

SUSTAINABLE DEVELOPMENT IN THE FIELD OF ENERGY BY PROCESSING RECURRING WASTES IN DIFFERENT WAYS

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ABSTRACT: With the alarming rate of enormous increase in the quantum and diversity of waste materials generated by myriad human activities, and their potentially harmful effects on the general environment and public health, there arises an invariable need of increasing awareness about an urgent need to adopt scientific methods for safe disposal of wastes. While there is an obvious need to minimize the generation of wastes and to reuse and recycle them, the technologies for recovery of energy from wastes can play a vital role in mitigating the problems. Besides, the education on how they can use it for generating a renewable and sustainable source of energy and the ways to generate would become utmost important and mandatory. Besides recovery of substantial energy, these technologies can lead to a substantial reduction in the overall waste quantities requiring final disposal, which can be better managed for safe disposal in a controlled manner while meeting the pollution control standards. So, this direction of research would yield multiple benefits and the world can even end up with a very minimum expenditure on new energy resources. So this paper mainly focuses on the types of wastes that can be processed to energy, and the ways in which it can be processed to energy, which is the ultimate requirement of the world today!

KEYWORDS: waste materials, disposal, renewable, sustainability energy, renewable source.

1 INTRODUCTION

Generally, Waste generation rates are affected by socio-economic development, degree of industrialization, and climate. Again these parameters widely vary across the globe and even across the states and cities in a country. Generally, the greater the economic prosperity and the higher percentage of urban population, the greater the amount of solid waste produced. They are linked as directly proportional. Reduction in the volume and mass of solid waste is a crucial issue especially in the light of limited availability of final disposal sites in many parts of the world. Although numerous waste and byproduct recovery processes have been introduced, anaerobic digestion¹ has unique and integrative potential, simultaneously acting as a waste treatment and recovery process. After reduction in volume, they can readily be classified, pretreated and processed to energy.

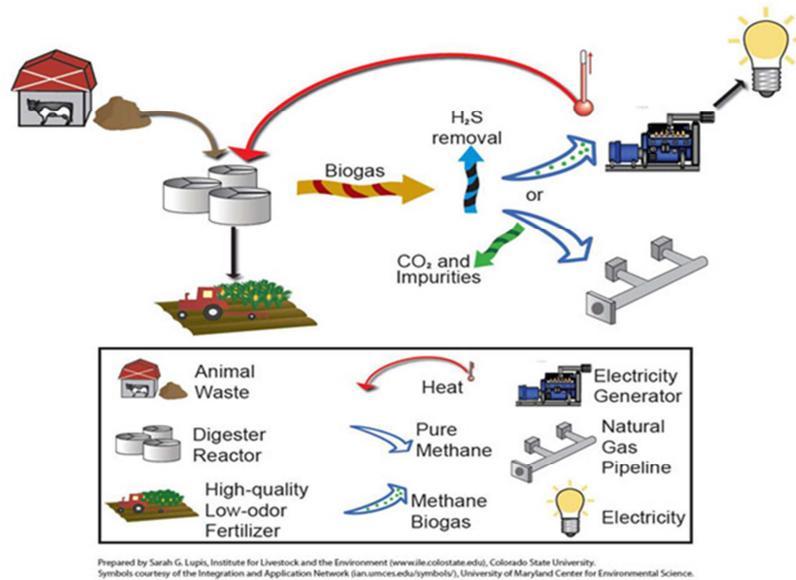


Figure 1 shows anaerobic digestion

2 A GLANCE ON THE TYPES OF WASTES THAT CAN BE USED FOR ENERGY PRODUCTION

2.1 INDUSTRIAL WASTES

The food industry produces a large number of residues and by-products that can be used as biomass energy sources. These waste materials are generated from all sectors of the food industry with everything from meat production to confectionery producing waste that can be utilised as an energy source. Solid wastes include peelings and scraps from fruit and vegetables, food that does not meet quality control standards, pulp and fibre from sugar and starch extraction, filter sludges and coffee grounds. These wastes are usually disposed of in landfill dumps.

Liquid wastes are generated by washing meat, fruit and vegetables, blanching fruit and vegetables, pre-cooking meats, poultry and fish, cleaning and processing operations as well as wine making. These waste waters contain sugars, starches and other dissolved and solid organic matter. The potential exists for these industrial wastes to be anaerobically digested to produce biogas, or fermented to produce ethanol, and several commercial examples of waste-to-energy conversion already exist.

2.2 MUNICIPAL SOLID WASTE (MSW)

Millions of tonnes of household waste are collected each year with the vast majority disposed of in landfill dumps. The biomass resource in MSW comprises the putrescibles, paper and plastic and averages 80% of the total MSW collected. Municipal solid waste can be converted into energy by direct combustion, or by natural anaerobic digestion in the landfill. At the landfill sites the gas produced by the natural decomposition of MSW (approximately 50% methane and 50% carbon dioxide) is collected from the stored material and scrubbed and cleaned before feeding into internal combustion engines or gas turbines to generate heat and power. The organic fraction of MSW can be anaerobically stabilized in a high-rate digester to obtain biogas for electricity or steam generation.

2.3 SEWAGE

Sewage is a source of biomass energy that is very similar to the other animal wastes. Energy can be extracted from sewage using anaerobic digestion to produce biogas. The sewage sludge that remains can be incinerated or undergo pyrolysis to produce more biogas. Figure 2 shows MSW digester.

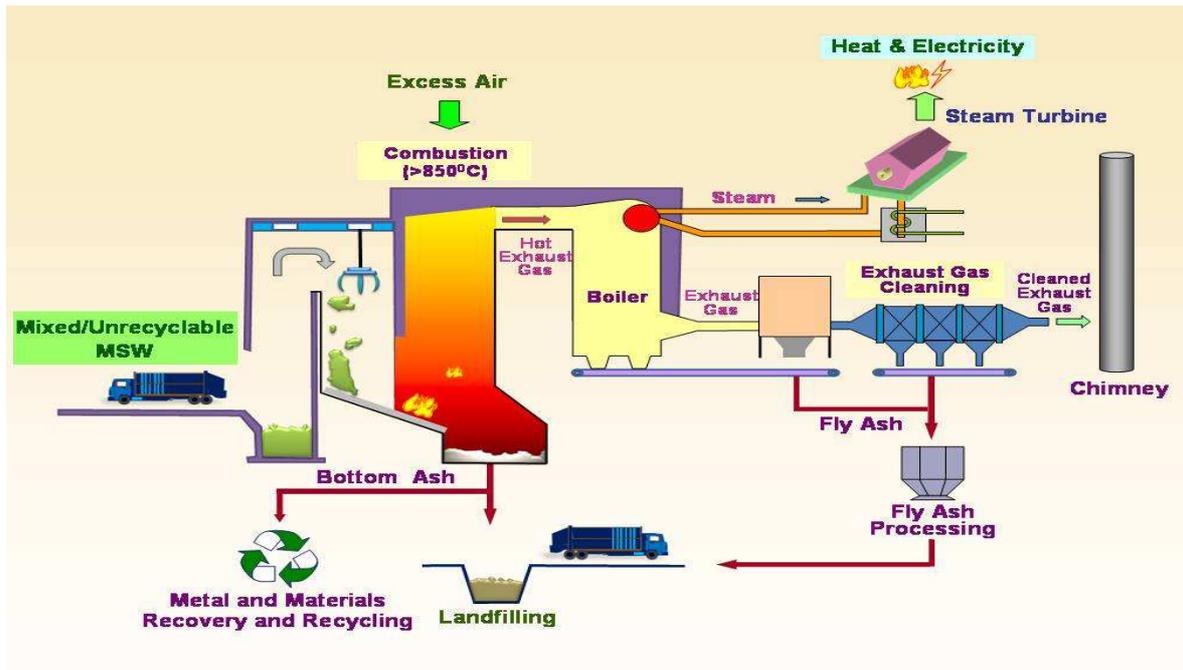


Figure 2.

2.4 BLACK LIQUOR

Pulp and Paper Industry is considered to be one of the highly polluting industries and consumes large amount of energy and water in various unit operations. The wastewater discharged by this industry is highly heterogeneous as it contains compounds from wood or other raw materials, processed chemicals as well as compound formed during processing. Black liquor can be judiciously utilized for production of biogas using anaerobic UASB technology.

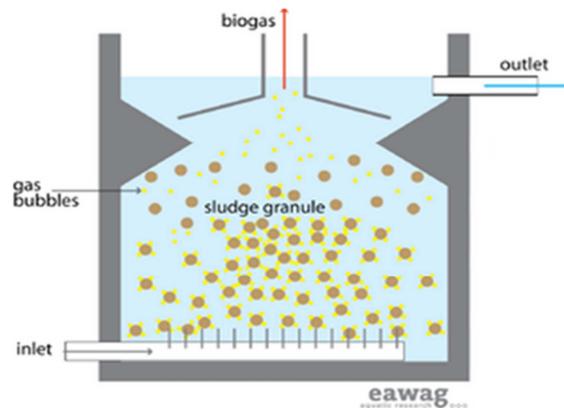


Figure 3. shows UASB reactor.(Upflow Aerobic Sludge Blanket reactor)

2.5 AGRICULTURAL RESIDUES

Large quantities of crop residues are produced annually worldwide, and are vastly underutilised. The most common agricultural residue is the rice husk, which makes up 25% of rice by mass. Other residues include sugar cane fibre (known as bagasse), coconut husks and shells, groundnut shells, cereal straw etc. Current farming practice is usually to plough these residues back into the soil, or they are burnt, left to decompose, or grazed by cattle. A number of agricultural and biomass studies, however, have concluded that it may be appropriate to remove and utilise a portion of crop residue for energy production, providing large volumes of low cost material. These residues could be processed into liquid fuels or combusted/gasified to produce electricity and heat. The waste may also be incinerated to energy.

2.6 ANIMAL WASTE

There are a wide range of animal wastes that can be used as sources of biomass energy. The most common sources are animal and poultry manures. In the past this waste was recovered and sold as a fertilizer or simply spread onto agricultural land, but the introduction of tighter environmental controls on odour and water pollution means that some form of waste management is now required, which provides further incentives for waste-to-energy conversion. The most attractive method of converting these waste materials to useful form is anaerobic digestion which gives biogas that can be used as a fuel for internal combustion engines, to generate electricity from small gas turbines, burnt directly for cooking, or for space and water heating. Food processing and abattoir wastes are also a potential anaerobic digestion feedstock.

2.7 SUGAR INDUSTRY WASTES

The sugar cane industry produces large volumes of bagasse each year. Bagasse is potentially a major source of biomass energy as it can be used as boiler feedstock to generate steam for process heat and electricity production. Most sugar cane mills utilise bagasse to produce electricity for their own needs but some sugar mills are able to export substantial amount of electricity to the grid.

2.8 FORESTRY RESIDUES

Forestry residues are generated by operations such as thinning of plantations, clearing for logging roads, extracting stem-wood for pulp and timber, and natural attrition. Wood processing also generates significant volumes of residues usually in the form of sawdust, off-cuts, bark and woodchip rejects. This waste material is often not utilized and often left to rot on site. However it can be collected and used in a biomass gasifier to produce hot gases for generating steam.

3 FACTORS AFFECTING ENERGY RECOVERY FROM WASTE

The two main factors which determine the potential of recovery of energy from wastes are the quantity and quality (physico-chemical characteristics) of the waste. Some of the important physico-chemical parameters requiring consideration include:

1. Size of constituents
2. Density
3. Moisture content
4. Volatile solids / Organic matter
5. Fixed carbon
6. Total inerts
7. Calorific value

Often, an analysis of waste to determine the proportion of carbon, hydrogen, oxygen, nitrogen and sulfur (ultimate analysis) is done to make mass balance calculations, for both thermochemical and biochemical processes. In case of anaerobic digestion, the parameters C/N ratio (a measure of nutrient concentration available for bacterial growth) and toxicity (representing the presence of hazardous materials which inhibit bacterial growth), also require consideration.

3.1 SIGNIFICANCE OF WASTE-TO- ENERGY (WTE) PLANTS

While some still confuse modern waste-to-energy plants with incinerators of the past, the environmental performance of the industry is beyond reproach. Studies have shown that communities that employ waste-to-energy technology have higher recycling rates than communities that do not utilize waste-to-energy. The recovery of ferrous and non-ferrous metals from waste-to-energy plants for recycling is strong and growing each year. In addition, numerous studies have determined that waste-to-energy plants actually reduce the amount of greenhouse gases that enter the atmosphere.

Nowadays, waste-to-energy plants based on combustion technologies are highly efficient power plants that utilize municipal solid waste as their fuel rather than coal, oil or natural gas. Far better than expending energy to explore, recover, process and transport the fuel from some distant source, waste-to-energy plants find value in what others consider garbage. Waste-to-energy plants recover the thermal energy contained in the trash in highly efficient boilers that generate steam that can then be sold directly to industrial customers, or used on-site to drive turbines for electricity production. WTE plants are highly efficient in harnessing the untapped energy potential of organic waste by converting the biodegradable fraction of the

waste into high calorific value gases like methane. The digested portion of the waste is highly rich in nutrients and is widely used as bio fertilizer in many parts of the world.

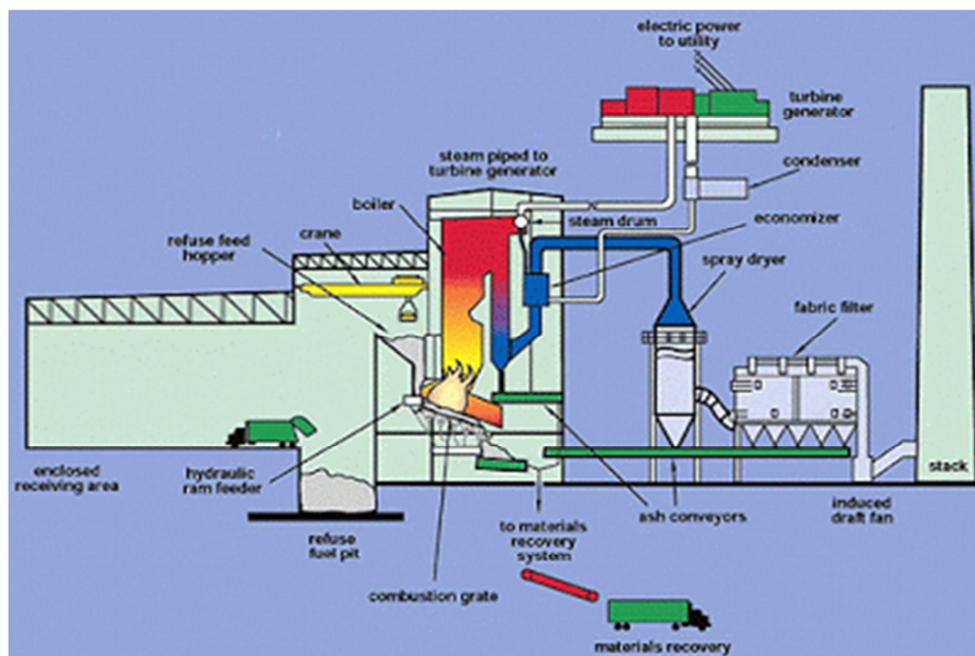


Fig 3. A typical waste to energy plant.

3.2 WASTE-TO-ENERGY AROUND THE WORLD

To an even greater extent than in the United States, waste-to-energy has thrived in Europe and Asia as the preeminent method of waste disposal. Lauding waste-to-energy for its ability to reduce the volume of waste in an environmentally-friendly manner, generate valuable energy, and reduce greenhouse gas emissions, European nations rely on waste-to-energy as the preferred method of waste disposal. In fact, the European Union has issued a legally binding requirement for its member States to limit the land filling of biodegradable waste.

According to the Confederation of European Waste-to-Energy Plants (CEWEP), Europe currently treats 50 million ton of wastes at waste-to-energy plants each year, generating an amount of energy that can supply electricity for 27 million people or heat for 13 million people. Upcoming changes to EU legislation will have a profound impact on how much further the technology will help achieve environmental protection goals.

4 WAYS TO PROCESS WASTE INTO ENERGY

A host of technologies are available for realizing the potential of waste as an energy source, ranging from very simple systems for disposing of dry waste to more complex technologies capable of dealing with large amounts of industrial waste. There are three main pathways for conversion of organic waste material to energy – thermo chemical, biochemical and physicochemical.

4.1 THERMO CHEMICAL CONVERSION

Combustion of waste has been used for many years as a way of reducing waste volume and neutralizing many of the potentially harmful elements within it. Combustion can only be used to create an energy source when heat recovery is included. Heat recovered from the combustion process can then be used to either power turbines for electricity generation or to provide direct space and water heating. Some waste streams are also suitable for fueling a combined heat and power system, although quality and reliability of supply are important factors to consider.

Thermo chemical conversion, characterized by higher temperature and conversion rates, is best suited for lower moisture feedstock and is generally less selective for products. Thermo chemical conversion includes incineration, pyrolysis and gasification. The incineration technology is the controlled combustion of waste with the recovery of heat to produce steam

which in turn produces power through steam turbines. Pyrolysis and gasification represent refined thermal treatment methods as alternatives to incineration and are characterized by the transformation of the waste into product gas as energy carrier for later combustion in, for example, a boiler or a gas engine.

4.2 BIOCHEMICAL CONVERSION

The bio-chemical conversion processes, which include anaerobic digestion and fermentation, are preferred for wastes having high percentage of organic biodegradable (putrescible) matter and high moisture content. Anaerobic digestion is a reliable technology for the treatment of wet, organic waste. Organic waste from various sources is composted in highly controlled, oxygen-free conditions circumstances resulting in the production of biogas which can be used to produce both electricity and heat. Anaerobic digestion also results in a dry residue called digestate which can be used as a soil conditioner.

Alcohol fermentation is the transformation of organic fraction of biomass to ethanol by a series of biochemical reactions using specialized microorganisms. It finds good deal of application in the transformation of woody biomass into cellulosic ethanol.

4.3 PHYSICO-CHEMICAL CONVERSION

The physico-chemical technology involves various processes to improve physical and chemical properties of solid waste. The combustible fraction of the waste is converted into high-energy fuel pellets which may be used in steam generation. Fuel pellets have several distinct advantages over coal and wood because it is cleaner, free from incombustibles, has lower ash and moisture contents, is of uniform size, cost-effective, and eco-friendly.

5 CONCLUSIONS

Energy conversion plants offer two important benefits of environmentally safe waste management and disposal, as well as the generation of clean electric power. Waste into energy facilities produce clean, renewable energy through thermochemical, biochemical and physicochemical methods. The growing use of waste-to-energy as a method to dispose off solid and liquid wastes and generate power has greatly reduced environmental impacts of municipal solid waste management, including emissions of greenhouse gases. Waste into energy conversion reduces greenhouse gas emissions in two ways. Electricity is generated which reduces the dependence on electrical production from power plants based on fossil fuels. The greenhouse gas emissions are significantly reduced by preventing methane emissions from landfills. Moreover, energy conversion plants are highly efficient in harnessing the untapped sources of energy from a variety of wastes.

An environmentally sound and techno-economically viable methodology to treat biodegradable waste is highly crucial for the sustainability of modern societies. A transition from conventional energy systems to one based on renewable resources is necessary to meet the ever-increasing demand for energy and to address environmental concerns.

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