, power and chemicals from biomass .The bio refinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum [12]. By producing multiple products, a bio refinery maximizes the value derived from a biomass feedstock. A bio refinery could produce one or more low-volume, high-value chemical products together with a low-value, high-volume liquid transportation fuel, while generating electricity and process heat for its own use and/or export. It is vital to the environmental sustainability of the bio refinery that low environmental impact technologies are used throughout the processing. The current availability of biomass in India is estimated at about 120-150 million MT/annum covering agricultural and forestry residues corresponding to a potential of 16,000 MW. This apart, 5000 MW can be installed through bagasse cogeneration. Plantations on waste lands also provide significant opportunity - about 62,000 MW for grid-interactive power and another 15,000 MW for off-grid applications[17]. Global industry particularly Indian Industry will benefit from bio-refining plant-derived raw materials for use in sectors as diverse as pharmaceuticals, chemicals and energy. In this regard this paper analysis the various biorefinery technologies used in India with their relative merits and demerits, their prospects as future energy resource and the solutions for the problems faced by Indian Industries are also discussed.

Keywords: *Biorefinery, Biomass, Energy.*

1.Introduction:

A bio refinery is a factory that processes crops to produce various refined specialized products in a similar way to which a petroleum refinery processes oil to make specialized chemical products. The ideal bio refinery of the future should be capable of taking low value local feed stocks, such as agricultural co-products, extracting the high value components and subsequently transforming the residues into 'platform molecules' or bio products, bio fuel, and bio energy[13]. It is vital to the environmental sustainability of the bio refinery that low environmental impact technologies are used throughout the processing. Among various options available for biorefinery, biodiesel , bioethanol, biomass gasification and digestion (Biomethanation) are the major options, which have huge potential in India to develop as energy sources and where investments made would be economical. India has approximately 50 million hectares of degraded wasteland that lie outside the areas demarcated as national forests, and another 34 million hectares of protected forest area, in much of which tree cover is severely degraded[3]. A massive programme is needed to develop energy plantations consisting of oil seed species for biodiesel production and fast-growing tree crops for a national network of small, decentralized biomass gasifies power plants. It is estimated that 30 million tones of solid waste and 4,400 million cubic meters of liquid wastes are generated every year in the urban areas of the country. The municipal solid waste (MSW) generation ranges from 0.25 to 0.66 kg/person/day, with an average of 0.45 kg/person/day[4]. The irrigated cropped area could be used for sugarcane growing for bio ethanol production.

2.Energy Scenario – India

Coal and oil constitute India's primary energy sources .Figures for 1997 indicate that the share of coal in total primary energy consumption was about 56.2% and the share of oil was about 32%, making up almost

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90% of India's total energy needs. Energy consumption has kept up with the pace of economic growth of about 6% since the post-reform period beginning in 1991. Coal consumption has steadily increased in the last decade; India used 283 million metric tons (MMT) of coal in 1997/1998, or 6.5% of the world's total consumption of coal. India's coal usage is expected to double from 405 MMT per year in 2001 to over 800 MMT by 2010. While India will continue to rely heavily on coal, its consumption of oil will steadily rise. India's oil demand currently exceeds 1.75 million b/d, and is the fourth largest oil consumer in the region). India imports about 700,000 barrels of the 1.7 million barrels it currently consumes per day. Imports are likely to increase to 1.5 million b/d by 2010, most from Russia, Iran, Saudi Arabia, Iraq, and the United Arab Emirates(UAE). The bulk of its oil imports will continue to come from the Middle East .Natural gas is a distant third in terms of India's current energy use, accounting for only a 8.5% share of the country's primary energy needs. [14]

3.Bio Refinery:

3.1.OPPORTUNITIES: RANGE OF BIOBASED PRODUCTS

Bio based products fall into three categories: commodity chemicals(including fuels), specialty chemicals, and materials. Some of these products result from the direct physical or chemical processing of biomass—cellulose, starch, oils, protein, lignin, and terpenes. Others are indirectly processed from carbohydrates by biotechnologies such as microbial (e.g.,fermentation) and enzymatic processing. Fermentation ethanol and biodiesel are examples of bio based fuels [12]. Ethanol is critical because this oxygenate can serve as a precursor to other organic chemicals required for production of paints, solvents, clothing, synthetic fibers, and plastics. While ethanol currently is the largest-volume and probably cheapest fermentation product, other chemicals such as lactic acid are under development as raw materials for further processing. Some biobased chemicals are becoming price and cost competitive. For example, vegetable-oil based inks and fatty acids now account for 8 and 40 percent of their respective domestic markets. Bio based chemicals (apart from liquid fuels)probably represent the greatest near-term opportunity for replacement of petrochemicals with renewable resources.

3.2.Bio Refinery - Process

Bio refinery concept is classified with sugar platform and syngas platform. Sugar platform is based on bio chemical conversion process and focuses on the fermentation of sugars extracted from biomass feedstock's .In Syngas platform gasification of biomass feedstock is taking place by means thermo chemical conversion process [7]

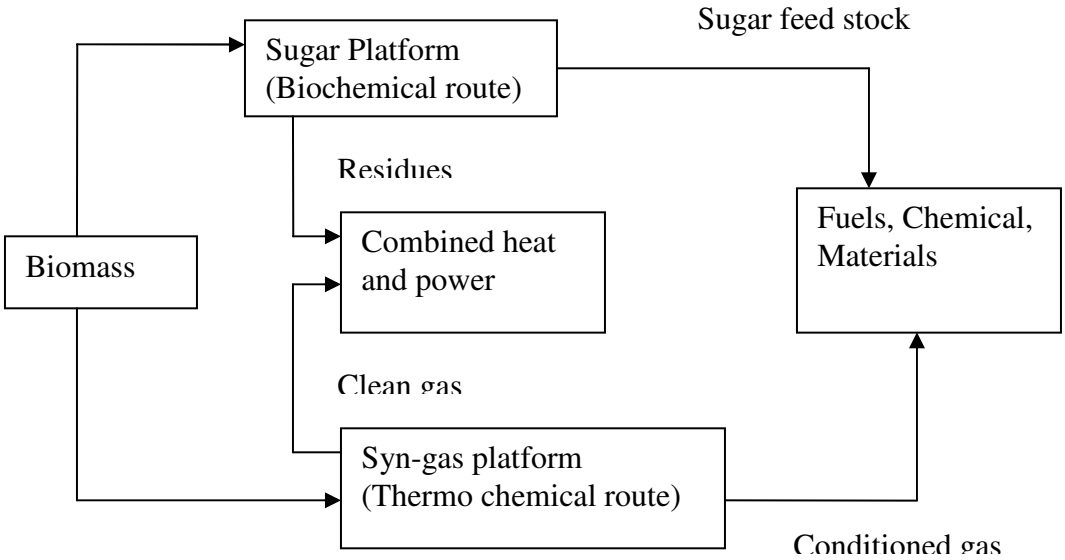

Fig.1. Bio refinery Concept

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A recent vision paper published by the Industrial Biotechnology section of the European Technology Platform for Sustainable Chemistry foresees up to 30% of raw materials for the chemicals industry coming from renewable sources by 2025. The change of raw materials and process technologies will also alter our industrial landscape. Oil refineries situated near ports will gradually be replaced by bio refineries located in the countryside.These factories of the future will integrate agriculture and a transformed chemical industry, converting biomass into a range of value-added products.

Plant cell walls will become increasingly high value feed stocks for bio refineries in the future. Whilst bio ethanol production from biomass is the principal driver currently, plant cell walls represent a unique resource that can potentially be used to provide pure components capable of functionality in their own right as well as providing feed stocks for the manufacture of novel products. Thus, purpose-built bio refineries could in future be integrated into .a bio refinery village, to manufacture a diversity of functional products derived from plant cell walls. [12]

3.3.Ultimate Bio refinery Goal From any Feed stock to any Product

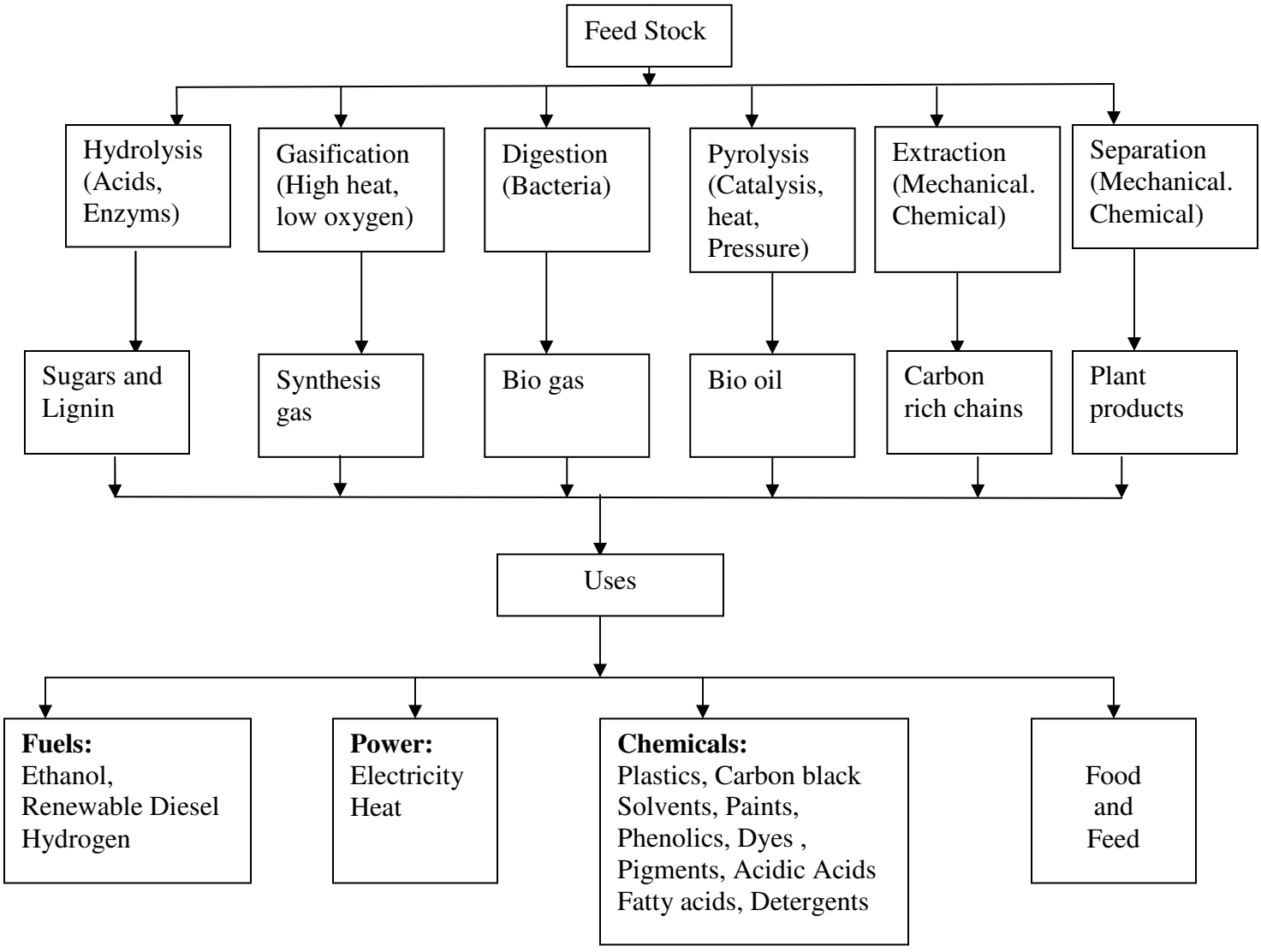

Fig .2.Ultimate Bio refinery Goal From any Feed stock to any Product [14]

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3.4. Need for Bio refinery in India:

The technological development in India has led to improvements in transport, communications, housing, energy and consumables and contributed to a significant increase in living standards. However, it has to be questioned whether this current situation is sustainable. The energy demand in India is increasing steadily in order to meet continuing economic growth. Carbon dioxide emissions are expected to continue to rise, with potential impacts on global temperatures. Concerning energy sources, oil use is expected to increase, although economics will ensure it never runs out since alternative technologies will be needed and developed to provide competitive replacement energy sources.

To increase the per capita energy consumption, more energy must be made available to our population, the first one is fossil fuel resources, which are limited in nature, the second one is renewable energy source namely biomass, which is highly suitable to developing countries conditions like India, because the developing countries are basically agricultural basis economy that produce a large quantity of biomass in the form of agricultural /crop residue, which are renewable in nature.

Towards 2025 there will be significant increases in population, coupled with a changing age distribution and growing health and welfare demands. Demands for oil will increase as water availability falls and land use shifts towards providing feed stocks for the bio-economy.The focus of agriculture is expected to change to serve these new and developing markets.

Large populations in the world are still not being serviced with energy needs at the minimum level even in the 21st century. This is true with developing nations like India, Bangladesh, Sri Lanka, Pakistan, Latin America countries, African countries and many others. Most of these countries are characterized by a large part of the population in scattered locals –in rural areas and hamlets. These remote locations make it uneconomical to extend the centralized grid. In addition, their economic structure is not strong towards importing oil for power generation applications. Further, the environmental considerations to reduce GHG have forced conservation of the use of fossil fuel. This has become one of the factors for the nations to reduce the use of fossil fuel and adopt suitable renewable energy like biomass.

India an oil importing country, with nearly 70% of its population living in half million villages, rural areas and hamlets across the country and rich in biomass resources is ideally suited for biomass based technology like bio refinery. The cost effectiveness and availability factor, biomass based technology are becoming popular as they have edge over other renewable. The estimated capacity of the biomass power is about 16,000MW,but the installed capacity is only about 484 MW.

4.Biomass Potential –India:

The current availability of biomass in India is estimated at about 120-150 million MT/annum covering agricultural and forestry residues corresponding to a potential of 16,000 MW. This apart, 5000 MW can be installed through bagasse cogeneration. Plantations on waste lands also provide significant opportunity - about 62,000 MW for grid-interactive power and another 15,000 MW for off-grid applications.

S.No	Residue	Quantity (10^3 Fresh tons)	Products
1.	Crops	325,800	Paddy, rice, wheat, barley, rye, oats, sorghum, millet, potatoes, sweet potatoes.
2.	Plantation	192,500	Oil palm, rubber, coconut sugar cane, coffee, tea, cocoa, cassava, maize, soybeans, sugar beets.
3.	Vegetable	25,100	Cabbages, lettuce, tomatoes, onion, carrots, spinach, eggplants, cauliflower, castor beans.
4.	Fruit	6,800	Bananas ,pineapples ,papayas,mangoes,apples,oranges,pears,graphs,watermelons,lemons,strawberries,kiwi fruits.
5.	Others	11,500	Groundnuts, pigeon peas ,broad beans, caster beans, chest nuts
	Total	561 700	

Table.1. Estimated quantities of Agricultural Reside in India

The fig shows the fuel wood consumption pattern in south Asia countries.it shows that the fuel wood consumption in India is very high as compare to other Asian countries during 1980 s the total fuel wood consumption was 200 million cubic meters and it is expected to increase the value of 375 million cubic meters in 2010. [1] The trends upto the year 2010 indicate that the consumption of fuel wood is likely to rise marginally in most countries. In India however, the projected consumption of fuel wood will be 365 million cu.m [1]

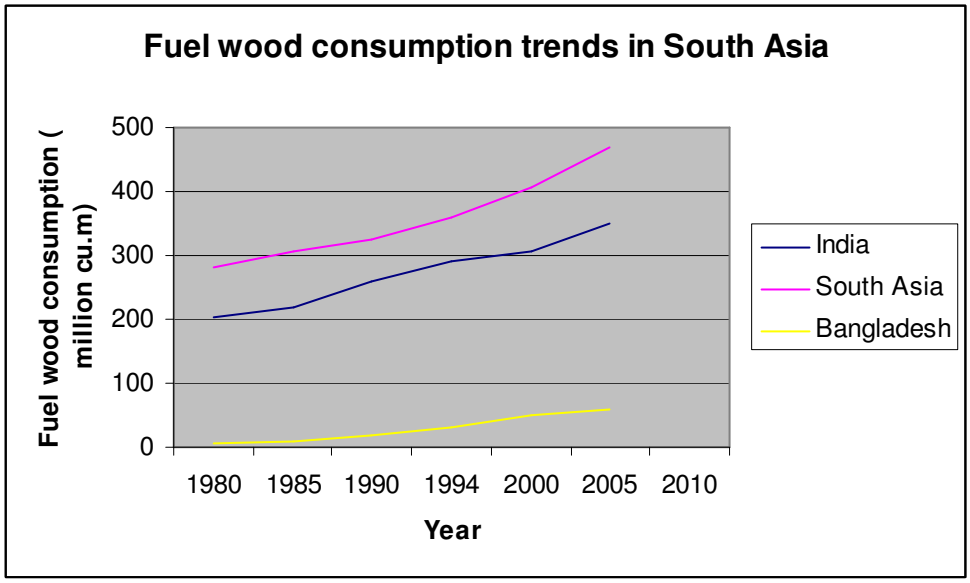

Fig.3. Fuel wood consumption trends in South Asia

5.Biorefinery Products

5.1**Bio Diesel:**

Biodiesel is a variety of ester-based oxygenated fuels derived from natural, renewable biological sources such as vegetable oils. It's name indicates, use of this fuel in diesel engine alternate to diesel fuel. Biodiesel operates in compression ignition engines like petroleum diesel thereby requiring no essential engine modifications. Moreover it can maintain the payload capacity and range of conventional diesel. Biodiesel fuel can be made from new or used vegetable oils and animal fats. Unlike fossil diesel, pure biodiesel is biodegradable, nontoxic and essentially free of sulphur and aromatics[2]

Bio diesel and bio ethanol are expected to make modest contributions to total Consumption of liquid fuels. Bio diesel provides good technical performance and acts as a lubricity agent, and also delivers environmental benefits.

Bio fuels like Bio diesel is one opportunity offering significant potential for development. These fuels can help to address global warming issues and reduce dependence on imported fossil fuels. Bio fuels are a sustainable alternative to traditional fuels and benefit the rural economy. Worldwide there is an opportunity totaling around 100 billion gallons with potential to use existing, emerging and advanced conversion technologies in production processes.

Starch and sugar, the existing raw material base for bio fuels, make use of current infrastructure and technology. Future raw materials will need to produce high yields, meet environmental constraints and suit processing that requires little or no pre-treatment. Processing facilities will need to have low capital intensity and the flexibility to take a variety of feed stocks.

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Year	Diesel requirement MMT	Biodiesel requirement blending MMT		
		5%	10%	20%
2004-2005	46.97	2.35	4.70	9.40
2006-2007	52.33	2.62	5.23	9.92
2011-2012	66.90	3.35	6.69	13.38

Table 2.Estimated bio diesel requirement in India [2]

With a view to substituting diesel for biodiesel the Government of India has launched the National Mission on Biodiesel to address the socio economic and environmental concerns and lay a strong foundation for production of biodiesel in the Tenth five year plan. The lands that can be targeted for such plantations are underutilized, fallow barren or degraded or under stocked forests such as in drought prone areas. It is technically feasible venture as up to 20% of bio diesel is being blended successfully with diesel for some years in a number of countries. *Jatropha curcas* as the most suitable Tree Borne Oilseed (TBO) for production of bio-diesel in view of its ability to thrive under a variety of agro-climatic conditions, low gestation period and higher seed yield.

In April 2003 the Planning Commission of India recommended a multi dimensional programme to replace 20% of India's diesel consumption. (Planning Commission 2004).The Planning Commission has integrated the Ministries of Petroleum, rural developmentPoverty Alleviation and the Environmental Ministry. One of the major objectives is to blend petro diesel with a planned 13 Million tons of biodiesel by 2013, produced mainly from non edible Jatropha oil. In the first phase the program intends to replace 5% of diesel Consumption by 2006 with 2.6 million tonnes of Jatropha bio diesel.

Biodiesel – Importance advantages:

As concentrations of greenhouse gases in the environment have been increasing, we need to find ways to decrease man's impact on the environment. Biodiesel is safe for the environment and produces less air pollution compared to petroleum diesel. When using pure biodiesel, the exhaust emissions of carbon monoxide (a poisonous gas and a factor in local smog formation) are 50 percent lower than when using petroleum diesel. The exhaust emissions of hydrocarbons, which also contribute to smog formation, are 95 percent lower. The exhaust emissions of sulfur oxides (Sox) and sulfates, which are major components of acid rain, from biodiesel are almost completely eliminated. However, studies have shown that the nitric oxide (Nox) emissions are increased..Biodiesel is Produced from sustainable / renewable biological sources, it is Eco friendly and oxygenated fuel

5.2.Anaerobic digestion (Biomethanation):

Anaerobic digestion (Biomethanation) is a multi-step biological process where the organic carbon is converted to its most oxidized (CO_2) and most reduced (CH_4) state. The main product of the process is biogas which is a mixture of methane and carbon dioxide, as well as trace gases such as hydrogen sulfide and hydrogen. The process involves several groups of microorganisms which makes it complex and sensitive, and makes it a valid subject for control and optimisation. [15]

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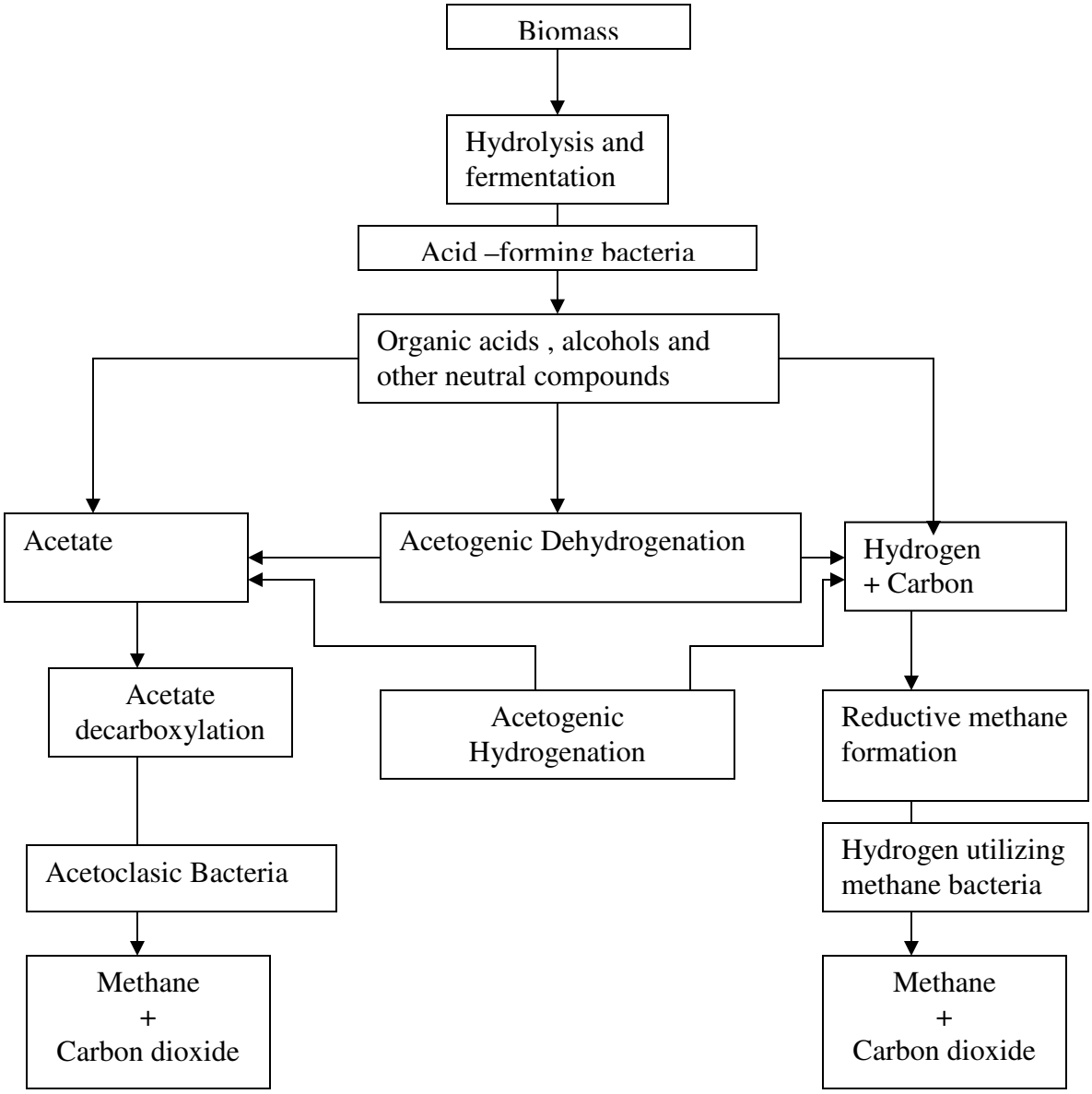

Fig.4. Bio methanation Procss

The important processes in anaerobic digestion are hydrolysis, fermentation, cytogenesis and methanogenesis. Anaerobic digestion for treatment of organic waste and biogas production is an environmentally attractive technology. It has environmental benefits with regard to waste treatment, pollution reduction, production of CO_2-neutral renewable energy and improvement of agricultural practices by recycling of plant nutrients. Anaerobic digestion (AD) has successfully been used for many applications that have conclusively demonstrated its ability to recycle biological wastes. More than 1,000 high-rate anaerobic digesters are operated worldwide to treat organic, polluted industrial waste water including processors of beverages, food, meat, pulp and paper, milk and other things. This paper discuss about the various stages involved in the anaerobic digestion, its trends in India and biogas utilization.

In India, it is estimated that 30 million tonnes of solid waste and 4,400 million cubic meters of liquid waste are generated every year in the urban areas of the country. This estimation was based on the structured data base prepared for 299 Class I cities and 36 Class II cities as part of the 'National Master Plan for

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Development of Waste to Energy in India' supported under a UNDP/GEF-assisted Project on the 'Development of High Rate Biomethanation Processes'. The study concluded that 17 (6%) cities have generation rates in excess of 1,000 TPD, and 80 cities (26%) generate 150 to 1000 TPD. The balance of 202 cities (68%) individually generates less than 150 TPD. The municipal solid waste (MSW) generation ranges from 0.25 to 0.66 kg/person/day, with an average of 0.45 kg/person/day.

5.3.Bio Ethanol

Bio ethanol or ethanol is a cleaner burning, high octane fuel that is produced from renewable starch or sugar source at its most basic ethanol is grain alcohol, produced from crops such as wheat or corn.

Ethanol is frequently used as a gasoline additive, or converted to additive called ethyl tertiary-butyl ether, to raise the octane level of gasoline and promote cleaner combustion. According to the U.S.Environmental Protection agency, the use of ethanol blended with gasoline can reduce motor vehicle emissions of carbon monoxide by 25%to 30% and also reduce ozone levels that contribute to urban smog. In addition, the combustion of ethanol produces 90%less carbon dioxide than gasoline.

Enzymatic and non-enzymatic route are the two important methods to produce ethanol from biomass. A study shows the amount of ethanol produced from bagasse is more in the case of enzymatic process (0.238 Kg ethanol/Kg bagasse) than the two-stage dilute acid process (0.186 ethanol/kg bagasse) clearly indicating superiority of enzymatic process.

Bio ethanol Plant Block Diagram

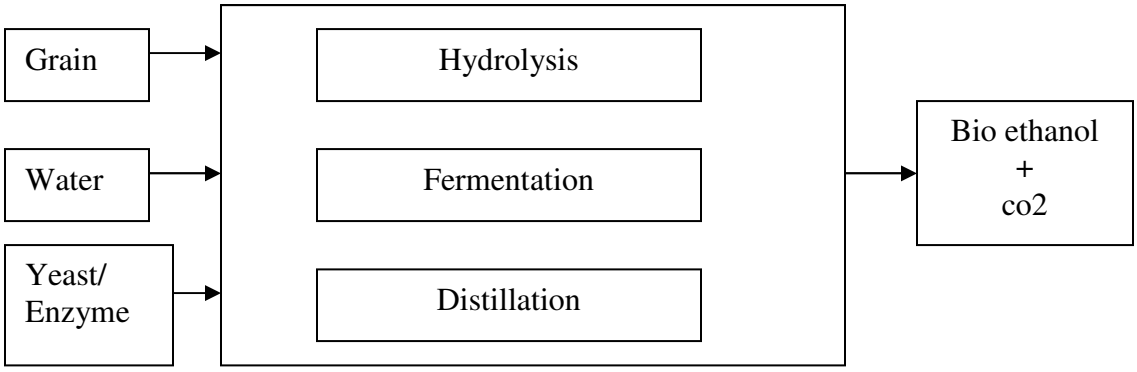

Fig .5. Bio ethanol Processing

Research focuses on low-cost production of enzymes to break down cellulose, improve microorganism performance, produce suitable energy crops.

Keeping in view the huge availability of raw material and ethanol demand, Acid Catalyzed Organosolv Saccharification (ACOS), the only known wood hydrolysis process capable of total (residue-free) dissolution of any wood or agricultural residue could be a good option for distillation of biological material and wood for ethanol production.

The important advantages of BioEthanol:

Bioethanol is non –toxic,and biodegradable ,
Can be blended with gasoline in standard engines up to 10%,
It reduces toxic emission and green house gas emissions
100% renewable energy ; reduces dependence on fossil fuels

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5.4.Gasification :

Gasification is the conversion of biomass to a gaseous fuel by heating in a gasification medium such as air, oxygen or steam. Unlike combustion where oxidation is substantially complete in one process, gasification converts the intrinsic chemical energy of the carbon in the biomass into a combustible gas in two stages. The gas produced can be standardised in its quality and is easier and more versatile to use than the original biomass e.g. it be used to power gas engines and gas turbines, or used as a chemical feedstock to produce liquid fuels. Strictly, gasification includes both biochemical and thermo chemical processes, the former involving microorganisms at ambient temperature under anaerobic conditions i.e. anaerobic digestion, while the latter uses air, oxygen or steam at temperatures >800^{o}C. In the gasifiers considered, the biomass is heated by combustion. Four different processes can be distinguished in gasification: drying, pyrolysis, oxidation and reduction

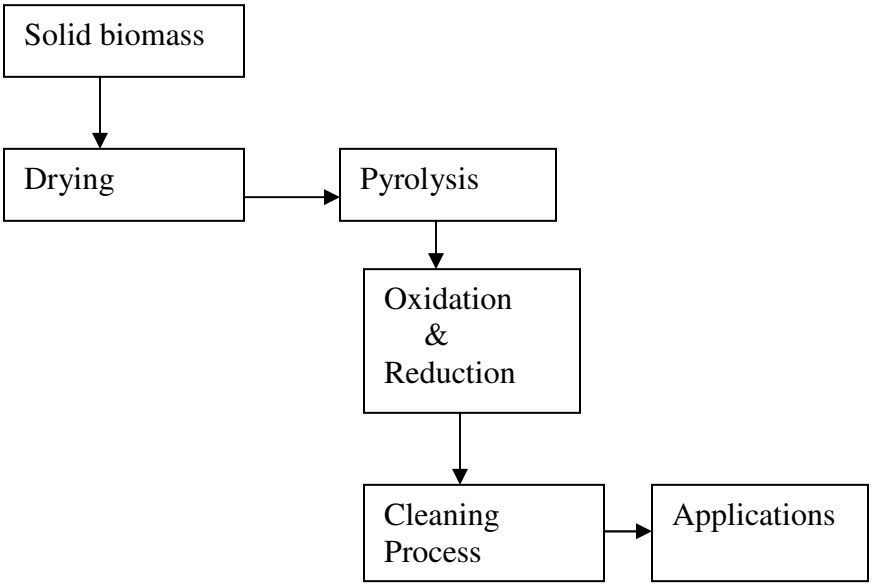

Fig.6. Process of Biomass Gasification

Multiple Advantages of Biomass Gasification:

Conversion of solid biomass into combustible gas has all the advantages associated with using gaseous and liquid fuels such as clean combustion, compact burning equipment, high thermal efficiency and a good degree of control. In locations, where biomass is already available at reasonable low prices (e.g. rice mills) or in industries using fuel wood, gasifier systems offer definite economic advantages. Biomass gasification technology is also environment-friendly, because of the firewood savings and reduction in CO2 emissions. Biomass gasification technology has the potential to replace diesel and other petroleum products in several applications, foreign exchange.

Applications of Biomass Gasification:

Thermal applications: cooking, water boiling, steam generation, drying etc. Motive power applications: Using producer gas as a fuel in IC engines for applications such as water pumping Electricity generation: Using producer gas in dual-fuel mode in diesel engines/as the only fuel in spark ignition engines/in gas turbines.

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6.Conclusion:

This research paper discuseed the various technologies that involved with the biorfinery process to produce the various useful product from the biomass , and also there is a lot of potential available for the biorefinery process. There will be a reduction of environmental pollution by going to the biorefinery process.In future biorefinery will take greater part in the economy of all the countries because there will be a limited resources of the fossile fuel.

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