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Transforming Waste into Green Energy

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ABSTRACT: “No energy No Life”. Energy is essential to all living organisms. It is a strength for performing any kind of activity. It is a well-known fact that energy can never be destroyed, it can only be transformed in one form to other. We are blessed with ‘Nature’ nurturing always with its energy, the solar energy which is the main source of all types of energy on earth. Today we are living in the “Age of Tools”, equipped with materials. When there is a material there is a material waste, which can be found everywhere on our planet. Day by day, the percentage of waste is increasing resulting to depletion of natural (green) energy resources, which is affecting every sector around us. Therefore, it is our moral responsibility to contribute our efforts towards sustainable and harmless energy resources. One of the important areas is transforming waste into green energy. The primary intent of this paper focuses on various innovative methodologies adopted for converting waste material into green energy.

KEYWORDS: Green energy, transformation, waste materials

I. INTRODUCTION

Today, we are living in a materialistic world. Material waste can be found everywhere on the planet. Water resources, land resources and air resources, none of them is being deprived with it. Billion tons of waste is produced annually. Our substantial population growth in urban areas has increased the percentage of waste generation which has a negative impact on health due to increase in pollution. In our country, unselective dumping of wastes, factious landfilling and mass burning are some of the conventional methods employed for waste disposal. Various unacceptable environmental and health consequences have generated to a great extent. But this alarming situation is being recognized and practices and affordable solutions are coming forward for eco-friendly biodiversity.

Electricity generation, most in demand, has increased the fossil fuel- based power plants generating abundant greenhouse gases and excessive carbon in the environment leading to global warming.[1] Our country is bestowed with several kinds of renewable energy sources such as solar, biogas, biomass, small hydro, and wind. Urban, industrial and municipal wastes could also be beneficial sources of energy employing safe disposal.

Major types of solid waste can be classified as municipal solid waste (MSW), hazardous wastes, industrial wastes, agricultural wastes, and bio-medical wastes. The tremendous growth in waste generation and its unscientific disposal methods are heading to the discharge of Methane, Carbon dioxide, etc. in the atmosphere. Safe waste management is essential for the green economy and sustainability intentions of both government and the private sectors. Renewable waste materials from agriculture, (livestock wastes, crop debris, butchery wastes, bulk forest wastes, etc.) [2,3,4,5,6] industries (paper and pulp, bagasse, press mud, contaminated petroleum or synthetic oil, water in oil, oil in water, tarry residue waste, coal tar, heavy metals, a metallic chemical element both lethal and dangerous)[7,8,9,10,11,12,13] and domestic sources (bottles, cans, clothing, compost, disposables, food packaging, food scraps, newspapers and magazines and yard trimmings) [14,15,16,17,18] are convertible to useful energy forms like bio-hydrogen, biogas[19], bio-alcohols, etc., through waste transforming energy routes for sustainable growth of the world. Total solid wastes are being produced annually as by- products through agricultural, industrial, municipal, and other processes in the country [20]. As of November 2017, municipal solid waste generation is around 1,45,626 metric tons /day and municipal solid waste per annum being 53.153 million metric tons. It is estimated that by the year 2021 the waste generation would increase to 71.15 million metric tons /year and 160.96 million metric tons /year by 2041 respectively [21].

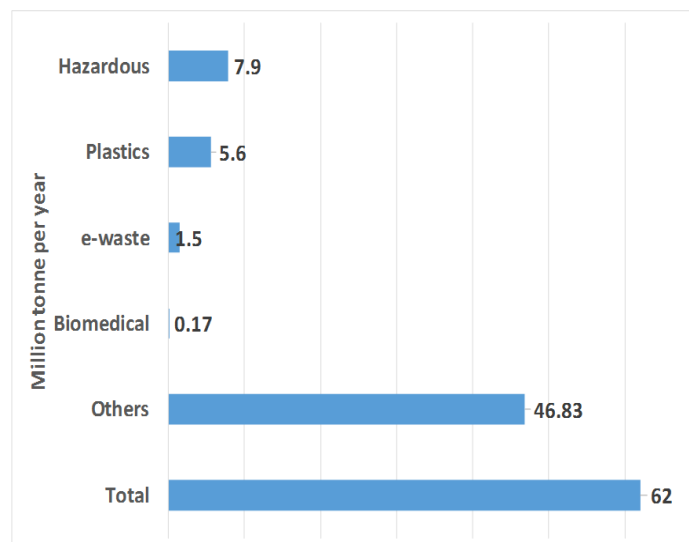


Figure 1: Waste generated in India per year (metric tons) [22].

Figure 1 shows the waste generated in India per year (metric tons). It shows that total of 62 metric ton created which includes 7.9 metric ton of hazardous, 5.6 metric ton of plastics, 1.5 metric ton of e-waste, 0.17 metric ton of biomedical waste and 46.83 metric ton are other wastes. The various technologies used to generate energy from waste are compiled in **Table 1**. Thermo-chemical methods include incineration, thermal gasification, and pyrolysis. Biochemical processes are fermentation, anaerobic digestion, landfill with gas capture, microbial fuel cell. The chemical process is esterification. The Incineration processes include mass burn, co- combustion, refuse-derived fuel, and the product is heat, power and combined heat and power. The product of thermal gasification is hydrogen, methane, and syngas. The product of pyrolysis is char, gases, aerosols, and syngas.

The fermentation process is dark fermentation, photo- fermentation, and the product are ethanol, hydrogen, and biodiesel. In anaerobic digestion and landfill with gas capture the product is methane.

In esterification, the end products are ethanol and biodiesel [23]. **Fig.2** shows the various techniques linked with different waste materials for example- inert materials are managed using landfills, plastic paper metals are recycled, and wet fractions are treated using anaerobic digestions.

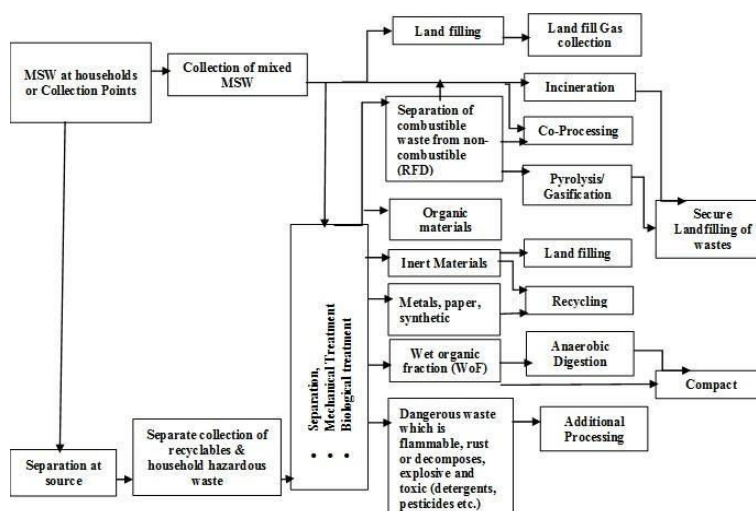


Figure 2: Summary of the various techniques linked with different waste materials.

Table 1: Current Technologies for waste to energy [24]

Technology	Method	Processes	End product
Thermo-chemical	Incineration	Mass burn: Burning the waste at a temperature above 1000 °C	Heat, Power, combined heat and power.
		Co- Combustion: with coal, biomass	
		Refuse-derived fuel: using pre-treated fractions of waste with higher and more stable energy contents	
	Thermal gasification	Conventional: Temperature of 750 °C	Hydrogen, methane, syngas
		Plasma arc: Passing waste into kin at 4000-7000 °C. Waste products are vitrified.	
	Pyrolysis	The temperature of 300-800 °C, at higher pressures and in the absence of oxygen	Char, gases, aerosols, syngas
Biochemical	Fermentation	Dark fermentation: Organic waste is treated with bacteria in the absence of a light source	Ethanol, hydrogen, biodiesel
		Photo-fermentation: Organic waste is treated with bacteria in the presence of a light source	
	Anaerobic digestion	Conversion process carried out by micro-organisms in the absence of oxygen	Methane
	Landfill with gas capture	Landfill with gas capture: extraction from existing landfill sites, by the natural decomposition of waste	Methane
	Microbial fuel cell	Microbial fuel cell: A catalytic reaction of nature microorganism and bacteria to convert the chemical energy content of organic matter.	Power
Chemical	Esterification	The reaction of acid and alcohol to create an ester	Ethanol, biodiesel

II. METHODOLOGIES ADOPTED

In this roundup, a glimpse of various more exciting methods of turning waste into energy around the world is shown.

Synova MILENA/OLGA Gasification Technology



(Image credit: Synova Technology)

Synova Technology has improved on old-world technology with its MILENA/OLGA gasification system. Its platform runs a four-step process to convert biomass and solid waste into gas, with the first step processing the waste, wherein all recyclables are removed. What's left is processed in its MILENA gasifier, where it is turned into a dense synthetic gas. That gas is then scrubbed of contaminants (including char, fine particles, aerosols, and tar), rendering a clean power source that can be used to produce power via a gas turbine or engine.

Harvest Power Energy Gardens



(Image credit: Harvest Power)

Harvest Power has taken on food waste to provide power through the company's Energy Gardens, which produce biogas through the anaerobic digestion of food scraps, yard trimmings, and other organic materials. The energy plants (located throughout North America and Canada) produce biogas by first mixing food and other organic waste with oils, fats, grease, and treated sewage. The slurry is then fed into 1.2-million-gallon tanks where anaerobic microorganisms digest the refuse, and in less than a month, produce a clean burning fuel. Harvest Power Energy Gardens are currently processing 260,000 tons of organic waste per year and generating 14.9 MW CHP (Megawatt Combined Heat and Power).

Plastic to Oil Technology Converts Plastics into Fuel

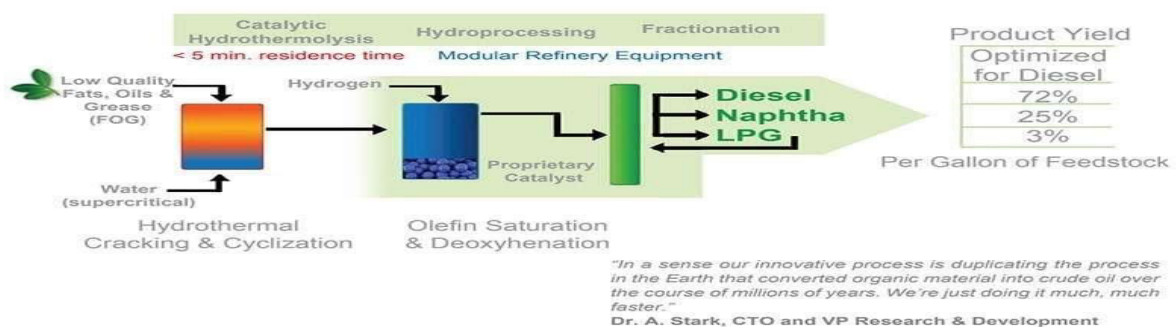


(Image credit: Plastic to Oil)

Clean energy company JBI has developed a process that turns all plastic refuse into oil using its Plastic to Oil technology. The process begins by feeding the plastics (even industrial non-recyclables) through a shredder and granulator to create feedstock, handling up to 1,800 pounds at a time. It is then heated in a process changer and then moved into the main reactor, where a "secret" catalyst is used to remove the plastics' hydrocarbons, exiting the plastic in a gaseous state. The gas is captured, compressed, and stored during the process.

Gases containing gasoline/diesel can be condensed, separated, and stored in tanks, while methane, ethane, propane, and butane off-gases are compressed and stored as well. The butane and propane liquefy when compressed, allowing them to be separated and stored, while the other gases are used to power the system.

Urban X Renewables Group Turns Waste Oil and Grease into Diesel Fuel



(Image credit: UrbanX Renewables Group)

California energy startup UrbanX Renewables Group produces a drop-in fuel (diesel) refined entirely from used restaurant and commercial kitchen grease using its XRD technology, which is based on the thermal Biofuels ISOCONVERSION process. The XRD technology uses catalytic hydro-thermolysis (CH) process whereby heated supercritical water converts fat into crude oil that is nearly identical to petroleum. That crude then goes through a hydrothermal process to remove any impurities and then undergoes fractionation, so that the oil can be dropped into any diesel engine without the need for conversion.

Michigan State University Uses Fermentation to Create Biofuel



(Image credit: Michigan State University)

Researchers from Michigan State University have designed a novel way of producing biofuel and hydrogen using microbes and bio electro chemical systems. The process involves using microbial electrolysis cells (MECs) and two types of bacteria — one that breaks down and ferments agricultural biowaste into ethanol, and another that cleans it while generating electricity in the process. That electricity isn't harvested but instead is used to produce hydrogen in the MEC cells to increase their efficiency.

BioHiTech's HEBioT Centers Turn MSW Into a Cleaner Burning Fuel

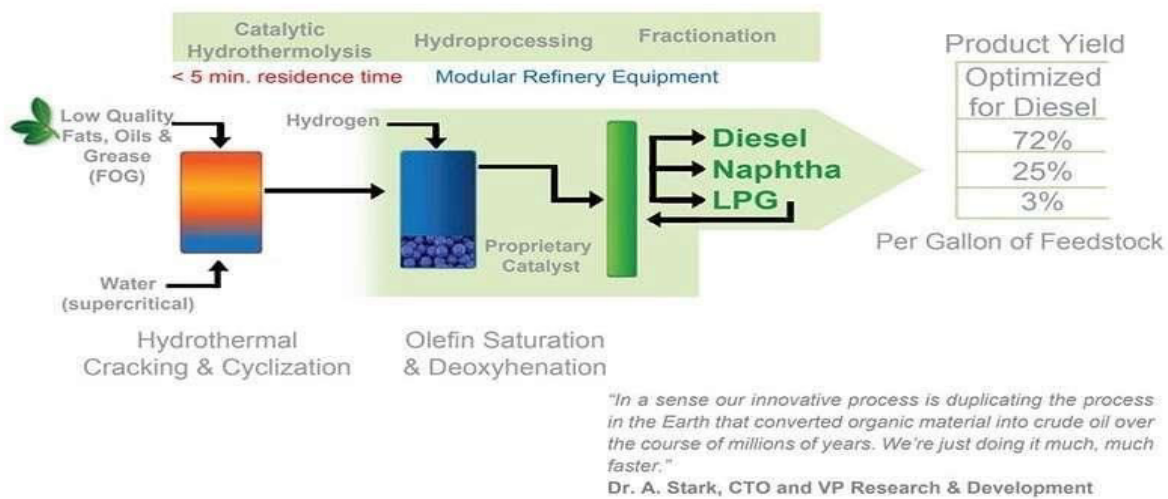


(Image credit: BioHiTech Global)

New York-based BioHiTech Global transforms municipal solid waste (MSW) into fuel, using proprietary mechanical biological treatment technology. The company's High-Efficiency Biological Treatment (HEBioT) process turns MSW into solid recovered fuel (SRF), an EPA-recognized alternative that burns significantly cleaner than fossil fuels. This process uses four steps to create fuel: reception, pre-screening, biological treatment, and refining.

Waste is processed, separated into large and small pieces and shuffled into a biostabilization area where toxic impurities are ejected. It then passes through a mechanical refinement platform where recyclable materials are removed, with the rest ground into a clean burning SRF.

Alter NRG Turns to Plasma Gasification to Process Waste into Fuel



(Image credit: Alter NRG)

Alberta, Canada-based Alter NRG designs plasma gasification plants that turn a wide variety of waste into clean synthetic gas, or syngas. The process involves shredding MSW feedstocks, which are then fed into a gasifier along with coke and flux (limestone), to promote proper slag flow. The mixture is superheated using plasma torches, converting any organic MSW material into syngas, that is water cooled at the top of the gasifier and then collected and stored. The leftover slag is then crushed and granulated, ready to be reused for other applications.

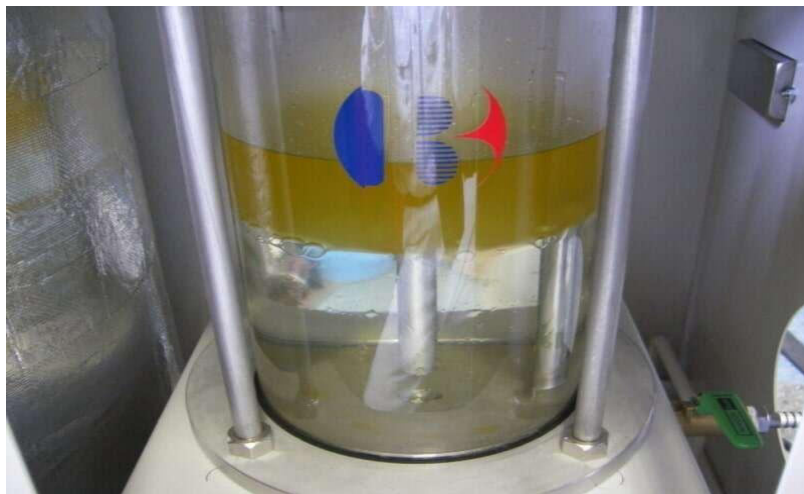
Purdue University Uses Hydrothermal Processing to Turn Waste into Fuel



(Image credit: Purdue University)

Researchers from Purdue University have developed a new technique to transform plastic waste into oil, which is known as hydrothermal processing. While the process has been used before, it has yielded only minor results. Purdue's new technique uses common plastic (polypropylene) feedstocks, which are placed into a reactor with water. The material is then heated up to temperatures ranging from 380 to 500 degrees Celsius for up to five hours at a pressure of 23 Megapascals, or 2,345 tons per square meter. Both the heat and pressure convert the plastic into oil, ready to be used for energy production.

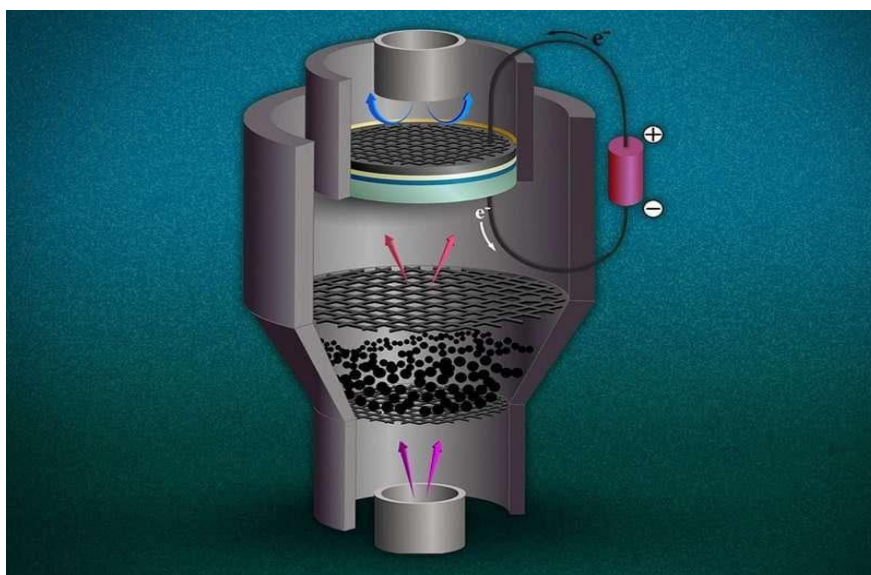
Blest Co.'s Waste Plastic Oiling System



(Image credit: Blest Co.)

Tokyo-based Blest Corporation is also working in plastics-to-fuel with its Waste Plastic Oiling Systems, which use the thermal depolymerization technique to convert plastic into oil. In this case, plastic bags are the feedstock, which is heated into a vapor and cooled in a series of pipes and water chambers transforming it into crude oil that can be used to heat buildings. Depending on the machine, two pounds of plastic results in one quart of oil using just one kilowatt of power.

MIT Combines Coal Gasification with Fuel Cell Technology to Boost Plant Efficiencies



(Image credit: MIT)

Several countries still rely on coal for power and don't have access to technology that can reduce the emissions associated with burning coal. Researchers from MIT have designed a solution that would generate energy from coal with greater efficiency while reducing carbon dioxide gases. The process involves combining coal gasification and fuel cells- coal is pulverized and super-heated, producing burnable gas, which is collected and contained in fuel cells. In fact, the fuel cells generate enough heat to sustain the gasification process, thus eliminating the need for a separate heating system.

While great inroads have been made to turn waste into energy, none of the technologies presented here are a perfect solution. None of them yet have a 100% conversion rate yet nor are entirely free from producing some toxic byproduct. Some of the technologies are modern updates of centuries-old technology, while others are recent developments. All examples presented here help to curb waste by turning it into energy, which is desperately needed considering the amount of trash we produce every year.

III. CONCLUSION

The energy generation cost from conventional energy sources is becoming very high and harnessing power from waste is becoming more important nowadays. The waste management- techniques are cost-effective, environmentally friendly and accepted socially. Waste management is showing more advantages such as reducing greenhouse gases, reducing wastes, income from energy sale, reuse of waste materials. Efforts are being made in this direction, but increasing population is demanding more and more. Need of the hour is to come up with more modified strategies, plans and policies to have an eco-friendly sustainable biodiversity.

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